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Communication Patterns Among Members of Engineering Global Virtual Teams

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ABSTRACT

Communication Patterns Among Members of Engineering Global Virtual Teams

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Global virtual (GV) teams provide an opportunity for engineering students to participate in meaningful, cross-cultural learning projects without additional costs of time and money associated with study abroad programs. However, students must learn how to communicate effectively with international team members. Instruction to help students learn which virtual communication technologies to use and how to use them is needed. Training must include cross-cultural training that facilitates team communications and interactions with people from different cultural backgrounds.

This study focused on how 10 specialized lessons, Principles of Global Virtual Teams (PGVT), facilitated the communications and interactions of students participating on GV teams in an advanced engineering design course. All GV teams provided evidence that communications and interactions on GV teams are different than Co-located teams. However, teams receiving the PGVT instruction showed indications of increased communication ability on GV teams. These indicators included technology use, vernacular phrase use, communication competence ratings and descriptors from team emails.

Keywords: Global virtual teams, Cross-cultural virtual teams, cross-cultural communication, virtual communication, international teams, colloquial phrases, trust building, teams,

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Chapter 1

Introduction

Over the past decade, increases in international commerce and the importance of foreign markets have necessitated collaboration among culturally and globally diverse groups of people (Ferraro, 2006). Historically, global business interactions required expensive and time-consuming travel (Morris, 2008). A better way was needed to connect global businesses that allowed teams of people separated by time, distance, and culture to work together in an effective and efficient manner without the time and financial costs associated with travel. Technology has provided a solution to this problem in that it has enabled teams separated by time and distance to collaborate more efficiently; however, technology has not eliminated the effects of culture on teamwork. In fact, globalization and technology have not only increased the likelihood that individuals will have to work in a culturally diverse setting, they have also changed the nature of collaborative teams and the skills needed to be an effective team member.

Theory on the development of team skills often focuses on co-located teams and how to improve the communication and interactions between local, culturally-similar, team members (Levi, 2011). On global teams, conventional team skills become intertwined with the cross-cultural skills that provide an individual the knowledge and the understanding to communicate and to work effectively with team members from other cultures. When team members remain located in their own culture, but communicate with international team members using Internet technologies, virtual communication skills are added to the skill set required to become an effective team member. Virtual communication skills provide people with an understanding of the various technologies and the ability to choose when and how to use virtual communication technologies in an efficient and successful manner. The interactions between these skills and the

resulting team and group settings are illustrated in Figure 1. Three general skills sets (i.e. teaming skills, virtual communication technology skills, and cross-cultural skills) are combined to identify four team and three group settings. The central focus of this depiction is global virtual teams.

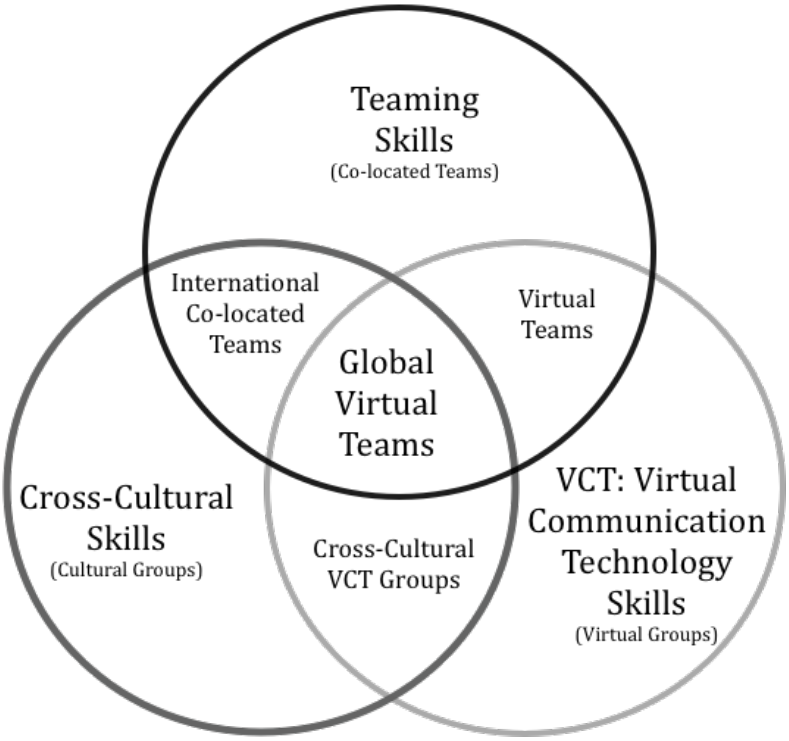

Figure 1. Skill interactions and resulting groups leading to Global Virtual teams.

Types of Group Settings

People participate in groups and interact for a variety of reasons. Group settings often involve distance, culture, or a combination of distance and culture. Groups of people interacting are not typically considered teams because they lack a purpose or defined goal centered in a work setting. Groups are formed primarily for social interactions, such as keeping in touch with friends or family, communicating with those who share common interests, providing

entertainment, or gaining insights on people from other cultures. Group members may connect with one another as virtual or cultural groups.

Virtual. When people form relationships and interact through social media and virtual communication tools, virtual groups are formed. A common virtual group is made through virtual games and social media centers where people communicate and interact via avatars. Other virtual groups share common interests such as genealogy. Virtual communications allow individuals to connect with other individuals or groups to further their interest in a given topic. In these group settings VCT skills are used to communicate with other group members.

Cultural. When individuals from different cultures form co-located groups to maintain or encourage interests, cultural groups are formed. An example would be a German club on a university campus where German nationals and other individuals who have experienced or who wish to learn more about the German culture meet. In cultural groups the intent is to maintain cultural values or to share those values with other cultures. In these situations cross-cultural skills are required for the group to associate amiably.

Cross-cultural VCT. When people form relationships and interact through social media or use virtual communication tools across cultural divides, cross-cultural virtual communication groups are formed. In order to participate in these types of groups, individuals need to develop both cross-cultural and virtual communication skills.

Types of Team Settings

Team interaction skills are needed for any type of setting where individuals come together for a specific purpose to accomplish a common goal. Team settings are delineated when a group has a defined goal or a specific purpose. Team formation often occurs in work settings. Depending on the setting, cross-cultural and virtual communication skills may be

needed in addition to basic teaming skills, to facilitate team interactions. The team settings (i.e., co-located, international co-located, virtual, or global virtual team) will dictate the required set of skills individuals will need to effectively work in that setting.

Co-located. When all team members, with relatively little cultural diversity, work in the same location, teams are known as co-located teams. Team meetings are typically face-to-face interactions with all members present. The team's work protocols and procedures are often established, determined, and enhanced by the fact that team activities take place in the same location. Essential team processes (e.g., trust building, conflict resolution, and knowledge sharing) occur as either planned interventions (e.g., team activities or retreats) or unplanned interactions (e.g., meeting in the hallway or having lunch together). Unplanned interactions often occur outside of team meetings and formal work situations. The unplanned interactions occur because team members are co-located. Many of the relationships developed in a work group occur naturally and continue even when the team has completed its task and is disbanded.

International co-located. When team members from international locations meet and work together in a common location, the team is an international, co-located team. This type of team combines teaming skills used in co-located teams with cross-cultural skills needed in culturally diverse non-team situations. International co-located teams often have members who travel for varying periods of time to work as part of the team. When the task, or a specific portion of the task, is completed, team members return home. The opportunities for communication and interaction among team members are similar to those in co-located team situations with the exception that the team is culturally diverse and in a location foreign to at least some of the team members. Team members must be aware of cultural differences and modify behavior as a result of those differences.

Virtual. Virtual teams blend teaming skills with virtual communication technology skills. While these teams may meet face-to-face, distance often dictates that their primary communication and interaction is done via the internet using a variety of virtual communication technologies. Although members may be dispersed across a city or the world, each member has similar cultural backgrounds and experience. There are little or no cultural differences, and communication is mostly seamless. Co-located teams often have a strong virtual team component in that co-located members will communicate with each other via virtual communication technologies even when personal contact is possible. However, virtual teams must communicate via virtual communication technologies out of necessity rather than convenience.

Global virtual. Teams whose members consist of individuals from different cultural backgrounds with specific expertise in a given skill or subject and who use a variety of virtual communication technologies to work across locational, temporal, cultural, and relational boundaries to accomplish a complex, specific task are known as global virtual (GV) teams. GV teams are not merely a re-invention of co-located teams, but a unique form of teams (Prasad & Akhilesh, 2002). They allow highly specific interactions with globally dispersed individuals with expertise in a less threatening environment, especially for team members with special traits or cultural values that may prevent open discussion in a face-to-face setting (Ahanchian & McCormick, 2009). GV team membership requires a combination of team, cross-cultural, and virtual communication technology skills. The addition of cross-cultural and virtual communication technology skills to team skills is what makes GV teams uniquely different from each of the previous types of teams.

The Development of Global Virtual (GV) Team Skills

Globalization in the field of engineering has caused university engineering institutions to reconsider the existing skill sets engineers need to be productive in the GV workplace. Prior to GV teams, most university engineering team experiences occurred in a co-located (i.e. classroom) or an international co-located team setting (i.e. study abroad programs). Specific instruction focused on the co-located team skills (e.g., engineering capstone experiences) or international co-located team skills (e.g., engineering study abroad or internship programs). Each setting provided engineering students with the opportunity to work in a specific team setting to learn engineering, cross-cultural, and team skills. However, neither program combined the cross-cultural skills and virtual communication skills with team skills required on a GV team.

Since face-to-face interaction is restricted or eliminated on GV teams, students need to learn how to communicate in different ways. Communication among team members becomes critical for GV team collaboration. Each team needs to learn how to use cross-cultural skills and virtual communication skills that are most effective, efficient, and appropriate (Barczak, McDonough, & Athanassiou, 2006; Poehler & Schumacher, 2007). This instruction should be grounded in meaningful engineering tasks and projects so students can learn engineering skills while applying the GV team skills. Learning how to effectively use virtual technologies to communicate with team members located throughout the world becomes critical to a GV team's success (Goodbody, 2005; Morris, 2008).

In addition to basic team skills, there are two different skill sets that need to be developed: (a) virtual communication technology skills and (b) cross-cultural competencies. Virtual communication technology skills are needed in order to choose and use virtual technologies that best suit the specific communication needs of a group at any given time.

(Huysman, Steinfield, David, Poot, & Mulder, 2003). When communication technologies are used to interact and build relationships with people of differing cultural backgrounds, individuals should also possess specified cross-cultural competencies (Ball, et. al., 2011). Knowledge of how cultures impact culturally diverse team situations is important if teams are to be successful in a GV environment. GV team members need to be aware of their own and others' cultural skills that might positively or negatively affect the success of cultural interactions on a GV team. Individuals need a high degree of virtual technology skill and cross-cultural competence (i.e., knowledge, skills, and attitudes) if they are to be successful in GV interactions. The acquisition of these skills occurs best as students collaborate on meaningful engineering projects with international team members on a GV team.

GV Team Instruction

In order to investigate how teaching GV team skills may be integrated into engineering education, an engineering design course was used to allow direct contact and interaction among local and international students. This interaction focused on a meaningful engineering design project that provided the opportunity to use virtual communication technologies to facilitate cross-cultural interactions. The GV team component to this project allowed students to develop their attitudes, knowledge, and skills of cross-cultural interaction through virtual communication technologies while completing the engineering project. Three types of instruction (imbedded, synchronous, and asynchronous) were piloted in beta versions of the GV engineering design course.

Embedded. In preparation for this study, a beta version pilot using the GV team intervention embedded cross-cultural training and a GV team experience into an existing advanced mechanical engineering design course. Original instruction in the engineering design

course was condensed, modified, or eliminated to provide room in the curriculum for instruction on cross-cultural competencies and virtual communication technology use. After this single semester pilot, several problems were identified that resulted in the suspension of the GV team aspect of the course for a semester to allow for modification of the instructional approach. Foremost among the problems was the issue of lost lecture time used to teach mechanical engineering design skills.

Synchronous. To solve this problem of lost engineering design skills, a new course, Principals of Global Virtual Teams (PGVT), was created to present GV team concepts concurrently with a GV engineering project-based course involving cross-cultural teams. In this new course, students received weekly instruction regarding the use of virtual technologies, cross-cultural issues, and differences in team processes resulting from interactions with different cultures in a global team context. The course presentation also provided an opportunity for local and international students to interact using virtual communication technologies. The interaction between the PGVT instruction and two capstone teams' experience provided the opportunity for students to establish and build relationships to facilitate successful GV team interactions. However, alignment of synchronous instruction times with partner schools in international locations, coupled with alignment of current BYU engineering curricula, made this method unwieldy.

Asynchronous. The PGVT synchronous instructional materials were revised into an asynchronous format that facilitated embedding the lessons into the GV engineering design course's labs. While content remained the same as the synchronously presented PGVT instruction, each lesson followed a common format with assessment questions at the end. It was expected that students would take about an hour to complete each lesson (depending on English

language skills) at a convenient time for each student. Lessons were organized to correspond with team interactions and tasks on the engineering design course group project. For example, a lesson on establishing team protocols was presented at the beginning of the course as students were organizing their teams, choosing leadership roles, and establishing team protocols. The intent of the PGVT lessons was to facilitate student understanding and skill development while interacting with culturally different team members via virtual communication technologies.

Research Purpose and Question

Since face-to-face contact is not possible on GV teams, communication and team member interaction through virtual communication tools increases in importance. Instruction described global competencies (Ball, et al., 2011) and provided students with the knowledge of how to use these competencies during a GV team experience. The instruction promoted positive communication patterns that enabled successful team work in a GV team setting. Instruction included items such as sharing personal stories, providing background information, solving team differences, adjusting conversations, and altering social interactions to promote trust and relationships among team members.

This study sought to understand how communication patterns on GV teams were influenced by the PGVT instruction. The research examined the differences between the communication patterns of engineering students who receive extensive cross-cultural and virtual communication technology training and practice versus engineering students with limited or no instruction on these topics (i.e. trust building, intercultural communication, cultural disposition) and traditional co-located teams.

The main research question this study addressed was the following: In what ways and to what extent does PGVT instruction influence the development of positive communication patterns for those participating on a GV team?

Chapter 2

Literature Review

Collaborative learning has traditionally been defined in terms of pairs or teams of students learning together to achieve a common educational goal. Such collaboration leads to "deeper level learning, shared understanding, critical thinking, and long-term retention of the learned material" (Tsai, 2010, p. 1137). University programs provide students the opportunity to participate on teams in collaborative learning situations in a wide variety of courses and internships (Dobson et al., 2001; Wojciechowski & Standridge, 2010). Engineering programs support this collaborative effort by providing the opportunity or by requiring undergraduate students to participate in a team experience prior to graduation. Students may be organized into co-located teams of students with a university coach to assist in solving a client-sponsored problem (Dekker, Sundarrao, & Dubey, 2010; Latino & Hagan, 2010). While these team experiences prepare engineering students for work on co-located teams, it does little to provide an authentic experience in global virtual (GV) team settings.

The Nature of GV Teams

The advent of internet technologies enables collaboration to extend beyond the classroom walls to students or experts in other locations. Internet and virtual communication tools enable internationally based team members to remain dispersed throughout the globe while working together as a GV team to solve specific engineering problems. Educational institutions need to respond to the changing nature of teamwork by providing authentic GV team educational opportunities and instruction to their students. These GV opportunities provide students with the knowledge, skills, awareness, and attitudes to be able to communicate and interact successfully

on GV teams (Anawati & Craig, 2006; King, 2007; Koszalka & Wu, 2010; Poehler & Schumacher, 2007; Roebuck, Brock, & Moodie, 2004; Starke-Meyerring & Andrews, 2006).

Working on a GV team with international partners provides the opportunity for collaborative learning. While students are co-operating on an engineering design project, they are also learning the positive communication skills needed to complete successful team interactions. This collaborative learning activity requires students to learn engineering skills necessary to complete the design project and positive GV communication skills needed to work on a GV team.

Instead of thinking of a GV team as a co-located team with virtual communication tools, new team practices are needed (Anawati & Craig, 2006). For example, get-acquainted activities (e.g., team dinners, after work activities) common to co-located teams are not possible with GV teams. Introductory activities designed to introduce and acquaint team members with one another must be planned and conducted via virtual communication technologies. In many cases this begins with students completing a personal profile that provides key information about oneself (e.g., language abilities, personal characteristics, interests, background experience, and expectations) that forms the basis for initial conversations among GV team members (Rus, 2010). The portfolio and initial conversations offer students the chance to get to know one another and begin to build trust and relationships. Kankanhalli, Tan, and Wei (2007) emphasized that GV team instruction provided students with the skills to recognize critical situations and to act appropriately before these critical situations interfered with team goals and prevented team success. Students learned to become proactive when interacting with team members.

Providing an authentic GV team experience for students required different approaches to presenting course concepts, lessons, and learning activities. Hastie, Hung, Chen, and Kinshuk (2010) reported that students and teachers needed to adopt new mindsets and skills to allow for improved educational, social, and economic prospects. They further emphasized a shift from collaboration within an educational organization to collaboration between educational organizations. Course instructors needed to work together and to collaborate on establishing and maintaining instruction with colleagues for their respective students. Student team members needed to learn how to communicate and to interact with GV team members in different ways, since the students were unlikely to meet face-to-face, but still needed to build strong, interactive relationships of trust and collaboration. GV instruction and learning provided students with a better idea of the knowledge, skills, and attitudes necessary for successful GV team interactions needed to complete a collaborative project.

GV Team Skills and Factors Influencing GV Team Interactions

Using the Engineering Village Compendex and ERIC databases a literature search was conducted using key terms (e.g., global virtual teams, cross-cultural virtual teams, computer-centered collaborative learning) to determine competencies needed for successful GV team communications and interactions. A total of 68 articles were used to identify, describe, and code similar constructs into 10 skills needed for successful GV team interactions and communications. These skills include (a) conversing, (b) cultural differences, (c) knowledge sharing, (d) social interaction, (e) language, (f) leadership, (g) protocols, (h) team disagreement, (i) technology use, and (j) trust building. Table 1 provides a list of these skills, the authors, and the articles discussing specific skills in GV team training.

Table 1

Identified GV communication skills discussed in articles listed alphabetically by author.

Authors	Identified Skill Categories										
	Conversing	Dealing with Cultural Differences	Sharing Knowledge	Adjusting Social Interactions	Adjusting Language	Developing GV Leadership	Establishing Protocols	Working through Team Disagreement	Choosing Technology	Building Trust
Anawati & Craig, (2006)	•	•		•	•			•		
Barczak, McDonough, & Athanassiou, (2006)	•	•		•	•		•			
Bergiel, Bergiel, & Balsmeier, (2008)		•				•	•	•	•	•
Boule, (2008)	•		•	•		•	•		•	
Brandl & Neyer, (2009)		•	•					•		•
Bulu & Yildirim, (2008)	•		•	•		•	•		•	•
Carte, Chidambaram, & Becker, (2006)						•	•	•		
Chen, Zhang, Vogel, & Zhao, (2009)			•	•		•				•
Cho, Gay, Davidson, & Ingraffea, (2007)				•			•			
Cogburn & Levinson, (2003)		•		•					•	•
Coppola, Hiltz, & Rotter, (2004)	•		•						•	•
Cramton & Hinds, (2004)		•	•						•	
Dorazio & Hickok, (2007)		•	•	•	•			•	•	•
Erasmus, Pretorius, & Pretorius, (2010)				•			•		•	
Flanagan & Runde, (2009)	•		•					•		•
Gibson & Gibbs, (2006)		•								•
Goodbody, (2005)	•	•	•				•		•	•
Goold, Augar, & Farmer, (2006)	•		•		•				•	
Gupta, Mattarelli, Seshasai, & Broschak, (2009)			•						•	
Hasler-Waters & Napier, (2002)	•			•			•			•
Hastie, Hung, Chen, & Kinshuk, (2010)				•			•		•	
Hinds & Bailey, (2003)				•				•	•	
Horwitz, Bravington, & Silvus, (2006)	•	•			•	•	•		•	
Hou & Wu, (2011)	•		•	•						
Hsu & Chou, (2009)	•			•				•		
Hung & Nguyen, (2008)	•				•			•	•	
Kankanhalli, Tan, & Wei, (2007)		•		•	•			•	•	
Karpova, Correia, & Baran, (2009)	•		•	•			•		•	
King, (2007)		•	•							•
Koszalka & Wu, (2010)	•		•				•		•	
Laroche, (2002)	•	•			•		•			•
Last, (2003)	•			•			•			•
Lee-Kelley, Crossman, & Cannings, (2004	•						•			•
Leede, Kraan, den Hengst, & van Hooff, (2008)			•							•
Liu, Luo, & Wei (2008)		•						•		
Liu, Magjuka, & Lee, (2008b)	•						•	•		•
Martins, Gilson, & Maynard, (2004)	•		•				•	•	•	•
May & Carter, (2001)			•						•	

Table continues

Table 1 continues

Authors	Identified Skill Categories: Conversing	Dealing with Cultural Differences	Sharing Knowledge	Adjusting Social Interactions	Adjusting Language	Developing GV Leadership	Establishing Protocols	Working through Team Disagreement	Choosing Technology	Building Trust
McNair, Paretti, & Kakar, (2008)		•			•		•			
Meirer, Spada, & Rummel, (2007)	•		•	•						
Moe & Šmite, (2008)		•		•	•	•	•	•		•
Ocker, Webb, Hiltz, & Brown, (2010)	•			•		•			•	
Panteli & Fineman, (2005)	•		•				•			•
Panteli & Tucker, (2009)			•			•			•	•
Panteli & Davison, (2005)	•			•			•			•
Paul & Ray, (2009)		•	•					•		•
Paul, Mcdaniel, & Paul, (2011				•					•	•
Paul, Seetharman, Samarah, & MyKytyn, (2005)	•			•				•		
Peters & Manz, (2007)	•		•				•			•
Prasad & Akhilesh, (2002)							•			
Rassmussen & Wangel, (2006)				•		•	•			•
Roebuck & Britt, (2002)	•	•		•	•		•		•	
Roebuck, Brock, & Moodie, (2004)	•			•			•			•
Ross, (2006)		•	•	•	•		•			•
Rus, (2010)	•				•		•		•	•
Rusman, et. al, (2009)			•	•						•
Sarker, Ahuja, Sarker, & Kirkeby, (2011)	•			•			•			•
Serçe et. al., (2011)	•		•	•			•			
Shachaf & Hara, (2007)				•	•				•	
Staples & Zhao, (2006)		•						•		
Starke-Meyerring & Andrews, (2006)			•						•	
Sudweeks & Simoff, (2005)	•		•			•				
Tavčar, Žavbi, Verlinden, & Duhovnik, (2005)									•	•
Tseng, Wang, Ku, & Sun, (2009)				•				•		•
Yoon & Johnson, (2007)							•			
Zakaria, Amelinckx, & Wilemon, (2004)	•	•	•				•		•	•
Zhang & Chen, (2010)		•	•					•		
Total Articles in Each Category	34	22	30	33	14	11	33	19	30	34

• indicates that the article identifies and describes this GV team interaction and communication skill.

Students working on GV teams need to identify what global skills they currently possess and those skills that they need to improve. Completing the Principles of Global Virtual Teams (PGVT) lessons provides students with the opportunity to learn GV team skills and implement them while working on a GV team project. Each skill represents a continuum of ability ranging from a novice to expert. Although each skill is presented individually, no skill is truly unique as each overlaps with other skills. However, for the purposes of this document each skill is presented separately.

Conversing. Conversations between people are more complicated on GV teams (Poehler & Schumacher, 2007). Virtual technologies that transmit text, still pictures, and/or video filter all conversations. Even with synchronous technologies (e.g., video conferencing) the receiver only sees a limited, sender-controlled image. This filtering results in a greater emphasis on spoken and written conversations as non-verbal cues are restricted or eliminated.

Modifications in conversations. After interviewing the employee responsible for an international organization's culture and training materials, Anawati and Craig (2006) created a questionnaire studying organizational and managerial practices. Items on the questionnaire included how long the respondent's team existed and the type of media (e.g., telephone conferencing, email, video conferencing) used by team members to converse. Other questions sought to determine behavioral adaptations (i.e., reading, writing, allowance for religious beliefs, or time zone differences). Questions also sought to determine how spoken conversation was influenced on the cross-cultural, virtual teams.

The study included questions about modifying speed of speech, length of sentences, and tone. Other conversation adaptations examined excluding use of vernacular phrases (i.e., slang, colloquialisms, metaphors, humor, jargon, and acronyms). The questionnaire also examined

skills such as verifying member's understanding of the conversation, inviting responses from all team members, allowing time to think before expecting a response, and writing key words or phrases by team members to aid conversations.

The results indicated several adaptations in team member conversations. For example, over half of the respondents altered the way they wrote messages by limiting or avoiding vernacular words and phrases (e.g., slang and colloquialisms). Instead, the participants used small, simple English words, and kept to the point of the message. Over 80% of respondents altered their manner of speech with most speaking slower and more clearly. Other researchers support this simplification of language in conversations and elimination of vernacular phrases to avoid misunderstandings and miscommunications (Laroche, 2002; Panteli & Fineman, 2005; Ross, 2006). To avoid these misunderstandings, individuals with strong bilingual skills need to be aware of which vernacular words and phrases are present in one language, but not the other language.

Context of conversation. Sometimes team messages are interpreted incorrectly even by those with strong bilingual abilities (Paul & Ray, 2009). In cultures with a common language, care needs to be taken when similar words have different meanings. Caution must be exercised to ensure that the receiver correctly understands the message. The message sender needs to write the message in terms that the receiver can clearly understand (Anawati & Craig, 2006; Paul & Ray, 2009). In a study that used blogs to facilitate communication between teams with students in Quebec and Delaware, students became aware of the influence of the French context on English Canadian words. This prompted all students to be more cautious and aware of differences when they wrote on the blog (Starke-Meyerring & Andrews, 2006). Whether sending or receiving dialogue, an attitude of tolerance and understanding is key to good group

conversations. Messages' content and purpose should be verified and clarified with subgroup team members.

Adjustment to subgroup conversations. Panteli and Davison (2005) studied the effect of subgroups on GV team performance of teams with students from two universities in different countries. In this study, teams with weak evidence of subgroups found team communications to be more relaxed. The teams' interactions supported a positive whole team spirit. Team members developed good social interactions by sharing opinions and views on issues other than the assigned task. Students would often begin conversations in an asynchronous forum before moving to a virtual classroom to continue.

As team members take the time to get to know one another, the level of team effectiveness improves (Tavčar, Žavbi, Verlinden, & Duhovnik, 2005). Conversations allowing team members to better understand and know one another help support team interactions. This understanding allows for more open sharing and builds stronger relations between team members. In many cases this relationship building was as important as producing quality deliverables (Ocker, Webb, Hiltz, & Brown, 2010; Sarker, Ahuja, Sarker, & Kirkeby, 2011).

Taking time to understand the background and history of other team members enables one to adapt conversations to those of their team members. Part of this adaptation runs counter to previous research and requires GV team members to know how to interpret and express themselves in the vernacular of other cultures. They also need to know what the other culture considers important and trivial. This allows international team members to accept more important cultural aspects and let go of trivial ones. In short, a GV team member needs to adapt to the language and traits of other team members' culture and language to reduce anxiety and uncertainty (Brandl & Neyer, 2009). Adapting to the culture and language of other team

members may occur in several forms (auditory or written) and both synchronously or asynchronously.

Media choice in conversations. A study conducted by Bergiel, Bergiel, and Balsmeier (2008) focused on conversing through asynchronous methods. They found that the type and frequency of asynchronous conversation affected GV teams. Teams who communicated more often had stronger team relationships. Team members needed to decide what, when, and how to communicate with other team members, using virtual communication tools such as chat rooms, wikis, or email. Sharing information through these and other virtual communication tools provided the opportunity for bonding relationships and building trust with other team members.

McNair, Paretti, and Kakar (2008) emphasized the need to teach and learn transferable communication practices that facilitated collaboration. They conducted a case study using a cross-cultural, cross-discipline design course with United States (USA) engineering students and European digital media students. Students were divided into two groups: seniors with little cultural or technical instruction (control group) and juniors with concurrent participation in a course on the global marketplace and global instruction (treatment group). Researchers examined team emails and conversations. They conducted focus groups and administered pre- and post-surveys incorporating rating scales and open-ended questions regarding the difficulty of cross-cultural and cross-disciplinary collaboration, as well as the students' overall experience.

While both groups entered the collaborative project with particularly naïve views of potential problems, the treatment group developed a greater sensibility and ability to identify potential differences. They also developed a richer sense of personal and collaborators' roles and identities and displayed a greater willingness to work to overcome those difficulties. The

control group never moved past a simplistic understanding of group relationships and roles (McNair et al., 2008).

Amount of conversation. As mentioned earlier, the frequency of conversations also became important. High-performing teams are known to exchange more messages overall (Carte, Chidambaram & Becker, 2006). This frequency indicated that students used their conversations to explain ideas and concepts more clearly and fill in gaps caused by the filtering of virtual communication tools. Instead of remaining silent in synchronous conversations, students frequently asked team members to repeat, clarify, or re-explain concepts. Similarly, those explaining ideas and concepts often paused to make certain team members understood what had been said and to invite questions (Panteli & Fineman, 2005; Peters & Manz, 2007; Poehler & Schumacker, 2007; Rassmussen & Wangel, 2006, Ross, 2006). These actions created an atmosphere of trust and collaboration as team members sought to better explain concepts and understand one another.

Conversations on GV teams must take into account the limiting factors of virtual communication tools, but use these tools effectively to create conversations of trust and relationship building. Since these conversations are unlikely to occur spontaneously, individuals need to schedule time for these conversations to occur. Initially the use of vernacular phrases needs to be reduced or eliminated. As team members gain greater cultural and communication understanding, they should learn to communicate using culturally based terms and phrases that provide a level of comfort and familiarity with their international team members. Conversations should be frequent and initiated by all team members. Teams should establish the common practice of seeking clarification or explaining concepts to international team members to increase their understanding and use of culturally sensitive language.

Dealing with cultural differences. Cultural differences can make communications more difficult. Team members need to alter how they interact since cultural influences in conversations may change the meaning in what and how something is communicated. For example, Japanese culture has several ways of indirectly saying no to a project or idea instead of directly saying no. This allows the individual to "save face" and not be embarrassed by a public refusal of an idea (Ferraro, 2006). Team members need to have a broad understanding of the cultural backgrounds of team members to be able to recognize and understand cultural communication patterns.

Cultural understanding. Brandl and Neyer (2009) suggest that it is not good enough to have culture-specific or country-specific knowledge. Rather the understanding of the other culture must be an in-depth knowledge of interpersonal interactions. Interpersonal awareness "seeks to enhance the team members' capabilities to adjust to unknown situations" (p. 347). Cross-cultural awareness alters GV team members' attitude so that the unknown is viewed as an opportunity to grow instead of being an obstacle or challenge. Other studies support this view as they cite an open attitude toward exploring other cultures, a willingness to understand team members' culture, and an ability to expand one's second language skills as important aspects of GV team functionality (Karpova, Correia, & Baran, 2009; McNair et al. 2008).

Cross-cultural communications. Other cultural communication issues may focus on cultural attitudes in communication. Barczak et al., (2006) described a situation where a USA team member was trying to communicate with a team member in Kenya. The Kenyan was not responding to emails because he (the Kenyan) had been waiting for an opportunity to introduce himself, talk about his background experiences, and learn more about the USA team member before focusing on the narrow issues of the team emails. Once the introductions were made and

backgrounds explained, communication via email improved. In order to communicate effectively, some cultures believe that visiting and socializing so team members become acquainted with one another is as important as conducting the business of the team.

Contextual information. Durnell and Hinds (2004) emphasized the importance of contextual information as team members from one culture may not fully understand the patterns of preference and behavior of their international team members. An example of this occurred in a study of technology teams made up of USA and German team members using bulletin boards to communicate with one another. While all team members were expected to participate in thread-related discussions to improve communication and understanding of one another, the Germans viewed this activity as senseless and baseless since it did not directly relate to the final project. When USA team members switched to emails to get feedback needed to submit project milestones for the USA course, the Germans disregarded the emails as they thought the emails were more of the unwanted contact from the discussion board. This delay resulted in the USA team members submitting assignments without the required feedback from the German team members. The more direct, project-focused culture of the Germans did not allow them to understand the need to form stronger relationships with the USA team members. The USA team members were not able to communicate why the required activities were important for them and their grades. The result was a breakdown in communication between the team members and a less effective GV team result (Dorazio & Hickok, 2007).

Cultural dimensions. Other cultural dimensions of communications focus more on how things are said rather than what is said. For example, high context communications have a great deal of implied understanding or communication through non-verbal means, whereas low context is more explicit in what and how things are said (Rassmussen & Wangel, 2006). High context

cultures may have difficulty explicitly explaining cultural nuances to international team members. Other cultural interactions may be laden with emotion, such as very loud and animated conversations. While some cultures see the expression of emotion as a sign of weakness, for others emotion-laden communications are a natural part of the culture. Some cultures are assertive in how they communicate, while others are passive and polite, deferring to those in positions of authority. In each case team members need to understand the cultural heritage of team members' communications (Hall, 2005).

Understanding team members' cultural background and heritage provides the knowledge and ability to communicate more effectively with team members. Understanding the heritage of how cultures communicate allows one to draw out more reserved or quiet cultures or to prepare for the shock of assertive, emotional cultures where yelling and arguing is part of a normal conversation. Cultural understanding helps students gain a sense of important and trivial components in communications with international partners. Knowing one's own cultural communication preferences becomes important so one's communications may be adjusted to those of team members.

Sharing Knowledge. Team members must willingly share information and knowledge needed for the team to create the final products and complete assigned tasks. Gupta, Mattarelli, Seshasai, and Broschak (2009) explored the possibility of teams working in a 24-hour factory model. The 24-hour model required one subgroup of the GV team to work on an assignment before handing off completed work to the other team subgroup at the end of a 12-hour cycle. Knowledge was shared on a daily basis as team members sought to transfer knowledge and completed work to each other. Teams, spaced 12 hours apart, were compared with a co-located team working on a similar project. Researchers conducted a two-hour interview with each

participant, observed weekly group meetings, and collected archival data. While both teams used written communication, the co-located team relied more on face-to-face interactions for knowledge sharing and short-term decisions. They did not document the decision making process. The co-located team used email as a way of continuing their group meetings while the GV team used email to document team discussions and decisions, to share knowledge to aid in decision making, and to resolve issues (Gupta et al., 2009). As a model, the expected efficiencies in sharing knowledge and tasks were offset by the complications that arose from too many handoffs between subgroups on the GV team.

Information sharing. On other GV teams, document and knowledge sharing focused on letting all team members know what had been done and what was scheduled for discussion at team meetings. Typically, critical documents, meeting agendas, and meeting minutes were shared so all team members had a point of reference on what decisions were made and what decisions needed to be made. The information was provided to help team members be ready to discuss the project decisions during the upcoming meeting in a more efficient manner (Barczak et al., 2006; Laroche, 2002; May & Carter, 2001). This sharing of knowledge via virtual communication technologies replaced the contact between co-located teams where members inform one another what they have done and what they are working on during brief, casual encounters.

Commitment to team. The advantage of this frequent, documented knowledge sharing is that it establishes the commitment of team members to the team project (Barczak et al., 2006; Boule, 2008; Zhang & Chen, 2010) and allows GV teams to apply technical and market knowledge of local economies and customers (Gibson & Gibbs, 2006). Knowledge sharing also allows team members to establish their roles and purpose on the team, why their role is of value,

and how other team members need their information to complete current and future tasks (Rasmussen & Wangel, 2006). When this knowledge sharing is done correctly it enables expertise and creativity from around the world to be used to solve a local problem.

Media choice for sharing. Knowledge sharing depends upon the available virtual communication technology allowing GV team members to store and distribute materials (Bergiel et al., 2008). Appropriate knowledge sharing requires team members to be able to share knowledge using the most effective medium (May & Carter, 2001). For example, team meetings may be conducted with a virtual communication tool that allows for a video, audio, text messaging, and screen sharing capabilities. Each of these tools facilitates team interactions during the meeting. However, storage of team minutes or team documents may be done using a cloud technology (e.g., Dropbox) that allows any team member to access and review any document. Each virtual tool facilitates a specific type of knowledge and document sharing. Team members need to know the most effective and timely ways to share knowledge and documents with the appropriate team members.

Knowledge sharing becomes critical as it helps to establish trust and relationships among team members. Documenting discussions and decisions allows team members to verify assignment completion. This verification demonstrates team members' commitment to the project and team. Knowledge sharing also facilitates team communications by providing information for team members to review and to prepare for discussions at team meetings. The willingness to share knowledge builds the trust needed to facilitate social interactions and team communications.

Engaging in social interactions. Social communication on co-located teams occurs in areas where students meet during daily activities. Students often have classes or labs with other

team members. Team members may meet in the hallway or other locations. They may meet socially outside of work for dinner or at a common event. In each situation, team members have the opportunity to become better acquainted with each other, find common interests, and talk about the project on an informal basis. Social interaction helps to form strong relationships of trust and common understanding among team members. These types of unplanned or casual social activities are not possible with international team members (Lee-Kelley, Crossman & Cannings, 2004). The lack of face-to-face interaction prevents the collection of information that may be determined from facial expressions, voice intonations, and body language as this type of information is severely restricted or eliminated by virtual communication technologies (Daim et al., 2011; Gibson & Gibbs, 2006; Peters & Manz, 2007; Roebuck et al., 2004). In addition, messages sent through virtual communication tools may become loaded with meaning and misunderstood because of the reduced visual and auditory cues, delayed response, or reduced language ability (King, 2007; Panteli & Fineman, 2005). These miscommunications have the potential for exaggerating the importance and influence of the message and the resulting interpretation.

Influence of culture. Cultural influences may hamper GV social interactions as some cultures are more formal or require team members to first build a relationship of trust and understanding before working on a project. Cultural mores and values may inhibit or prevent interaction between segments of the GV team (e.g., male-dominated cultures prevent interaction with or disregard comments from female team members). Cultural influence may also extend to English-as-a-second-language (ESL) team members who prefer not to speak directly to other team members because of self-perceived language deficiencies (Peters & Manz, 2007). Poor team socialization may also prevent an open and honest dialogue about the project, as one culture

may be reluctant to criticize international team members' suggestions because they do not feel that they have a strong enough relationship to do so. The unwillingness to socialize prevents teams from forming strong, trusting relationships that allows team members to foresee and discuss potential problems or team concerns. Cultural interactions and the lack of face-to-face contact on GV teams require team members to move out of comfort zones and try new communication methods adapted to the culture of GV team members to establish and build relationships (Staples & Zhao, 2006).

Willingness to communicate. The willingness to initiate communication with different people in various settings provides the opportunity for teams to build the relationships needed for success (Cho, Gay, Davidson, & Ingraffea, 2007; Daim et al., 2011; Gibson & Gibbs, 2006). For this reason, GV teams need to encourage and support open interactions among team members in a variety of planned virtual interactions. Team members must be aware of and use a variety of virtual communication technologies to initiate and maintain contacts with team members (e.g., Facebook to share personal pictures or Google+ to create team and personal hangouts). When one team member sees another team member is online, he or she may send a quick hello and visit much as one would when passing a team member in the hallway. Instead of allowing or expecting these interactions to occur spontaneously, Maznevski & Chudoba (2000) advocate scheduling such interactions with team members in such a way that a rhythm is formed where the social interactions have a strategic place and are expected to occur as part of GV team meetings.

The humanizing of interactions. However, using new virtual communication tools and meeting new, unknown team members may be an intimidating experience "characterized by a great deal of uncertainty and mutual suspicion" (Paul & Ray, 2009, p. 5). During initial meetings, team members need the opportunity to freely communicate with each another to

understand whom their team members are, how they function, and where they fit into the team's organization. This understanding may be achieved by having participants interview one another online and share experiences or personal stories about themselves and the people around them. It also includes team members encouraging all other members to share their thoughts and opinions, even when their opinions are counter to group discussion (Hasler-Walters & Napier, 2002).

Grosse (2002) encourages GV team members to find ways to humanize interactions via technologies. This includes sharing photos and celebrating special occasions. Of course for this to happen this information needs to be shared with other team members. Rusman, van Bruggen, Cörvers, Sloep, and Koper (2009) used a case study of the European Virtual Seminar on Sustainable Development (EVS) to study the use of student profiles. They had participants fill out a profile with personal information including educational background, non-work personal information (e.g., hobbies, music preferences, spare time activities), a photo, demographic information (e.g., age, gender, organization affiliations), future plans, expectations of the course and motivation for taking the course along with any other information that would seem of interest or importance.

Initially students used the profile to intermingle virtually with other team members. However, team members reported referring to the profile frequently throughout the EVS team activities to better understand embedded social orders of other team members. The profile refreshed team member memories regarding student interests and abilities. The portfolio enabled team members to forge a connection with each other and contact teammates with the appropriate skills when technical questions arose. Other studies confirmed the importance of providing key personal information (e.g., beliefs, values, assumptions, and opinions) and communicating in an open manner that may include thoughtful humor, honesty, respect, and motivational or positive

messages to enable team members to become acquainted with and support one another (Bergiel, et al., 2007; Hasler-Walters & Napier, 2002; Morris, 2008). However, it is important that information shared be relevant to the team and not have the potential for misuse should it fall into the wrong hands.

Other methods to humanize the team interactions through virtual communication technologies focus on issues of courtesy where team members introduce themselves, other team members, or new participants as some cultures are reluctant to interact unless introduced. Courtesy also included allowing for time delays caused by the virtual communication tools and the need for ESL speakers to process and become involved in the conversation (Laroche, 2002). Team members need to be patient and respectful when there are periods of silence in communications and interactions as these may be functions of the tools being used, the language abilities of international team members, or cultural values dictating how conversations should proceed.

The nature of team cohesion. In a study of the development of global software teams pairing students from Sweden and the USA, Last (2003) reported that teams that exhibited more team cohesiveness intermixed humor and social comments with technical discussion. Team members were enthusiastic about their projects and often provided supportive encouragement and praise to team members. Conversations among team members were characterized by ample give and take and greater commitment to the project by team members. Teams that did not demonstrate team cohesiveness did not attempt to engage in social interactions and relationships were more impersonal. There was increased team conflict and lack of commitment to the project.

Social interaction becomes an important communication skill as it serves as a blueprint for building a sense of community among team members (Bulu & Yildirim, 2008). Planned and prolonged social interactions provide team members the opportunity to communicate and interact in ways that increase understanding. As team members understand social preferences and backgrounds of their team members, they are better able to facilitate communications. Understanding how cultures interact on a social basis cannot occur on a superficial level but must be an in-depth interaction that helps team members better communicate with one another. Understanding the social interactions of team members includes the use of language phrases that are common and familiar to team members. This culturally specific language use helps to establish relationships of trust where team members are willing to interact with each other in an open, honest manner.

Adjusting language. A common language is needed for people from different cultures to be able to communicate effectively. The common international language of engineering is English. However, there is considerable difference in the type of English spoken by native speakers and English-as-a-second-language (ESL) speakers. Native English speakers typically know between 20,000 and 35,000 English words. ESL speakers typically know about 2,500 to 9,000 English words (http://testyourvocab.com). This presents clear problems when ESL team members are trying to find the right words to express what they want to say. In particular, vernacular phrases (e.g., colloquialisms, slang) common to native English speakers may have entirely different meanings as ESL speakers may use a literal interpretation of the vernacular phrase (Barczak et al., 2006).

For this reason several approaches are recommended. First, native English speakers need to be patient and willing to explain concepts multiple times using virtual communication

technologies (e.g., audio, screen sharing, texting) to help the ESL team members gain an understanding of what is being said (Dorazio & Hickok, 2007). Second, native English speakers are encouraged to learn the language of their ESL counterparts and use the new language where appropriate. English speakers learning and using the international team member's native language indicates willingness on the part of the native English speakers to interact and communicate with their ESL counterparts. As the English speaker learns the new language, they gain an understanding of the trials and frustrations their international team members encounter when using English. As the English speaker learns the second language, the international team member is placed in the role of the expert instead of a novice. This sharing of languages also aids in better understanding of team communications (Dorazio & Hickok, 2007; Moe & Šmite, 2008).

Third, team members are encouraged to create a resource of common terminology with clear definitions unique to the discipline or project (Barczak et al., 2006). This resource enables students to refer to common, new, or task-specific words. The resource helps to enlarge students' vocabulary and provides the opportunity for more open and clear communications. Finally, all team members need to pause and check for understanding or ask team members to re-explain concepts they are saying. While asserting oneself to ask for an explanation may be opposite to some cultural values and traditions, asking for clarification of what has been communicated is imperative to facilitate understanding.

With the removal of body language, written and spoken language becomes the common denominator for team members with different cultural backgrounds on GV teams. The better one is able to communicate ideas, values, and interests, the stronger the GV team communications will become. Where some cultures are reluctant to ask for clarification and

speak up on issues, other team members, especially team leaders, need to encourage and foster an atmosphere of sharing and learning. Second-language communication with culturally different international team members provides an opportunity to hear native pronunciations and use of grammar. As language abilities improve, second-language speakers are able to communicate using the phrases and expressions familiar to team members. This language development assists communication that builds trust, deepens commitment, and strengthens team relations.

Developing GV leadership. Leaders on GV teams have a crucial role as they must monitor and disseminate the progress of all team members, establish the team meeting agendas, foster an open, knowledge-sharing environment, facilitate collaboration, and address team dissonance with globally dispersed team members (Carte et al., 2006; Tavčar et al., 2005; Zakaria, Amelinckx & Wilemon, 2004). On a GV team, leaders must be clear, concise, and excellent communicators as they define, facilitate, and encourage the performance of all team members (Barczak et al., 2006; Horwitz, Bravington & Silvus, 2006). Leaders must be both macro and micro managers, being able to understand the larger picture and goals of the team, but provide feedback and support for each team member's assignment.

Sending team messages. Gavidia, Mogollon, and Baena (2004) reported that the majority of team messages originated with team leaders. The GV leader's communications help other team members get to know and trust one another, maintain a positive atmosphere, answer requests for information, or redirect requests to appropriate expertise on the team. As other team members are encouraged to use their expertise, the team leader allows for emergent leaders to advance and lead when the project's focus requires their area of specialty and expertise (Sudweeks & Simoff, 2005).

Providing feedback from leaders. Leaders also offer positive feedback and encourage the group's individual and collective performance (Boule, 2008). This includes conducting regular and frequent meetings that remind team members of decisions that support the exchange of ideas and discussion on new team-created solutions (Chen, Zhang, Vogel, & Zhao, 2009). The leader offers positive support and encouragement at the beginning or end of emails, text messages, or auditory communications. It becomes the leader's responsibility to draw out team members whose culture fosters a more quiet and reserved approach while moderating team members whose cultures foster more aggressive and bold interactions.

The leader must have or gain expertise in knowing the best virtual communication tool to use and how to use the tool. He or she should be knowledgeable of team members' skills and experience, so this expertise may be drawn upon to help in problem solving. He or she should be able to assist other team members when they encounter difficulty communicating or sharing documents. The leader facilitates the development and use of team protocols that aid team communications and interactions. In short the team leader must find ways to facilitate team needs.

Establishing protocols. Prasad and Akhilesh (2002) strongly emphasized that a large amount of effort is needed to put together a virtual team in terms of its design, planning, and operations. Distance separating team members not only divides team members physically, but intellectually, culturally, and emotionally. Key to beginning successful communication on teams is the introduction of GV team members to each other and the formation of team protocols. Meeting face-to-face is the preferred method for introducing team members and establishing protocols (Staples & Zhao, 2006). Some advocate up to three days to set goals, assure commitment to the project, define roles and responsibilities, and build relationships (Barczak et

al., 2006). The reality is that most student GV teams do not have the means or opportunity to meet at the beginning of the project, if at all. Alternative actions need to be used to help students set team protocols that facilitate communication and interaction.

Personal Portfolios. Part of the process to establish protocols is the development and use of student profiles to introduce student experience, strengths, and personality (Coppola, Hiltz, & Rotter, 2004; Daim et al., 2011; Goold, Augar, & Farmer, 2006; Horwitz et al., 2006; Roebuck et al., 2004). As mentioned earlier Rusman et al. (2009) researched the use of profiles by students participating in EVS to facilitate team introductions. The use of student profiles in the EVS extended beyond the initial introductions as the profiles became vital for team members to review the training and experience of their counterparts. Portfolios may include a variety of information, but it's overriding objective is to introduce team members and allow them to describe who they are and what they can do. This knowledge allows team members to quickly understand and assess one another, to set team goals better, to determine team objectives, and to choose team leadership.

Rule and goal setting. Team protocols establish strategic rules for communication among team members. The protocols clarify the purpose of the team as well as how and when team members should share knowledge (Chen et al., 2009), define roles and responsibilities (Cramton & Hinds, 2004; Lee-Kelley et al., 2004; Tseng, Wang, Ku, & Sun, 2009), respond to communication requests (Gareis, 2006; Gavidia et al., 2004; Kankanhalli et al., 2007), establish working norms, behavior and commitment (Hasler-Waters & Napier, 2002; Ross, 2006), resolve team disagreements (Hinds & Bailey, 2003), and build the team's identity (Rasmussen & Wangel, 2006). Goodbody (2005) stated that communicating the team's purpose enables team members to set clear goals. When all team members discussed cultural and virtual issues

influencing the project and goals, team member ownership of the goals and commitment to achieving them improved decision-making (Bergiel et al., 2008; Martins, Gilson, & Maynard, 2004; Panteli & Tucker, 2009).

GV team members should also establish communication protocols and strategies that consider time zones. For example, GV teams should identify times convenient for contact with team members in different time zones. When some team members must meet late at night and others early in the morning, GV teams should alternate early-late meeting times so one member is not always meeting early in the morning or late at night, unless that is the best situation for all team members.

Communication clarification. Another protocol, illustrated by Roebuck and Britt (2002), required GV team members to explicitly communicate assumptions, expectations, roles, procedures, standards, norms, and processes. This communication allowed teams to establish the best practices that fit the team needs and enabled best performance among team members with proper management of team affairs. Other studies have affirmed the importance of such explicit communications with team members (Hung & Nguyen, 2008; Monalisa et al., 2008).

Time spent establishing team protocols at the beginning of the project allows the team to move through the project more smoothly. Protocols prevent team dissonance and provide for a way to manage team relationships and interactions when team disagreement occurs. Protocols formalizes the time and manner that social interactions and work needs can be met, ensuring that time is set aside to visit and form relationships instead of just hoping that these communications and interactions will happen. While the protocols need flexibility to adjust as the team works on a project, sound protocols provide a strong foundation for the team's communication and interactions to build upon.

Working through team disagreements. Two types of conflict, relationship and task, were identified in the literature review. Relationship conflict occurred between group members and included emotional or interpersonal issues. The disagreements referred to people not being able to communicate appropriately or get along with each other. Relationship disagreement may be rooted in nationalistic attitudes (i.e., ethnocentric or prejudicial) or team understanding of how to proceed with the task (Hinds and Bailey, 2003; Kankanhalli et al., 2007). Disagreements often occurred because of the lack of feedback between team members on critical project details (Moe & Šmite, 2008). Relationship disagreements were harmful to teams since members were less willing to communicate with each other and, when they did, their communications were not co-operative or helpful (Dorazio & Hickok, 2007).

Task conflict referred to the differences in the way team members wanted to proceed on the project. While relationship conflict harmed team processes, task conflict was beneficial to the overall functioning of a team (Liu, Luo, & Wei, 2008; Paul & Ray, 2009). Task conflict allowed opportunity for team members to highlight and account for cultural differences in the final product and examine team actions through a different perspective. Such disagreements required team members to defend proposals or critiques. In this way, the team processes were reviewed and the final product improved. In either case, being able to work through team disagreements was critical to the successful completion of the project.

Influence of virtual tools. In a study using GV teams consisting of information systems and management undergraduate students from a major Asian university and a private, Eastern USA university, Hung and Nguyen (2008) allowed interaction among team members only through assigned communication media: synchronous (instant messaging) and asynchronous (email, discussion forum and file repository). Use of sound and image transmissions were

prohibited. Each team analyzed a system implementation case and submitted an interim report. Pre-surveys and post-surveys were administered to all group members. As well, each team submitted their communication logs, archives, discussion minutes, and shared documents.

Hung and Nguyen (2008) examined the impact of communication technology on relationship confrontations. Asynchronous communication allowed GV team members to carefully rehearse and craft their message to help smooth out confrontations. Synchronous communication did not provide similar opportunities. Using asynchronous tools enabled students to carefully choose their words. Being able to use care in choosing what was written was particularly important for ESL team members, as they wanted to ensure there was no miscommunication or offense.

Styles of conflict resolution. Overcoming conflict also required patience in communicating what one thought and felt regarding the conflict. Paul, Seetharman, Samarah, and MyKytyn (2005) studied team conflict in a controlled laboratory setting using MBA students in a mid-western USA university and premier management students in India. All students were provided instruction on group decision support system software and then assigned a contrived task. Upon task completion each participant completed a short questionnaire on perceived decision quality and satisfaction with the decision-making process.

When personal conflict arose on GV teams, Paul et al. (2005) reported that teams who employed an integrative resolution style had better outcomes than teams who employed other styles. An integrative resolution style considered how all members felt before making a final decision. After communicating everyone's feelings, the team sought a compromise or best position for all. Teams that attempted to arrive at solutions and outcomes satisfactory to all team members fared better than teams trying other approaches.

Task conflict challenges team members' choices and thinking. This type of conflict requires team members to justify or defend choices and to examine alternatives. This disagreement provides for a stronger decision and a more focused effort. Panteli and Tucker (2009) described a GV team consisting of members from Japan, the USA, and Singapore. Each team had its own focus and agenda. After a meeting was called to highlight the team differences, each section of the team moved a little in their position. As a result the GV team scrutinized performance criteria and agreed to new standards to enable a better functioning team. Stopping the project to re-examine team protocols and team goals provided the foundation for this team to successfully move forward with the project.

Role of relationships in conflict resolution. Hinds and Bailey (2003) emphasized that teams members who were more familiar with each other and had strong friendships and relationships were better able to manage and work through conflict. This lends support to taking the time at the start of the project to get to know one another and scheduling time to develop virtual relationships fundamental to team success. In a study of media stickiness, Huysman et al. (2003) described a situation where GV team members had difficulty acquiring, understanding, and acting on feedback that would have resulted in communication changes. In this case team members had not taken the time to become well acquainted with remote teammates. The relationships were not present that allowed the international team member to feel they could offer critiques. Trust building and understanding of each other's culture had not yet occurred. As a result, teammates were unable to confront remote teammates and express their frustrations. Better communication was needed to allow teams to build trust and cultural understanding before such critiques could happen.

Conflict will occur on GV teams. Too little conflict is a sign that team members are unwilling to face contentious issues and resolve them. Too much conflict reflects poor team cohesion and a lack of cooperation that may hamper team communication and interaction (Zhang & Chen, 2010). Providing the opportunities for team members to increase communication and develop relationships helps prepare GV team members for disagreements. Forging friendships and relationships enables team members to balance disagreements by being able to disagree in a proper manner without making the disagreement contentious and personal. This skill strengthens GV teams as different perspectives are considered and the final product improved.

Choosing technology. Lappalainen (2009) suggested that communication could become the "decisive instrument in helping outperform the competitors and in shaping the company's future through visionary strategy creation, effective strategy implementation, and ethical and empowering cultural traits" (p. 128). Teaching engineering students how to communicate with virtual tools enables greater integration of GV teamwork activities and relationships. Understanding communication patterns facilitates the exploration of virtual communication tools to match which tool is best suited to the communication and interaction (Boule, 2008; Cho et al., 2007). On a GV team, virtual communication tool training becomes an integral part of engineering skills. Learning to choose and use a variety of virtual communication technologies becomes key for engineers' communication skills.

Media richness. GV teams, with the right collaborative platforms and training, offer the ability to connect users and information regardless of location (Cogburn & Levinson, 2003; Daim et al., 2011). The wide variety of virtual communication tools provides a wide choice of which tool to use and how well it facilitates communication. The level of information provided by the virtual communication tool is referred to as its Media Richness (Erasmus, Pretorius, &

Pretorius, 2010; Hinds & Bailey, 2003; Shachaf & Hara, 2007). The greater the media richness of the virtual communication technology, the more information it communicates. For example, texting via some cell phones would be low in media richness as it only sends text and still pictures. Video conferencing is higher in media richness because it allows for real time images, audio, and instant messaging. Matching a suitable virtual communication tool with a GV team task becomes as important as being able to correctly use the tool. For example, one would not use a group videoconference tool (e.g., Tandberg) to contact a single international team member to request a data document.

Repertoire of tools. Karpova et al. (2009) combined students from a USA university and a Denmark university to understand how and why virtual teams select and use technology. All teams were required to use WebCT (an online proprietary management system including discussion boards, email, live chat, and assessment) so course instructors could monitor team progress. WebCT served as the initial technology but after the start of the project each team could choose which type of technology to use and when to use the technology. As the project advanced, in addition to WebCT, teams used Acrobat Connect Professional, Google docs, email, and Skype. While each technology had specific advantages and disadvantages, team members used the virtual communication technologies they felt were best suited to the task. Each team used between three and five different types of technology. The type of technology was chosen directly for its ability to support team communications and fulfill social needs. After the task completion, interviews with team members indicated that no one single type of technology satisfied all of the demands of any GV team. Students needed to develop a repertoire of virtual communication tools to use.

This repertoire of virtual communication technologies ensures team communication will happen in case of a technology glitch. In a study relating the level of trust in a GV team to successful GV team practices, Jarvenpaa and Leidner (1999) reported that GV team members developed schemes to improve communication and avoid technological and task uncertainty on GV teams. Emails were numbered so team members could discern if they had missed a message. Work times and schedules were provided in advance to assist contact. The Hi-trust teams exchanged unlimited messages to clarify issues and reach consensus on decisions. Explicit and prompt responses indicated that assignments were read and evaluated. Together these engendered high trust and ensured a quality product.

Team task. A repertoire of communication technologies is needed to adequately address team needs. For example, for initial contact, teams relied on a less personal technology like email or discussion board. Audio/video conferencing was used for brainstorming, interviewing, and problem formulation. Chat was used along with audio/video conferencing to keep a written record of the conversation. Audio/video conferencing was considered critical for important decisions because of its immediate feedback and real-time decisions. WebCT was used to share resources, information, or organizational procedures (Karpova et al., 2009).

Tool use frequency. The exchange of multiple messages among team members is a key indicator of team cohesion and collaboration (Hou & Wu, 2011). While some team members prefer to communicate using multiple messages, care needs to be taken that there is not media overload. Kankanhalli et al. (2007) reported that information overload, caused by excessive emails between team members, reduced the amount of communication as some team members ignored or overlooked emails. This overload caused contention in two of the teams being studied. However this finding supports the use of multiple technologies directing

communications to the team members so contact is made in a way that facilitates team interactions. Using a repertoire of technology tools requires team members to be willing to shift to different or new technologies that better facilitate team interactions (Boule, 2008; Dorazio & Hickok, 2007; Gavidia et al., 2004; Hsu & Chou, 2009; Ocker et al., 2010).

Since virtual communication tools filter any communication between team members, care needs to be taken to ensure that the correct tool is used for the communication. Students should be encouraged to explore and try new technologies. As new technologies are found, each student's repertoire of virtual communication tools increases. This repertoire of virtual communication tools allows for several tools to be used at the same time when communicating with team members. Having a strong list of tools also assists communications when tool use needs to be adjusted (e.g., only using audio if bandwidth will not facilitate audio and video) or switching from one tool to another when the need arises (e.g., switching from Skype to Google+ when team members are in several locations instead of just two endpoints). Knowing what virtual communication tools are available and being able to access those tools facilitates team communications and interactions.

Building trust. The literature describes trust as a foundational or enabling condition for successful GV teams. Without trust team members cannot move forward in completing team goals. Trust is built from each team member's communication, commitment, and performance on interdependent tasks. As team members complete assigned tasks on time and fulfilled team responsibilities, confidence is established in team members and trust is built (Bergiel et al., 2008; Paul, Mcdaniel, & Paul, 2011).

Communication frequency. Typically trust forms with increased formal or informal communication. While formal communications build on the professional level, informal

communications establish and build relationships on a personal level. Communicating successfully on both levels provides for a deeper, longer lasting trust. Since global virtual teaming does not provide the opportunity for face-to-face meetings, trust should be pursued and developed with intentionally planned activities. Common methods, interests, and language increase the strength of friendships and working relationships (Roebuck & Britt, 2002).

Using the a questionnaire and follow-up interviews, Monalisa et al. (2008) analyzed eight GV teams in the high tech industry and discussed the most common issues and problems surrounding them. Among other findings, the communication of social and emotional information was key to building trust among team members. Communication became a virtual way to know one's distant team members and build the trust needed to resolve the team issues and problems.

Emergent leadership. In a study of power and trust in 18 globally distributed teams within a Fortune 500 global IT organization, team members were asked to recount their experiences of what did and did not work well in a GV team. Power, defined as, who controlled the team's actions, was found to play a key role in team dynamics and interactions (Panteli & Tucker, 2009). In high trust teams, a single individual did not hold power. Rather power shifted from one member to another depending on the stage of the project and the requirements needed to move the project forward. Emergent leaders facilitated team interactions and task completion. Trust among team members allowed them to communicate when this authority needed to move from the current leader to the individual with the most relevant knowledge for the next stage of the project. Trust and honest communication enabled power transfer and team progress (Panteli & Tucker, 2009).

Communication Methods. When team members are able to easily contact other team members, ask questions, and receive helpful responses, trust was formed and deepened among team members (Boule, 2008). As a result team members need to develop strategies and practices that encourage and facilitate communication. For example, checking and responding to email messages (even if the response is that you have read the email and cannot respond fully at the moment), reporting progress, and sharing knowledge are all communication methods that serve to reinforce and build trust among team members.

Flanagan and Runde (2009) reported that for trust to fully develop team members needed to make themselves vulnerable through communications that were frank, predictable, and open to new ideas. Such communication created a psychologically safe environment that helped to over come the challenges of virtual communications. These interactions provided opportunities for team members dispersed across distance and culture to move out of their comfort zones and openly express ideas, concerns, and innovations. Such sharing helped build relationships among team members, formed social links needed for trust, and provided an open sharing of knowledge and resources (Gibson & Gibbs, 2006; Leede, Kraan, den Hengst & van Hooff, 2008; Liu, Magjuka, & Lee, 2008b).

Ability and trust alignment. Peters and Manz (2007) indicated that trust served as an alignment mechanism for geographically dispersed team members. Trust allowed them to work without direct supervision and to take risks. Having trust helped team members understand the expertise of other team members and how to access this expertise. Trust fostered the ability to have an open mind and to be willing to listen to fellow team members. As this was done trust was deepened and stronger more collaborative relationships formed. A more collaborative effort resulted in a stronger team product.

Trust among GV team members becomes a critical aspect to develop and form. It begins with meeting team assignments and commitments and moves to deeper relationships that enable one to collaborate and share. As team members communicate with one another and better understand each other's backgrounds, they are willing to listen to and share insights, and open themselves up to other team members. Trust is formed and deepened. Trust is the glue that holds all other GV communication skills together. As trust strengthens richer communications and collaboration occurs.

Summary of Literature

Communication skills are often referred to as soft skills among engineers because the skills are used for the complexities of human interactions and results of team member interactions may change as the skill is applied. The categories of communication skills discussed in this chapter are not unknown to engineers or those who have worked on co-located teams. In fact, it is common for engineering courses to provide students the opportunity learn about and develop most of these skills through teamwork. However, on GV teams the nature of these skills changes due to the blending of cultural and virtual communication skills.

As teamwork moves from co-located teams to GV teams, the nature of communication skills changes. The students learn new skills that help them focus on how to communicate with distant, culturally diverse team members through virtual communication tools. A review of literature indicates that GV communication skills are intertwined with each other. As seen in the description of literature, it is difficult, if not impossible to discuss one skill without describing how it affects another skill. Overlapping skills requires one to think of communication and personal interaction on GV teams as an integrated whole instead of the sum of 10 individual skills. As students compare their individual communication strengths and weaknesses to these

10 communication skills, students gain more knowledge and understanding of when to use and how to develop each skill. Since each skill is interrelated with several other skills, strengthening one skill also strengthens other skills. This strengthening allows a student's weak communication to become stronger through the increased power of his or her skills.

Part of this development and growth requires students to better understand the communication patterns on GV teams. While some of this understanding occurs by participating on a GV team, instruction in these communication patterns would accelerate and facilitate the development of positive communication patterns on GV teams. Students need to know how the GV communication skills interact with one another to produce better communication and interactions with team members. The knowledge of communication patterns facilitates students' skill development from the start up of a team project through to the project's completion. Knowing the effect of the interactions of skills allows individuals to determine how team member interactions involving one skill may affect other skills. While authors speak of the importance of the development of each of these skills, there is a lack of training designed to present the combined repertoire of skills needed for positive successful GV team communications and interactions.

Understanding GV communication skills and patterns allows for properly prepared materials and assignments. Combining this instruction with a GV team experience provides abundant opportunities for students to recognize when these skills are needed and to develop their capacity in using them. Good instruction helps students develop and use these GV communication skills more quickly and effectively. As instructors integrate GV teaming skills instruction with a meaningful engineering activity, students have the opportunity to develop the skill and ability to navigate GV team interactions successfully.

Chapter 3

Method

The purpose of this study was to examine whether focused instruction facilitated the development of positive communication patterns on global virtual (GV) teams. The specific research question was: In what ways and to what extent does Principles of Global Virtual Team (PGVT) instruction influence the development of positive communication patterns for those participating on a GV team?

In order to answer this question the research was divided into two components. The first component sought to determine whether the PGVT instruction resulted in significant changes in positive communication patterns between and among groups. If the PGVT instruction was effective at producing positive communication patterns, a significant difference in communication patterns between the pretest and the posttest within the treatment group would occur. Furthermore, a significant difference in communication patterns between the treatment and control groups would occur. The second component of this research used email communications to examine the type and quality of communication that occurred among PGVT group team members.

Research Design

This study used a mixed methods approach to study the efficacy of PGVT instruction on GV team communication patterns. The mixed methods approach allowed for the comparison between teams with a GV experience and teams with only a Co-located experience. It also allowed for comparison between teams receiving PGVT instruction and those not receiving the instruction.

Quantitative. A quasi-experimental, pretest-posttest, nonequivalent group design was used to examine the degree to which positive communication patterns developed as a result of the treatment group receiving PGVT instruction. The research design is shown in Table 2.

Table 2

Quantitative Research Design

			Pretest					Posttest		
Type of group	Number of teams	Size of group	IC	TU	CR	PGVT instruction	GV Team Opportunity	IC	TU	CR
Treatment 1 (PGVT only)	5	31	I_1	C_1	U_1	Yes	Yes	I_2	C_2	U_2
Treatment 2 (nPGVT only)	3	20	I_1	C_1	U_1	No	Yes	I_2	C_2	U_2
Control (Co-located only)	4	20	I_1	C_1	U_1	No	No	I_2	C_2	U_2

IC = initiated contacts, TU = Virtual Communication Technology Used, CR = Communication Competency Ratings

The independent variables for this study were the type of PGVT instruction students participated in and the opportunity to participate on a GV team. Treatment and contol groups each received some instruction in virtual communication technologies and cross-cultural influences in engineering design. All students were encouraged to interact virtually with all of their team members on a professional and personal basis. The first treatment group (PGVT students), however, had further instruction on using virtual communication technologies on a GV team for establishing team protocols, understanding cultural backgrounds and perspectives, developing trust, resolving team disagreements, and other areas deemed critical to GV team success. Part of this instruction required students to complete online assessments of their understanding of the concepts presented in the principles of global virtual teams instruction.

The dependent variables were the types and frequency of contacts among team members and self-reported ratings of team interaction competence. The first measure of the dependent variable for this study included the total number of initiated contacts, defined as one team

member initiating a contact with another team member using a variety of virtual communication technologies. A second measure of the dependent variable included the total number of vernacular phrases used per email per week for each team in each group. The final dependent variable included students' self-reported initial and end level of competence on five communication competencies deemed important to GV team interactions and communications. These competencies included (a) communicating engineering tasks with people of different cultures, (b) openly discussing team differences, (c) building and maintaining trust, (d) establishing team protocols, and (e) having non-engineering conversations with culturally diverse international team members via virtual communication technologies. Together the dependent variables examined a variety of communication skills needed for successful GV team communication and interaction. The dependent variables also allowed for comparison between traditional co-located teams and GV teams, with and without principles of global virtual teams instruction.

Qualitative. The study used the critical incident technique (Flanagan, 1954; Gremler, 2004; Butterfield, Borgen, Amundson, and Maglio, 2005) to provide functional descriptions of communication patterns among PGVT team members from email communications. Using the critical incident technique, the researcher developed key descriptions of email communications students had with their respective team members. These communications included incidents that helped team progress. This qualitative research provides a deeper look at GV team communications using a single virtual communication technology. In addition to providing greater insight into student communications on a GV team, this research provided additional links to how the PGVT lessons assisted communication patterns development on GV teams. The descriptions also allowed for comparisons to previous and current findings.

Participants

The participants in the study included 31 mechanical engineering students at Brigham Young University (BYU) and 40 international (Canada, China, Brazil, Korea, Mexico, and Taiwan) mechanical engineering students during the fall semester (September-December, 2011). All students participated in the engineering design course either locally at BYU or virtually (synchronously or asynchronously) at their respective universities. All students had completed two or more years of undergraduate studies in engineering. The participating students constituted a convenience sample in that students voluntarily registered or chose to participate in the engineering design course.

The engineering design course instructor and his assistants determined student placement on each GV team. They considered student background, expertise with modeling software, student choice to learn NX or CATIA modeling software, language ability, and, in the case of two students, participation in another GV team experience. Co-located students at the University of British Columbia (UBC) self-selected team members. All other international programs had limited numbers of students registered for the course. Students from these international programs were placed with BYU counterparts to form a single team with six or seven students. Co-located teams had four, five, or six students on a team.

As mentioned earlier, two students who enrolled in the engineering design course used in this study also enrolled in an international engineering capstone project using GV teams. These students and their GV team were included in the treatment group because the international GV capstone team had the opportunity to use the same asynchronous principles of global virtual teams instruction. No BYU student in the engineering design course participated in more than one group or on more than one team for the engineering design course project.

Three considerations of potential bias for all team members in all groups should be noted. First, to counter the possibility of bias due to differential withdrawal rates of participant withdrawal, each group consisted of teams with membership that did not change over the duration of the course. Teams were not organized until the drop-class deadline had passed. Students withdrawing from the engineering design course were not able to make up credit in another course in the semester. The engineering design course was also highly valued by mechanical engineering students and employers as a course critical for future job opportunities. For these two reasons no students withdrew from the course and there was minimal attrition of students participating in the study. Second, to avoid the bias of participants being part of more than one group, each team was not allowed to have any member crossover to another team. However, all participants could interact with local students from other teams outside of the course instruction and project. The opportunity for this interaction only occurred at BYU and UBC since all other partner universities only had enough students for one team. Finally, all students were third year or higher engineering students. All students had a common educational background and prior engineering instruction and experience.

Description of Groups

The PGVT, nPGVT, and Co-located groups are described below. A summary of all groups is provided in Table 3.

PGVT group (first treatment). The first treatment group had specialized instruction relating to GV teams, virtual communication or cross-cultural interactions. Other than the project tasks, interaction with international team members was required to complete the PGVT lessons. Professional and personal interaction with team members was encouraged. This group received the instruction, presented to all three groups, on how to use virtual communication

tools, the effects of culture on engineering, and encouragement to interact with international team members.

Each team in the PGVT group had half of its members from BYU and half from international partner universities. The partner universities included National Taiwan University (NTU), UBC, Wayne State University (WSU), Universidad Iberoamerican (UIA), and ITESM-Toluca University (Toluca). WSU was considered an international partner because all three participating students were from India and had lived in the United States for less than three months.

There were a total of 31 students (4 females, 27 males) in this group. Countries of origin for these students included Canada, India, Mexico, Nepal, Pakistan, South Africa, and USA. Twenty-five of the students had resided in their current country for five or more years. Seven students had never lived outside of their country of residence. Thirteen students had lived outside their country or residence for two or more years with 11 living outside their country of residence between zero and two years. Of those who had traveled outside of their home country, 20 had done so for vacation, 16 for an educational experience (i.e., study abroad, student exchange or internship), 14 had provided service abroad, and eight did not provide a reason for other international travel.

Native languages in the PGVT group included English, Mandarin Chinese, Spanish, Hindi, Urdu, Nepali, and Gujarati. Languages spoken by students, in addition to their native language, included English, Estonian, Hindi, Mandarin Chinese, Spanish, Malayalam, French, and Urdu.

nPGVT group (second treatment). The second treatment group had no specialized instruction relating to GV teams, virtual communication or cross-cultural interactions. Other

than the project tasks, no interaction with international team members was required, but professional and personal interaction with team members was encouraged. This group received the same instruction on how to use virtual communication tools, the effects of culture on engineering, and encouragement to interact with international team members. The nPGVT group consisted of three teams with half of each team coming from BYU and half from international partner universities. The partner universities included Honjik University (HU), Tongji University (TU), and University of Sao Paulo (USP).

There were a total of 20 students (3 females, 17 males) in this group. Countries of origin for these students included Brazil, China, South Korea, and USA. All students had lived in their current country of residence for five or more years. Six students had never lived outside of their country of residence, only one student reported living outside the country of residence for longer than two years, with 13 living between zero and two years in another country. Of those traveling outside of their country of residence, seven had done so for vacation, three for an educational experience (e.g., study abroad), and seven had provided service abroad.

Native languages in the nPGVT group were English, Chinese, Portuguese, and Korean. Second languages included English, Portuguese, German, Spanish, Armenian, Polish, Tagalog, and Mandarin Chinese.

Co-located group (control). The control group received no instruction relating to GV teams, virtual communication or cross-cultural interactions. Other than the project tasks, no interaction with co-located team members was required, but professional and personal interaction with team members was encouraged. This group received the same instructions on how to use virtual communication tools, the effects of culture on engineering, and encouragement to interact with team members. These teams ranged in size from four to six members all of whom were co-

located, but did not necessarily have the same ethnic background. This group represented the traditional engineering teams where all members work in the same location.

The Co-located group consisted of four teams with all team members co-located at BYU (1 team) or UBC (3 teams). There were a total of 20 students (4 females and 16 males). Countries of origin included Canada, Indonesia, Japan, Nepal, South Africa, and USA. Seventeen of the students resided in their current country of residence for five or more years with the remaining three residing between one and five years. Twelve students had never lived outside of their country of residence with six living outside for two or more years and two between zero and two years. Of those traveling outside of their country of residence, 17 had done so for vacation, six for an educational experience (i.e., study abroad or an internship), three had provided service abroad and four had traveled for other unspecified reasons.

Table 3

Summary of Group Characteristics.

Group	Members per team	Gender		Countries of origin	Native Languages	Additional Languages
		Female	Male			
PGVT	6-7	4	27	Canada, India, Mexico, Nepal, Pakistan, South Africa, USA	English, Mandarin Chinese, Spanish, Hindi, Urdu, Nepali, Gujarati	English, Estonian, Hindi, Mandarin Chinese, Spanish, Malayalam, French, Urdu
nPGVT	6-7	3	17	Brazil, China, South Korea, USA	English, Chinese, Portuguese, Korean	English, Portuguese, German, Spanish, Armenian, Polish, Tagalog, Mandarin Chinese
Co-located	4-6	4	16	Canada, Indonesia, Japan, Nepal, South Africa, USA	English, Indonesian, Nepalese, Mandarin Chinese, Japanese	English, Italian, Mandarin Chinese, Cantonese Chinese, French, Hindi, German, Spanish, Taiwanese, Vietnamese, Portuguese

Native languages on the Co-located teams included English, Indonesian, Nepalese, Mandarin Chinese, and Japanese. Second languages included English, Italian, Chinese (Mandarin and Cantonese), French, Hindi, German, Spanish, Taiwanese, Vietnamese, and Portuguese. Students in all three groups reported fair, good, or excellent ratings of second language reading, writing, and speaking skills. However, when rating third and fourth languages, the student ratings of third and fourth language ability dropped to poor and fair ratings.

Treatment for PGVT Group

Members in the PGVT (first treatment) group received the instruction on how to use virtual communication tools, the effects of culture on engineering, and encouragement to interact with international team members. In addition, students completed 10 asynchronous PGVT lessons and 10 corresponding quizzes focused on virtual communication skills and cross-cultural competencies deemed essential for successful GV teams. Each lesson required all students to complete a short, online multiple-choice or alternate-response quiz. Each lesson, including the quiz, took approximately one hour to complete. The lessons and quizzes were only presented in English. In addition to project task contact, students were expected to use the virtual communication skills taught in the PGVT lessons to interact with their international team members within and outside of the engineering design course. As an incentive to complete the lessons, students who completed 8 or more of the 10 lessons, were offered a reduced final exam. Of the 31 students in this group 23 (74%) completed 8 or more lessons. This represented at least half of the students in each team.

Data Collection Sources and Instruments

The conditions of this study required specialized data collection methods because participants were spread across 14 time zones in 7 countries. As the researcher could not travel to each location, data were collected using virtual communication tools for international participants. For BYU participants, virtual communication and face-to-face data collection methods were used. Sources were used to collect data include (a) initiated contacts, (b) emails, (c) surveys, and (d) student interviews.

Initiated contacts. Each team member reported the total number of initiated contacts with all other members of his or her team using phone calls, email, text messaging, and personal or group videoconferencing. Students self-reported all initiated contacts for a one-week period after the students were assigned to a group and for a one-week period, prior to the end of the course. The initial reporting period occurred two weeks after the team was chosen. The final reporting period occurred four weeks prior to the end of the course.

Emails. Each student in each group was asked to copy any and all emails between themselves and any teammate to a third party email for the researcher to collect and analyze. The emails included conversations among team members, instructions, and other interactions among team members. Social interactions between team members via emails were also examined.

Surveys. The team experience (TE) survey pretest used included two sections. The first section collected demographic information such as the extent of each student's international experience, additional language ability, and personal identifiers such as participation in the PGVT instruction. The second section was used to collect information about the nature and extent of each student's GV team experience. All students rated their GV team experience and

competence on a five-point Likert type scale. The anchor points for the five-point scale varied depending on the nature of the information being asked (see Appendices A and B).

The TE pretest and posttest were identical except that the TE posttest provided the opportunity for students to give open-ended responses to key communication issues and portions of the demographic section were not repeated. Open-ended responses focused on virtual communication technology choice and use. In addition, students had the opportunity to comment on specific communication issues (e.g., establishing team protocols, building, and maintaining trust, team decision processes) that occurred on their team. The open-ended survey questions used in the TE posttest are found in Appendix B.

The TE pretest was administered to all students in the second week of the engineering design course. The TE posttest was administered to all students two weeks prior to the completion of the engineering design course.

Student interviews. During the third week prior to the end of the engineering design course, the researcher interviewed two members from each of the teams regarding their project experience. One interviewee was the team leader. The second interviewed was chosen by each team leader. The interview questions are displayed in Appendix C.

Procedures

Depending on the university, participants in the study began the engineering design course in late August or early September in 2011 and continued until mid-December. All students were administered two pretests in September and two posttests in November. The initiated contact (IC) pretest and posttest collected information regarding students' initiated contact with team members using a variety of virtual communication tools. The TE pretest and posttest collected demographic data, about the students, their experience on teams, self-ratings of

their competency, their use of virtual communication tools and their responses to open-ended questions about their communication experiences.

In addition to the surveys each student was requested to send a copy of any and all emails to team members to a third party email address unique to each team. Emails were collected on a weekly basis. Finally, three weeks prior to the end of the course, each team leader and another team member, chosen from each team by the team leader, were interviewed either in person, or in the case of international students, via Skype. All interviews were recorded and transcribed.

Conducting self-reported GV team initiated contact. The self-reported GV team IC survey required all students in all groups to report the number of initiated contacts they had with team members using telephone, email, text messaging, document sharing, and video conferencing (group or personal) in a one-week period. Students reported initiated contacts for the second week after the project portion of the engineering course began (IC pretest) and four weeks prior to the end of the engineering course (IC posttest). To assist students in keeping track of initiated contacts, students were asked to self-report their technology use in a log. At the end of the week all initiated contacts were reported to the researcher via an internet survey tool.

Administering team experience (TE) pretest and posttests. All students in each group were administered another survey where students provided self-reported team experience, team member interactions, and personal use of virtual communication tools communications. The students completed the pretest form of this survey in the second week of the engineering design course (September, 2011). They completed the posttest of this survey two weeks prior to the end of the engineering design course (November, 2011). Both surveys were identical except for the demographic information on the TE pretest and the open-ended responses on the TE posttest.

Both surveys were administered using a web-based survey tool. Multiple reminders, via email and local professors, were sent to students who had not completed the survey. Because of time zone differences, language abilities, and engineering design course commitments, students were allowed 10-14 days to complete each survey.

Collecting emails. Students on each team were asked to copy emails sent to a single team member, multiple team members, or the entire team to the unique third-party email address assigned to each team. Emails from all teams were collected and categorized weekly over 10 weeks of the course. Students were sent written email reminders and given oral reminders in class to encourage participation.

Conducting student interviews. Over a one-week period, three weeks prior to the end of the engineering design course, the researcher interviewed two members from each of the teams regarding their project experience. The team leader from each team was interviewed. The team leader identified the team member he or she communicated with the most on the engineering design course project. This person was selected for the second interview. For the GV teams, if the team leader was from BYU, then an international student was chosen for the second interview from that team. If the team leader was from an international school, then a BYU student was chosen for the second interview from that team. For the Co-located teams, the team leader identified which local team member he or she communicated with the most for the second interview.

All students were interviewed using a standard set of questions as well as questions derived from email communications (see Appendix C). Questions covered topics such as team protocols, choice of leadership, personal communications, issues of trust, and other team interactions. When needed, follow-up contacts were made with individual students for

clarification of data collected in the initial interview. All interviews were conducted at a time and in a location convenient to the researcher and the student. Where possible, interviews were conducted in person, otherwise a personal video call with Skype was used to conduct the interview. All interviews were audio recorded and transcribed.

Throughout the study an audit trail was kept chronicling reliability checks, creation and use of interview questions, verification of interview procedures, and transcribing protocols. The audit trail provided a clear picture of how data instruments were created and used, and how data was analyzed. Where possible, after the interviews, reliability and validity checks were performed by individuals other than the researcher to maintain clarity and openness of any qualitative procedure.

Data Analysis

Data analysis examined (a) virtual communication technologies, (b) initiated contacts, (c) vernacular phrases, (d) GV communication competencies, and (e) email conversations. Each analysis is described below.

Virtual communication technologies. The technology use options in this section of the team experience (TE) surveys were categorical and used pretest and posttest repeated measures for each student. For this reason a chi square test of independence was used to indicate significant changes among groups on the TE pretest and posttest. To facilitate the use of the chi square test of independence analysis and because of the low number of participant responses, the six categories used to collect data were collapsed into three categories. The *never*, *less than monthly* and *monthly categories* were collapsed into the *monthly or less* category. The *daily* and *more than once a day* categories were collapsed into the *daily or greater* category. The *weekly* category was not altered. The Bowker test for of internal change was used to indicate significant

changes within each group on the TE pretest and posttest, because the technology use data had low participant responses.

Figure 2 illustrates a summary square for the Bowker test. As a refinement for the McNemar test of internal consistency, the Bowker test examines all possible 2 X 2 squares (with un-collapsed and collapsed categories) for significant change from the pretest scores to the posttest scores. The direction of change is indicated by examining the secondary diagonals (2 & 6 or 4 & 8) parallel to the central diagonal (1, 5 & 9). The secondary diagonals represented a one-level change in response from the pretest to the posttest. A one-level, increasing change was represented by a change from monthly or less to weekly (2) or a change from weekly to daily or greater (6). A value in each corner represented two levels of change from monthly or less to daily or greater. Opposite patterns would occur for the decreasing diagonals. Significance is reported when the changes are not symmetrical within any of the 2 X 2 squares. The results are reported and discussed for each technology tool.

	Monthly or less	Weekly	Daily or greater
Monthly or less	1	2	3
Weekly	4	5	6
Daily or greater	7	8	9

Figure 2: Example of a summary square from a Bowker test.

Initiated contacts. A three-factor, mixed, repeated measures ANOVA design with one within-subjects variable (test occasion) plus two between-subjects variable (PGVT instruction and GV team opportunity) comparing the reported initiated contact scores at the beginning and

end of the project was conducted to determine any differences between the treatment and the control groups (see Figure 3). Scores for each participant were calculated by adding the total number of initiated contacts with all students using all virtual contact methods.

Vernacular phrases. Upon completion of the study, two raters re-read all emails and identified any and all vernacular phrases. Vernacular phrases included words, phrases, or sentences that contained slang, colloquialisms, metaphors, humor, jargon, and acronyms unique to a given culture. To identify the vernacular phrases two raters (one from USA and one from Korea) independently read through and identified all of the vernacular phrases in the emails submitted by each group on a week-by-week basis. Where the initial two raters did not agree, a third rater (from Canada) arbitrated the identified vernacular phrases to determine if the vernacular phrase should be included or excluded. A weekly score was determined by dividing the total number of vernacular phrases in each group's emails each week by the total number of each group's emails. A one-way independent ANOVA comparing the vernacular phrases for all groups was conducted to determine any differences between treatment and control groups.

A one-way ANOVA was used to determine significant changes between groups on each of the five communication competencies on the TE pretest and the TE posttest. To facilitate the analysis the no relevant experience and the little competence categories were combined into the little or no competence category. All other categories were unaltered. To determine differences within groups from the TE pretest to the TE posttest, the Bowker test of internal change was used in a similar manner as discussed with the technology use data.

Email conversations. All emails were analyzed using a critical incident technique (Butterfield, et al., 2005; Flanagan, 1954; Gremler, 2004). The critical incident technique is a flexible process that allows researchers to provide functional descriptions of activities. In this

case the critical incident technique was used to provide functional descriptions of email communications between PGVT team members. These descriptions were used to increase the current understanding of communication patterns of students on GV teams and how those patterns change as work on a common project proceeds. The understanding of email communication patterns were also used to better understand how the PGVT instruction aided positive communication patterns.

Each email copied to the researcher was the primary source used to determine communication incidents. A word, phrase, paragraph, or passage that communicated important information to other team members was considered to be a communication incident. Two raters independently placed each of these communication incidents into common categories of team communications. Communication categories were determined by the content of the email communication incidents.

Each week the raters would meet to compare and discuss placement of communication incidents into each communication category. If the categories needed to be modified or deleted or a new category was needed, the raters would re-examine the previous weeks' emails to ensure correct placement of the communication incidents within each new or revised category. Each week the percent agreement between each rater's categorization of communication incidents within the each category was recorded.

When the raters did not agree on placement within a category, the communication incident was discussed until a consensus was reached. In some cases communication incidents may have been placed in more than one category. For example, if an email requested a team meeting on a given date and referred to the time zone of one or both sub-groups of the team (e.g., an email asking, "Would it be possible to discuss this with you on Wednesday at 5:00 PM BYU

time (8:00 PM USP time)") would be categorized in both the calendaring and time zone categories). Following the categorization of the communication incidents into general categories, descriptions of each major category were written using the communication incidents within that category. The categories were added to and modified up through the fifth week of the research. Thereafter, all communication incidents were placed into the existing categories and used to provide descriptions of each category.

Any changes in the email communication patterns during the duration of the project or differences in how each groups' communication patterns using email were noted. Data collected in the interviews and survey comments were used to help clarify these descriptions and provide a better understanding of how each GV team communicated. The communication patterns and comparison with the control groups were used to determine any effects of the PGVT instruction on students' communication patterns.

Ethical Issues and Research Limitations

IRB approval for the study was obtained under the National Science Foundation grant (EEC 0948997) obtained by the Fulton College of Engineering and Technology. All students were asked to consent to participate in the study prior to being included in the study. At any time, any student was allowed to withdraw from participation. While no students formally withdrew from the study, several students (IC pretest = 11, IC posttest = 10, TE pretest = 6, TE posttest = 16, interviews = 2) chose not to complete part or all of the requested information.

Some teams copied more emails to the third-party email than other teams. While part of this was due to the choice of communication methods used by each team, it was also apparent that not all emails between team members were copied to the third-party email address. A total of 747 emails were used in the analysis. While these emails were an incomplete collection of all

team email communications, they provided a representative sample of emails and were considered sufficient to provide descriptions of the listed email communication patterns.

Potential threats to validity are presented in Appendix D. After each threat is presented, steps taken to reduce or eliminate the threat are also presented. Limitations to the research are presented in Appendix E.

Chapter 4

Results

In this section I first present the virtual communication technologies used by each group as reported on the TE pretest and posttest. Following this I report the analysis of student-reported initiated contacts with selected virtual communication technologies. An analysis of each group's use of vernacular phrases in email conversations and students' initial and end ratings on five communication competencies is presented next. Finally, a description of email conversation categories from the PGVT group is provided.

Patterns of Virtual Communication Technology Use Across the Tools

Students used several tools to communicate with their team members. The use of the tools depended on the team task, student familiarity with the tool, and cost associated with using the tool. The list of communication tools examined in this study included (a) email, (b) phone call, (c) text messaging via cell phone, (d) instant messaging via computer, (e) personal video conferencing, (f) group video conferencing, (g) computer screen sharing, (h) online document/file sharing, (i) online engineering collaboration tools, (j) online calendaring tools, and (k) online team management applications. These tools were chosen based on virtual communication tool use in previous iterations of the GV engineering design course.

Email. There was no significant difference found in the usage patterns between groups based on participant responses on the pretest. The pretest was administered in the second week of the engineering design course. This finding suggests that groups used email about the same amount at that time. However, a statistically significant difference in email use patterns was found between groups on the posttest (see Table 4).

Table 4

Email Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	0%	3%	97%	30	.86	2	.650
	nPGVT	0%	0%	100%	17			
	Co-located	0%	5%	95%	19			
	Combined	0%	3%	97%	66			
Posttest	PGVT	11%	59%	30%	27	10.59	4	.032
	nPGVT	0%	71%	29%	18			
	Co-located	17%	17%	66%	12			
	Combined	9%	54%	37%	57			

The results presented in Table 5 show significant decreases in the use of email from pretest to posttest for all groups. The majority of students changed from daily or greater use to weekly use. In the PGVT group 63% of participants decreased their use of email by one level and another 7% decreased their use by two levels. A similar trend occurred in the nPGVT group with 71% of participants indicating a decrease from daily to weekly use. While the Co-located group's participants also reported a significant decrease, it was not to the extent of either of the GV groups. Seventeen percent of participants indicated a decrease from daily to weekly use. Another 17% indicated a two-level decrease from daily to monthly or less use. The majority of participants in this group (58%) indicated daily use of this technology at the beginning and end of the project.

Both of the GV groups indicated a decreased use of email. This decrease to weekly use potentially reflects the need for teams to share documents (e.g. agendas, presentation pictures) around their weekly team meetings, but otherwise email was not a preferred means of communication between team members on a daily basis. While approximately one-third of the Co-located group's participants reduced their use of email, it continued to be a daily source of team interaction and communication for 58% of team members.

Table 5

Within Groups Pretest to Posttest Change for all Groups for Email Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	4%	**0%**	0%	1	19.00	3	< .001
		Daily or greater	7%	59%	**30%**	26			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**0%**	0%	0	21.00	3	< .001
		Daily or greater	0%	71%	**29%**	17			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**0%**	8%	1	20.00	3	< .001
		Daily or greater	17%	17%	**58%**	11			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Personal video calls. An analysis of the results in Table 6 shows that while useage patterns for personal video calls was similar between each of the groups on the pretest, a significant difference in use patterns was found between groups on the posttest. However, unlike emails, the results presented in Table 7 show differences in the change patterns within each of the groups.

The response patterns presented in Table 7 show a significant decrease in the use of personal video calls with 42% of Co-located team members reducing from weekly to monthly use. Half of the Co-located group's members reported no change in their monthly use personal video calls from the pretest to the posttest. As a result 92% of the Co-located group's participants used this technology on a monthly basis at the end of the project.

In contrast, the majority of students in both GV groups reported almost identical, non-significant symmetrical shifts towards weekly use of personal video calls. Both groups increased from the monthly to weekly category or decreased from the daily to the weekly category. In the PGVT group, 37% of participants remained at weekly use of this technology while a further 38% reduced or increased their use to weekly. Similarly, 53% of the nPGVT participants reported no change in their weekly use of personal video call, while another 30% reported increasing or decreasing their personal video calls to a weekly basis.

While some on the Co-located team members initially tried personal video calls, they quickly decreased their use of this technology. This is not a surprising result as the Co-located team members saw each other on a daily basis as they took common classes or met in work environments. This finding would support the assertion that, while use of personal video conferencing was a convenience for Co-located teams, for GV teams it was an essential tool for weekly communication and interaction.

Table 6

Personal Video Call Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	27%	57%	17%	30	.83	4	.934
	nPGVT	29%	53%	18%	17			
	Co-located	37%	53%	11%	19			
	Combined	30%	55%	15%	66			
Posttest	PGVT	22%	75%	4%	27	24.88	4	> .001
	nPGVT	18%	83%	0%	18			
	Co-located	92%	0%	8%	12			
	Combined	35%	61%	4%	57			

Table 7

Within Groups Pretest to Posttest Change for all Groups for Personal Video Call Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**7%**	19%	0%	7	2.78	2	.249
		Weekly	15%	**37%**	4%	15			
		Daily or greater	0%	19%	**0%**	5			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**18%**	12%	0%	5	5.00	2	.082
		Weekly	0%	**53%**	0%	9			
		Daily or greater	0%	18%	**0%**	3			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**50%**	0%	0%	6	6.00	2	.050
		Weekly	42%	**0%**	8%	6			
		Daily or greater	0%	0%	**0%**	0			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Group video calls. An analysis of the results in Table 8 shows that while usage patterns for group video calls was similar between each of the groups on the pretest, a significant difference in use patterns was found between groups on the posttest. The results presented in Table 9 show most of the participants in all of the groups reporting no significant change in their use of group video calls. However, the PGVT group had similar numbers of students increasing and decreasing their use of group video calls.

The members of the nPGVT and Co-located groups indicated about twice as many students decreasing their use of this technology tool as those who increased their use. In fact by the posttest 92% of the Co-located participants reported a monthly or less use of group video calls. This finding parallels change in use patterns for personal video call use. While not as pronounced, 59% of the nPGVT participants reported group video call use in the monthly or less category on the posttest. This result contrasts with the PGVT group where shifts in use resulted in 52% of participants reporting weekly use of this technology.

In the interviews some GV teams reported a consistent weekly use of group video calls where all team members could discuss project progress and interact with one another. On these occasions team members not only discussed engineering design tasks, but they also scheduled time for visiting, telling jokes, and sharing personal stories. However other GV teams reported a communication structure where sub-group team leaders would lead the discussions during group meetings or hold separate meetings and then communicate with their respective team members. The PGVT students reported using the former structure whereas the nPGVT students reported the latter. This would explain the lower monthly use of personal video calls by the nPGVT participants and the higher use of the weekly group video calls by the PGVT students.

Table 8

Group Video Call Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	40%	57%	3%	30	7.66	4	.105
	nPGVT	41%	59%	0%	17			
	Co-located	74%	21%	5%	19			
	Combined	50%	47%	3%	66			
Posttest	PGVT	41%	52%	8%	27	11.26	4	.024
	nPGVT	59%	41%	0%	18			
	Co-located	92%	0%	8%	12			
	Combined	58%	37%	5%	57			

Table 9

Within Groups Pretest to Posttest Change for all Groups for Group Video Call Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**30%**	7%	4%	11	1.20	3	.753
		Weekly	11%	**41%**	4%	15			
		Daily or greater	0%	4%	**0%**	1			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**24%**	18%	0%	7	1.00	1	.317
		Weekly	35%	**23%**	0%	10			
		Daily or greater	0%	0%	**0%**	0			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**75%**	0%	0%	9	3.00	2	.223
		Weekly	17%	**0%**	8%	3			
		Daily or greater	0%	0%	**0%**	0			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Computer screen sharing. The results in Table 10 established that computer screen share patterns were significantly different between groups on the pretest and the posttest, suggesting that the groups used computer screen sharing in different ways at the start and at the end of the engineering project. The results presented in Table 11 reflect these patterns. The nPGVT participants reported a weekly use (65%) of computer screen share from the beginning to the end of the project. Similarly, 58% of the Co-located group's participants reported using computer screen share monthly or less from the start to the finish of the project. Neither group reported a significant change from this pattern although the nPGVT group indicated a four-fold decrease in students using this technology as those increasing use. The PGVT group approached a significant change in use of this technology with 41% of respondents increasing use of this technology. However, both GV teams indicated a strong use of this technology with 78% of the PGVT and 77% of the nPGVT teams reporting a weekly use of this communication tool. The Co-located participants (74%) reported using this technology on a monthly or less basis.

Neither of these results was unexpected. Each reflects the needs of GV and Co-located group members. When a team member on a team in the Co-located groups had trouble using an engineering design technology, team members arranged to meet to give or receive help as confirmed by shared emails between team members. However, GV team members did not have the luxury of meeting face-to-face with their international counterparts. As a result being able to share one another's computer screen allowed one team member to direct the other team member through the necessary steps much as a Co-located team member would do in a face-to-face situation. In interviews GV team participants commented that using computer screen sharing technology was essential to helping one another understand how to successfully complete tasks.

Table 10

Computer Screen Share Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	37%	50%	13%	30	19.29	4	.001
	nPGVT	12%	82%	6%	17			
	Co-located	79%	16%	5%	19			
	Combined	42%	49%	9%	66			
Posttest	PGVT	11%	78%	11%	27	18.52	4	.001
	nPGVT	24%	77%	0%	18			
	Co-located	74%	25%	0%	12			
	Combined	30%	65%	5%	57			

Table 11

Within Groups Pretest to Posttest Change for all Groups for Computer Screen Share Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**7%**	30%	0%	10	5.59	2	.061
		Weekly	4%	**33%**	11%	13			
		Daily or greater	0%	15%	**0%**	4			
nPGVT			Posttest						
			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**6%**	6%	0%	2	2.00	2	.368
		Weekly	18%	**65%**	0%	14			
		Daily or greater	0%	6%	**0%**	1			
Co-located			Posttest						
			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**58%**	17%	0%	9	1.33	2	.513
		Weekly	8%	**8%**	0%	2			
		Daily or greater	8%	0%	**0%**	1			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Online team calendaring. Analyzing the results in Table 12 shows that the use patterns for online team calendaring reported a significant difference in use patterns between groups on the pretest but not on the posttest. The significant results suggests that the groups initially used online team calendaring for different amounts of time at the start of the project, but their use was similar to each other by the end of the project. The results presented in Table 13 show significant reductions in the use of online team calendaring by both GV teams. In the PGVT group, 41% of respondents scaled back their use of this tool to a weekly or a monthly basis. The nPGVT and Co-located group members indicated near similar reductions (35% and 33% respectively) from weekly to monthly or less use. It is interesting that by the posttest approximately two-thirds of participants in each group used this tool on a monthly or less basis. This would indicate that some team members found this tool helpful and used it on a frequent basis while others did not find the tool helpful with team interactions and decreased their use.

A possible explanation for this pattern of use lies in the utility of the communication technology. In interviews students reported a willingness to try technologies. However, if the technology was not seen as something that contributed to the team's overall effectiveness and success, use of the technology was decreased or eliminated.

Another possible explanation focuses on the sub-group team leaders. Most teams consisted of six members located on two sub-teams. Each sub-team had a local leader. As a result the sub-group team leaders constituted one-third of each team. Since one-third of the participants reported a consistent use of on-line calendaring, it is possible that only the sub-team leaders used the on-line calendaring to keep track of team activities.

Table 12

Online Team Calendaring Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	40%	40%	20%	30	9.58	4	.048
	nPGVT	24%	71%	6%	17			
	Co-located	63%	32%	5%	19			
	Combined	42%	46%	12%	66			
Posttest	PGVT	67%	26%	7%	27	1.52	4	.823
	nPGVT	65%	29%	6%	18			
	Co-located	66%	16%	16%	12			
	Combined	67%	25%	9%	57			

Table 13

Within Groups Pretest to Posttest Change for all Groups for Online Team Calendaring Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**41%**	0%	0%	11	11.00	2	.004
		Weekly	26%	**11%**	0%	10			
		Daily or greater	0%	15%	**7%**	6			

			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**24%**	0%	0%	4	8.00	3	.046
		Weekly	35%	**29%**	6%	12			
		Daily or greater	6%	0%	**0%**	1			

			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**33%**	8%	0%	5	2.80	2	.247
		Weekly	33%	**8%**	8%	6			
		Daily or greater	0%	0%	**8%**	1			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Phone calls. An analysis of the results in Table 14 shows that use patterns for phone calls did not differ between groups on the pretest or the posttest. The results presented in Table 15 however show significant decreasing trends in phone use for all groups. This would indicate that all teams reduced their phone call use in similar ways. An examination of Table 15 indicates the similar patterns of decreased use. In each group students decreased their use of this technology by one or two levels from daily use to weekly or monthly use. In the PGVT group 45% of participants indicated a one level drop in use with a further 37% indicating a two level drop to monthly or less use. The nPGVT group had a similar decline with 35% decreasing from daily to weekly use and another 59% decreasing from daily to monthly or less use. The Co-located group indicated a similar decline from daily to weekly use as the other two groups (42%). A further 25% decreased from daily to monthly or less use.

Table 14

Phone Call Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	3%	7%	90%	30	.90	4	.924
	nPGVT	0%	6%	94%	17			
	Co-located	5%	5%	90%	19			
	Combined	3%	6%	91%	66			
Posttest	PGVT	41%	45%	15%	27	6.39	4	.172
	nPGVT	59%	41%	0%	18			
	Co-located	25%	50%	25%	12			
	Combined	44%	44%	12%	57			

The expense of international phone calls limited the use of phone calls by GV team members. However a potential bias needs to be explained for the PGVT results. The BYU-WSU team was considered an international team because all three WSU team members were from India and had lived in the USA for less than three months. However, students on this team

Table 15

Within Groups Pretest to Posttest Change for all Groups for Phone Call Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	4%	0%	1			
		Weekly	4%	**0%**	0%	1	21.00	3	<.001
		Daily or greater	37%	41%	**15%**	25			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**6%**	0%	1	16.00	2	<.001
		Daily or greater	59%	35%	**0%**	16			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**8%**	0%	1	8.00	2	.018
		Daily or greater	25%	42%	**25%**	11			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

reported in interviews that they often phoned one another to visit about both engineering and non-engineering topics. Had the WSU students truly been located in India, this contact would not have been affordable or practical with the time zone differences. This may explain the 15% daily or greater use of phone calls by the PGVT group.

The additional functionality of phones has changed in recent years. What initially was a technology solely for audio communications has now evolved to be able to use text messaging, instant messaging, pictures, personal video calls, and email. The ways that a phone is used and what constitutes a phone call are becoming increasingly blurred. In one example all but one member of a Co-located UBC team had smart phones with email capability. In emails copied to the researcher, it was apparent that this team used their phones to communicate via email as if emails were text messages. In another example a GV team leader reported using his phone to receive emails and to respond with personal video calls so he could see an image of his team member and have an immediate conversation. While phones were still used for communications, the type of communication tool use via phone has dramatically changed. In this sense phones are more like hand-held computers than the simple phones of a few years past.

Text messaging via cell phones. An analysis of the results in Table 16 establishes that use patterns for text messaging via cell phones found no significant difference between groups on the pretest and the posttest. However, like the pattern for phone call usage, the results presented in Table 17 show a downward trend for the use of text messaging via cells phone for each of the groups from the pretest to posttest. In the PGVT and nPGVT groups, almost half of the participants (48% and 47% respectively) reported decreasing from a daily to a weekly or a weekly to a monthly or less use of this technology. A further 26% of the PGVT participants and 29% of the nPGVT participants decreased from daily to monthly or less use. The Co-located

group also reported similar decreases with 42% of students decreasing from daily to weekly use and another 17% decreasing from daily to monthly or less use.

In several interviews with GV team members, students reported that text messaging was not used at all with international team members, but only with local GV team members. This was typically to confirm or remind a team member of a scheduled meeting or appointment. The Co-located team members also reported a similar use for its team members. In all cases text messaging appears to be a technology tool limited to local use among team members. From interviews, it also appears to fulfill a limited but important role in local sub-team communications. All team members who reported using text messaging did so to contact other members at the last minute who were late for a meeting or to inform other local members that they would be late for a meeting. Outside of this limited function, participants did not use text messaging often for other team communications and interactions.

Table 16

Text Messaging via Cell Phones Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	7%	7%	87%	30	4.73	4	.316
	nPGVT	0%	12%	88%	17			
	Co-located	0%	0%	100%	19			
	Combined	3%	6%	91%	66			
Posttest	PGVT	34%	48%	18%	27	4.78	4	.310
	nPGVT	29%	59%	12%	17			
	Co-located	17%	42%	42%	12			
	Combined	28%	51%	21%	57			

Table 17

Within Groups Pretest to Posttest Change for all Groups for Text Messaging via Cell Phone Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**4%**	0%	0%	1			
		Weekly	4%	**4%**	0%	2	20.00	3	< .001
		Daily or greater	26%	44%	**18%**	24			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**12%**	0%	2	13.00	2	.002
		Daily or greater	29%	47%	**12%**	15			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	0%	0%	0			
		Weekly	0%	**0%**	0%	0	7.00	2	.030
		Daily or greater	17%	42%	**42%**	12			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Instant messaging. The patterns of use for instant messaging were similar to that of both cell phone use and text messaging via cell phones. An analysis of the results in Table 18 shows that use patterns for instant messaging between groups was similar on both the pretest and the posttest. It should be noted that the results approached significant differences between groups on the TE Posttest. The results present in Table 19 show similar, significant downward trends for all groups in the use of instant messaging. However, the degree of the downward trend differed between the GV groups and the Co-located groups. Both of the GV teams' participants indicated a 41% reduction in use of this technology from a daily to a weekly basis. While the Co-located groups' students reported a 25% reduction from daily to weekly use, 33% reported decreasing

their use from daily to less than monthly. The nPGVT and Co-located groups also reported a two level decline of 18% and 17% respectively from daily to less than monthly use. By the administration of the of the posttest, the PGVT and nPGVT groups moved toward a weekly use pattern (52% and 71% respectively), the Co-located group's participants reduced the use of this technology to a monthly or less rate (58%).

Table 18

Instant Messaging Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	17%	27%	57%	30	2.84	4	.586
	nPGVT	24%	18%	58%	17			
	Co-located	5%	32%	63%	19			
	Combined	15%	26%	59%	66			
Posttest	PGVT	29%	52%	19%	27	8.00	4	.092
	nPGVT	30%	71%	0%	18			
	Co-located	58%	33%	8%	12			
	Combined	35%	54%	11%	57			

The nPGVT group's moderate use may be explained by the English language skills of the international counterparts. Students in this group reported using the strategy of texting key words to clarify communication when speaking to international team members. Participants in the nPGVT group reported in interviews that they often used instant messages as part of their weekly meetings to help explain concepts or tasks and clarify communications. Both international and BYU team members used this technology to better recognize words with difficult pronunciations. Seeing the word allowed students to better understand one another and often correct mispronunciations.

Table 19

Within Groups Pretest to Posttest Change for all Groups for Instant Messaging Use.

PGVT			Posttest						
			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**11%**	4%	0%	4			
		Weekly	11%	**7%**	4%	6	11.33	3	.010
		Daily or greater	7%	41%	**15%**	17			

nPGVT			Posttest						
			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**12%**	12%	0%	4			
		Weekly	0%	**18%**	0%	3	12.00	3	.007
		Daily or greater	18%	41%	**0%**	10			

Co-located			Posttest						
			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**8%**	0%	0%	1			
		Weekly	33%	**8%**	0%	5	9.00	3	.029
		Daily or greater	17%	25%	**8%**	6			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Similar to text messaging with local team members, instant messaging appears to have a limited but important role in team communications. When team member pronunciation of common words was not clear, sending the word via instant messaging often helped the team member better understand what was being said. Instant messaging was not a one-way process as native-English speakers had accents resulting in unfamiliar pronunciations to the non-English speakers. While the use and role of instant messaging was limited on teams, it provided an important communication function for GV teams.

Online document or file sharing. The results in Table 20 show that use patterns for online document or file sharing found a significant difference between groups on the pretest and the posttest. The results presented in Table 21 show distinct, non-significant patterns in the use of online document sharing within all groups. Both GV teams reported a strong use of online document and file sharing throughout the project. Participants in the PGVT group reported a 63% use on a weekly or greater basis. Similarly, the nPGVT participants reported a 58% weekly or greater use of this technology tool. In contrast, no student in the Co-located group used this technology tool continually throughout the project on a weekly or greater rate of use. However, all groups reported increases in use of online document or file sharing. Both GV groups' students reported an increased use of this technology that resulted in two-thirds of the students using this technology on a daily or more basis. The Co-located group's students reported 59% of students increasing their use of this technology on a daily or greater basis.

This trend of increased use by all groups was likely explained by the project's activities at the time of the posttest. At the time of posttest administration, all groups' participants were completing the modeling and the assembly of their project. Collecting all modeled parts required team members to share these files with each other and to notify team members that the part had been downloaded into a common file. Since the Co-located group's students had the opportunity to use local file sharing technologies, one-quarter of Co-located students reported monthly or less use of this technology. This technology also illustrated a communication pattern mentioned earlier. While Co-located students used cloud technologies to share documents and files out of convenience, the GV teams had to use these technologies out of necessity.

Table 20

Online Document or File Share Use on Pretest and Posttest by Treatment Group.

Occasion	Group	Frequency of Response: Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	27%	23%	50%	30	9.93	4	.042
	nPGVT	12%	59%	29%	17			
	Co-located	32%	53%	16%	19			
	Combined	24%	41%	35%	66			
Posttest	PGVT	4%	30%	67%	27	9.29	4	.054
	nPGVT	6%	28%	67%	18			
	Co-located	33%	8%	58%	12			
	Combined	10%	25%	65%	57			

Table 21

Within Groups Pretest to Posttest Change for all Groups for Online Document or File Share Use.

			Posttest: Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
PGVT	Pretest	Monthly or less	**4%**	11%	11%	7	6.33	3	.096
		Weekly	0%	**15%**	7%	6			
		Daily or greater	0%	4%	**48%**	14			
nPGVT	Pretest	Monthly or less	**0%**	0%	12%	2	7.00	3	.072
		Weekly	6%	**29%**	24%	10			
		Daily or greater	0%	0%	**29%**	5			
Co-located	Pretest	Monthly or less	**25%**	0%	17%	5	5.67	3	.129
		Weekly	8%	**0%**	42%	6			
		Daily or greater	0%	8%	**0%**	1			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Online collaboration tools. An analysis of the results in Table 22 shows that use patterns for online collaboration tools found were not significantly different but approached significance between groups on both the pretest or the posttest. Based on the results presented in Table 23, only the PGVT participants reported a significant decrease in the use of online collaboration tools with 30% of students decreasing use from daily to weekly use and another 4% decreasing from daily to monthly or less use. The nPGVT students demonstrated a similar decrease with 35% of participants decreasing from daily to weekly use. In contrast the Co-located participants reported a non-significant trend of increased use of online collaboration tools with 33% increasing from weekly to daily use and 8% increasing from monthly to daily and monthly to weekly use.

It is noteworthy that 56% of the participants in the PGVT group and 52% of participants in the nPGVT group used online collaboration tools consistently from the beginning to the end of the project. This pattern of use indicated that both GV groups initially had a strong need for online collaboration tools and that students maintained this need throughout the duration of the project.

A potential explanation for the adjustments in tool use by groups may be in the required project tasks. GV teams needed to use online collaboration tools to interact with team members throughout the project. This collaboration focused on teaching one another how to use the engineering design tools. By the time of the posttest, students had learned how to use the tools and online collaboration was reduced to using cloud technologies to share and assemble parts. Conversely the Co-located teams were able to teach each other how to use the technologies face-to-face. The need to collect and assemble modeled parts required an increased use of cloud tools to complete this task efficiently and effectively at the end of the project.

Table 22

Online Collaboration Tools Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	13%	17%	70%	30	8.64	4	.071
	nPGVT	6%	35%	59%	17			
	Co-located	26%	42%	32%	19			
	Combined	15%	29%	56%	66			
Posttest	PGVT	4%	52%	45%	27	8.30	4	.081
	nPGVT	0%	70%	29%	17			
	Co-located	17%	16%	66%	12			
	Combined	7%	49%	44%	57			

Table 23

Within Groups Pretest to Posttest Change for all Groups for Online Collaboration Tool Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	7%	4%	3	10.00	3	.019
		Weekly	0%	**15%**	0%	4			
		Daily or greater	4%	30%	**41%**	20			
			Posttest						
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**0%**	6%	0%	1	4.57	2	.102
		Weekly	0%	**29%**	6%	6			
		Daily or greater	0%	35%	**23%**	10			
			Posttest						
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**17%**	8%	8%	4	6.00	3	.112
		Weekly	0%	**8%**	33%	5			
		Daily or greater	0%	0%	**25%**	3			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Online team management system. An analysis of Table 24 indicates there was no significant difference in the use of online team management between groups reported on either the pretest or the posttest. Similarly, based on the results reported in Table 25, no significant difference was reported for any group from the pretest to the posttest. Approximately one-half of the participants in each group reported using online team management the same amount of time throughout the project. The remainder of the students split between increasing and decreasing use during the course of the project.

A potential explanation of these results may lie in the use of emergent leaders on all teams. At the start of the project, each team member chose a leadership role on his or her respective team. One of the roles was the team leader of the entire team or a sub-team leader on the GV teams. These students may have used the online team management tools throughout the course of the project as indicated by the moderately high numbers that used this tool in a consistent way throughout the project. As each team member assumed or relinquished a leadership role for his or her respective team responsibility, the use of online management tools would wax or wane in a corresponding manner. As a student emerged as a temporary leader and the need arose to use the tool, students used it. When the student relinquished leadership for the next emergent leader, they no longer needed the on-line management tool to keep track of team assignments and completion of tasks. As a result students decreased their use of the online management tool. This result is consistent with other findings that indicated the utility of the virtual communication tool determined whether the tool was used and the duration of use for the tool. Tools that facilitated communication and interaction between team members became part of the student's communication tool repertoire.

Table 24

Online Team Management Use on Pretest and Posttest by Treatment Group.

		Frequency of Response						
Occasion	Group	Monthly or less	Weekly	Daily or greater	*n*	Chi Square	*df*	*p*
Pretest	PGVT	40%	47%	13%	30	6.77	4	.149
	nPGVT	41%	53%	6%	17			
	Co-located	74%	21%	5%	19			
	Combined	50%	41%	9%	66			
Posttest	PGVT	56%	37%	8%	27	2.42	4	.659
	nPGVT	59%	35%	6%	18			
	Co-located	67%	17%	16%	12			
	Combined	60%	32%	9%	57			

Table 25

Within Groups Pretest to Posttest Change for all Groups for Online Team Management Use.

			Posttest						
PGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**37%**	4%	0%	11	3.67	2	.160
		Weekly	19%	**22%**	4%	12			
		Daily or greater	0%	11%	**4%**	4			
nPGVT			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**35%**	6%	0%	7	3.00	3	.392
		Weekly	18%	**29%**	6%	9			
		Daily or greater	6%	0%	**0%**	1			
Co-located			Monthly or less	Weekly	Daily or greater	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Monthly or less	**42%**	17%	0%	7	1.2	2	.549
		Weekly	25%	**0%**	8%	4			
		Daily or greater	0%	0%	**8%**	1			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Number of Initiated Contact Communication Patterns

To examine how often students communicated and interacted using virtual communication technologies, students were asked to keep track of the total initiated contacts over a one-week period using a variety of virtual communication tools (i.e. email, video conferencing, document sharing). This was done at the beginning and at the end of the project. An initiated contact (IC) was defined as a student initiating contact with another team member. If a student responded to an initial comment or request, the contact was not counted.

A 3 x 2 mixed, repeated measures ANOVA was calculated to examine the effects of the groups (PGVT instruction and GV team opportunity) and testing occasion (IC pretest and IC posttest) on initiated contacts with team members. No significant main effects or interactions were found. The PGVT instruction group-by-occasion interaction, $F(1, 49) = .273$, $p = .603$, the GV team opportunity group-by-time $F(1, 49) = .016$, $p = .899$, the main effect for testing occasion, $F(1, 49) = .137$, $p = .713$, the main effect for PGVT instruction group, $F(1, 49) = .051$, $p = .822$, and the main effect for GV team group $F(1, 49) = 2.691$, $p = .107$ were not significant.

This result suggests that initiated contact scores were not influenced by either time or instruction. While the results are not statistically significant, it is noteworthy that PGVT students reported making twice as many initiated contacts compared to individuals from the control groups on the IC pretest and approximately a third as many initiated contacts on the IC posttest (see Figure 3).

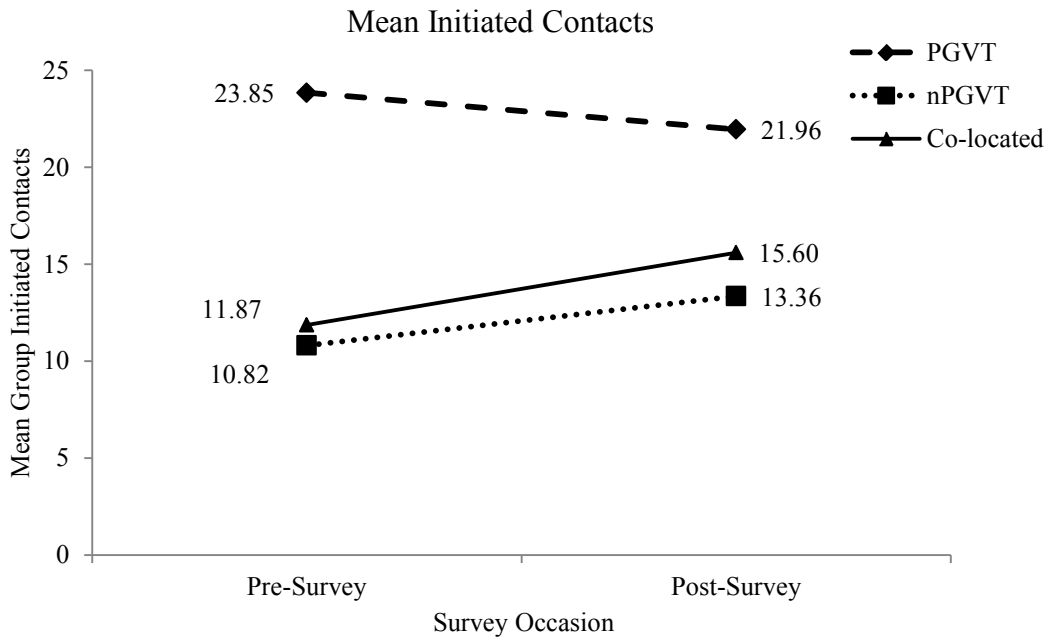

Figure 3: Mean initiated contacts between team members in all groups.

Amount of Vernacular Phrases Used in Email Communications

A post-hoc analysis of team email communications examined the use of vernacular phrases in emails between each of the three groups. A one-way ANOVA, comparing the number of vernacular phrases (e.g., slang and colloquialisms) per email per week used by individuals in the PGVT, Co-located, and nPGVT groups, was computed. A significant difference was found between the groups, $F(2, 26) = 9.44$, $p < .001$. A post-hoc analysis using Tukey's HSD method was conducted to determine the nature of the differences between the groups. This analysis revealed that students in the nPGVT group had an overall lower vernacular phrase score (m = .180, SD = .166) than students in the PGVT group (m = .605, SD = .499) and the Co-located group (m = .802, SD = .246). Students' vernacular phrase use in the PGVT group was not significantly different than students' use in the Co-located group (see Figure 4). It is important

to note that the vernacular phrases per email for the PGVT group and nPGVT group were almost identical (.409 and .444 respectively) in the first week of the project.

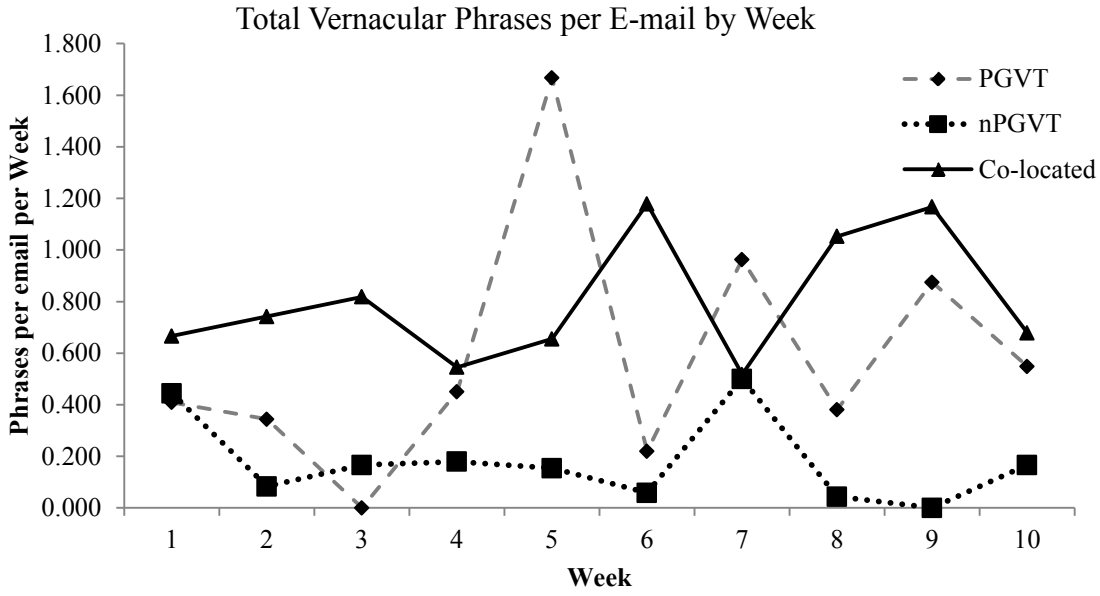

Figure 4. Total vernacular phrases per email by each week for all groups.

Ratings of GV Communication Competencies

Students were asked to rate their level of competence on five items relating to one's ability to communicate on a GV team on both the pretest and the posttest. Students only rated their end competence on the posttest. This procedure provided two ratings of students' initial competence for comparison. Both initial competence ratings were correlated to determine how well the initial competence ratings on the prestest compared to the initial competence ratings on the posttest (see Table 26). Such a comparison would highlight students' ability to better rate their initial competence because of participation in the engineering design course course and project.

In general, the correlations between the self-rating of initial communication competence on the pretest and the posttest for the PGVT group were weak or moderate in across all

competencies. For the nPGVT group correlations were moderate with only one indicating a strong correlations. The Co-located group had strong or moderate correlations. These results indicate that individual participants' perceptions of their ability to communicate changed from the beginning to the end of the project. The moderate or strong correlations with the Co-located group is supported by their lack of change in reported competence and may serve as an indicator that their perception did not change from the pretest to the posttest.

Table 26

Correlations Between the pretest and posttest Initial Communication Competence Ratings by Group.

Item	PGVT	Co-located	nPGVT
I am able to communicate on engineering tasks with people from different cultures.	.49	.89	.54
I am able to openly discuss engineering team differences before making a team decision.	.48	.73	.81
I am able to build and maintain a working relationship of trust with engineering team members.	.00	.59	.58
I am able to establish team rules, procedures and protocols that consider cultural differences of team members.	.35	.83	.72
I am able to have a non-engineering conversation with a person from a different culture via virtual technologies.	.69	.97	.67

When comparing students' ratings of their initial ability to communicate, it is interesting to note that before the project began students on the GV teams tended to rate their initial ability higher than they did, in retrospect, once the project was completed. This lends support to the idea that students were unaware of the true level of their competence because they had not participated in a prior GV team experience. For this reason, the student self-ratings of competence provided in the posttest were used in the following analyses because they were considered to be a more accurate measure of students' initial competence.

In order to compare changes in perceptions of communication competence between groups, an ANOVA was calculated for each of the specific communication competence items to

analyze any between group differences. A Bowker test of internal change was used to determine any response pattern changes in communication proficiency from the pretest to the posttest within groups. Response pattern differences on the pretest and the posttest for each group provide an estimate of between group differences. Each individual competency item is reported and discussed separately below.

Communicate engineering tasks with people from different cultures. When asked about their ability to communicate with people from other cultures regarding an engineering task, response patterns differed between groups on the pretest but were similar on the posttest (see Table 27). Using Bowker's test of internal change, an examination of Table 28 indicates a significant increase in competence ratings for both GV teams from the pretest to the posttest. Response patterns from students in the Co-located group did not change significantly from pretest to posttest. The majority of Co-located students (67%) did not change their rating from the pretest to the posttest. Since the Co-located group was supposed to be more homogeneous in terms of culture, this finding may indicate a perception that is not based on experience.

Table 27

Begin and End Reported Competence Between Groups on the competence: I am able to communicate on engineering tasks with people from different cultures.

Occasion	Group	Mean	SD	*n*	*F*	*df*	*p*
Begining	PGVT	2.35	.85	26	8.51	2	.001
	nPGVT	1.56	.73	16			
	Co-located	2.83	.73	12			
	Combined	2.22	.95	54			
End	PGVT	3.08	.80	26	.88	2	.421
	nPGVT	2.81	.40	16			
	Co-located	3.08	.67	12			
	Combined	3.00	.67	54			

Both GV teams reported increases in their competent or very competent ratings from the pretest to the posttest. The PGVT group had 58% of student increase in one level of competence

with another 12% increasing two levels of competence. The nPGVT group had similar gains in competence with 50% of students reporting a one level increase with another 38% increasing two levels. This result was not unexpected as students had to communicate on engineering tasks with their international counterparts to have any measure of success.

Through interviews, collected emails, and open-ended survey responses, all team members indicated a willingness to explain and clarify engineering tasks to their team members. However, the Co-located group had a distinct advantage as all team members spoke the same language and had common cultural threads uniting each team. The PGVT group also had considerable commonalities with international team members. For example, one team in this group had international team members from Canada, which shares multiple cultural commonalities with USA. Another team had international members who had lived between five and six years in the USA or South Africa. In both cases international team members had strong English language skills and fair to strong cultural ties.

The nPGVT students struggled communicating with international team members because of English language ability barriers. Two teams had international members with weak English language skills. During group meetings, the team's sub-group leaders would carry the conversation between each local sub-group. This struggle to communicate with international team members provided the BYU team members in this group the opportunity to try a variety of communication techniques with their international partners. Interviews with BYU students revealed that Asian team members worked hard on their assigned tasks, but the poor English language skills hindered team interactions. This would potentially explain the dramatic increase of the nPGVT group's competent rating and the absence of any team members reporting very competent ratings.

Table 28

Within Groups Pretest to Posttest Change for all Groups on the competence: I am able to communicate on engineering tasks with people from different cultures.

PGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**4%**	4%	12%	0%	5	16.00	4	.003
		Moderate Competence	0%	**0%**	31%	0%	8			
		Competent	4%	0%	**19%**	23%	12			
		Very Competent	0%	0%	0%	**4%**	1			
		Combined	16%	4%	62%	27%	26			

nPGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	19%	38%	0%	9	14.00	3	.003
		Moderate Competence	0%	**0%**	31%	0%	5			
		Competent	0%	0%	**13%**	0%	2			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	0%	19%	82%	0%	16			

Co-located			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	8%	0%	0%	1	3.00	2	.223
		Moderate Competence	0%	**8%**	17%	0%	3			
		Competent	0%	0%	**42%**	0%	5			
		Very Competent	0%	0%	0%	**25%**	3			
		Combined	0%	16%	59%	25%	12			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Discuss engineering team differences in an open manner. When asked about discussion of team differences, response patterns between groups did not differ on the pretest or the posttest (see Table 29). However, an examination of Table 30 indicated significant increases in both GV groups. Within groups, over half of the PGVT participants reported increases in competency with 8% of these participants increasing two levels to competent ratings and another 4% increasing three levels to very competent ratings. These increases were not as dramatic in the nPGVT group where 62% of students reported a one level increase in competence with another 6% indicating a two level increase to the competent category. The Co-located group's participants did not report significant gains in competence.

Table 29

Begin and End Reported Competence Between Groups on the competence: I am able to openly discuss engineering team differences before making a team decision.

Occasion	Group	Mean	SD	*n*	*F*	*df*	*p*
Begining	PGVT	2.31	.68	26	1.11	2	.337
	nPGVT	2.00	.97	16			
	Co-located	2.42	.79	12			
	Combined	2.24	.80	54			
End	PGVT	3.00	.63	26	1.14	2	.328
	nPGVT	2.75	.68	16			
	Co-located	2.67	.89	12			
	Combined	2.85	.71	54			

Of interest was the difference between the groups' ratings in the competent or very competent categories. The PGVT group reported 88% of students finishing with competent or very competent ratings. The nPGVT and the Co-located groups reported lower ratings (62% and 57% respectively). One potential cause for this difference may have been the PGVT lessons. One lesson was devoted to identifying and resolving team differences on GV teams. It provided strategies for resolving conflicts. The nPGVT and Co-located groups did not receive this instruction and did not view team differences as a positive aspect of team interactions.

Table 30

Within Groups Pretest to Posttest Change for all Groups on the competence: I am able to openly discuss engineering team differences before making a team decision.

PGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**4%**	4%	0%	4%	3	14.00	5	.016
		Moderate Competence	0%	**4%**	34%	8%	12			
		Competent	0%	0%	**38%**	4%	11			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	4%	8%	72%	16%	26			

nPGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	31%	6%	0%	6	11.00	4	.027
		Moderate Competence	0%	**6%**	25%	0%	5			
		Competent	0%	0%	**19%**	6%	4			
		Very Competent	0%	0%	0%	**6%**	1			
		Combined	0%	37%	50%	12%	16			

Co-located			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**8%**	0%	0%	0%	1	3.00	2	.223
		Moderate Competence	0%	**33%**	8%	8%	6			
		Competent	0%	0%	**33%**	0%	4			
		Very Competent	0%	0%	0%	**8%**	1			
		Combined	8%	33%	41%	16%	12			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

In interviews, the PGVT group reported having open discussions on what should be done and how. Often differing approaches to an engineering task were presented and the team would openly discuss the advantages and disadvantages of each approach before making a team decision, either by vote or consensus. Team members freely shared ideas with one another. The control group's teams typically presented tasks and team members chose a task or the team leader assigned the task. Several teams reported that if a team member presented an idea, the team would take a go-ahead-if-you-want-to approach instead of discussing the idea's merit. Teams had little discussion and focused on getting the task done rather than discussing advantages and disadvantages of how to proceed.

Build and maintain a working relationship of trust. When asked about their team's ability to build and maintain trust, response patterns differed on the pretest but were similar on the posttest (see Table 31). Using Bowker's test of internal change, both GV teams reported significant increases in their competence ratings from the pretest to the posttest. While initial competence ratings were moderately high in the PGVT group, 31% of students reported one level increases to the competent and very competent categories. A further 16% of participants reported two level gains to the same categories (see Table 32). The nPGVT group reported even larger gains in competence with 44% of students reporting a one-level gain in competence and a further 19% of students reporting a two-level increase to the competent category.

Student comments in the interviews and open-ended survey responses helped to explain this change in competence. Teams from UBC in the Co-located group were self-selected. Students reported choosing team members who were friends and had a previous working relationship on previous team assignments. From the start of the project there was a high level of trust among team members and strong relationships were formed.

Table 31

Begin and End Reported Competence Between Groups on the competence: I am able to build and maintain a working relationship of trust with team members.

Occasion	Group	Mean	SD	*n*	*F*	*df*	*p*
Begining	PGVT	2.46	.65	26	4.76	2	.013
	nPGVT	2.13	.89	16			
	Co-located	3.00	.74	12			
	Combined	2.48	.80	54			
End	PGVT	3.00	.63	26	.98	2	.382
	nPGVT	2.94	.57	16			
	Co-located	3.25	.62	12			
	Combined	3.04	.61	54			

While both GV teams saw substantial gains in their ability to build and maintain trust with team members, the nature of the trust differed between the PGVT and nPGVT groups. PGVT team members reported strong trust with team members built upon member relationships. Students on these teams referred to camaraderie among team members and friendships that had developed among the team members. Team members were not only thought of as collaborators on the engineering project, but as friends, even though they had never met in person. All team members looked forward to the weekly meetings where time was scheduled to tell jokes and visit as well as discuss project tasks and assignments.

In contrast, the nPGVT group based their team member trust solely on the ability of team members to complete assigned tasks on time. While team members thought highly of one another, there was no mention of friendship as a component of their trust. Weekly meetings were only viewed as business meetings and no time was scheduled for visiting. There was little humor or laughter reported during team meetings. Not all team members looked forward to the weekly team meetings.

Table 32

Within Groups Pretest to Posttest Change for all Groups on the competence: I am able to build and maintain a working relationship of trust with team members.

PGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	0%	8%	0%	2	10.33	4	.035
		Moderate Competence	0%	**8%**	23%	8%	10			
		Competent	4%	0%	**42%**	8%	14			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	4%	8%	73%	16%	26			

nPGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	13%	19%	0%	5	10.00	4	.040
		Moderate Competence	0%	**6%**	19%	0%	4			
		Competent	0%	0%	**31%**	12%	7			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	0%	19%	69%	12%	16			

Co-located			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	0%	0%	0%	0	2.00	2	.368
		Moderate Competence	0**%**	**8%**	8%	8%	3			
		Competent	0%	0%	**50%**	0%	6			
		Very Competent	0%	0%	0%	**25%**	3			
		Combined	0%	8%	58%	31%	12			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

Establish team protocols considering team members' cultural differences. When asked about establishing team protocols, response patterns differed on the pretest but were similar on the posttest (see Table 33). The GV groups reported strong one level increases in competence (PGVT = 27%, nPGVT = 56%). However, the PGVT participants also reported a strong two and three level increases (27% and 8% respectively). The nPGVT participants (19%) also reported a two level increase. As with earlier categories the PGVT group reported the highest ratings in the competent and very competent categories (77%) followed by the nPGVT group (63%) and the Co-located group (42%).

The data from interviews and open-ended responses revealed that both GV teams took time to present and discuss protocols for team interactions. While the protocols focused on accountability and procedures, there was considerable flexibility and protocols were modified and adjusted as needed. The PGVT instruction taught what should be determined for protocols and how it should happen, but the experience of establishing protocols appears to have greatly influenced the level of competence of each GV groups' participants. This is evidenced by the higher competent and very competent category ratings.

Table 33

Begin and End Reported Competence Between Groups on the competence: I am able to establish team rules, procedures and protocols that consider cultural differences of team members.

Occasion	Group	Mean	SD	*n*	*F*	*df*	*p*
Begining	PGVT	1.85	.83	26	3.57	2	.035
	nPGVT	1.69	.79	16			
	Co-located	2.50	.91	12			
	Combined	1.94	.88	54			
End	PGVT	2.88	.82	26	.52	2	.600
	nPGVT	2.63	.72	16			
	Co-located	2.83	.94	12			
	Combined	2.80	.81	54			

Table 34

Within Groups Pretest to Posttest Change for all Groups on the competence: I am able to establish team rules, procedures, and protocols that consider cultural differences of team members.

PGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**8%**	8%	19%	8%	11	16.00	6	.014
		Moderate Competence	0%	**8%**	15%	8%	8			
		Competent	0%	0%	**23%**	4%	7			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	8%	16%	57%	20%	26			

nPGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**6%**	31%	13%	0%	8	12.00	4	.017
		Moderate Competence	0%	**0%**	25%	6%	5			
		Competent	0%	0%	**19%**	0%	3			
		Very Competent	0%	0%	0%	**0%**	0			
		Combined	6%	31%	57%	6%	16			

Co-located			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**8%**	0%	0%	0%	1	3.00	2	.223
		Moderate Competence	0%	**25%**	17%	8%	6			
		Competent	0%	0%	**25%**	0%	3			
		Very Competent	0%	0%	0%	**17%**	2			
		Combined	8%	25%	25%	17%	12			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

This finding contrasted with the Co-located group's teams where little, if any, time was spent on establishing team protocols. One team leader reported that there was no need to establish initial team protocols because the team members were already familiar with one another and as the project continued the types of behaviors that would and would not be tolerated on a team became clear to all team members. This attitude was not supported by interactions on all teams as one UBC team reported considerable problems motivating a team member to complete his assigned tasks. Without protocols for dealing with such situations this team conflict escalated to the point where the UBC professor was required to intervene and restore a semblance of order.

Engage in a non-engineering conversation with a culturally different person. When asked about non-engineering conversations with culturally different individuals via virtual technologies, response patterns between groups on the pretest and the posttest did not differ significantly (see Table 35). A significant within group difference was only reported for the PGVT group (see Table 36). A one level increase in competence was reported by 39% of the PGVT participants.

Table 35

Begin and End Reported Competence Between Groups on the competence: I am able to have a non-engineering conversation with a person from a different culture via virtual technologies.

Occasion	Group	Mean	SD	*n*	*F*	*df*	*p*
Begining	PGVT	2.54	.91	26	1.44	2	.248
	nPGVT	2.15	.99	13			
	Co-located	3.00	1.41	5			
	Combined	2.48	1.00	44			
End	PGVT	3.12	.82	26	.127	2	.881
	nPGVT	3.00	.82	13			
	Co-located	3.20	1.10	5			
	Combined	3.09	.83	44			

Table 36

Within Groups Pretest to Posttest Change for all Groups on the competence: I am able to have a non-engineering conversation with a person from a different culture via virtual technologies.

PGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**4%**	4%	0%	4%	3	12.00	5	.035
		Moderate Competence	0%	**11%**	23%	4%	10			
		Competent	0%	0%	**23%**	12%	9			
		Very Competent	0%	0%	0%	**15%**	4			
		Combined	4%	15%	46%	35%	26			

nPGVT			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	23%	8%	0%	4	9.00	5	.109
		Moderate Competence	0%	**8%**	15%	8%	4			
		Competent	0%	0%	**15%**	15%	4			
		Very Competent	0%	0%	0%	**8%**	1			
		Combined	0%	31%	38%	31%	13			

Co-located			Posttest							
			Little or no Competence	Moderate Competence	Competent	Very Competent	*n*	Bowker Test Statistic	*df*	*p*
	Pretest	Little or no Competence	**0%**	20%	0%	0%	1	2.00	1	.157
		Moderate Competence	0%	**20%**	0%	0%	1			
		Competent	0%	0%	**0%**	0%	0			
		Very Competent	0%	0%	0%	**60%**	3			
		Combined	0%	40%	0%	60%	5			

Note. Boldface diagonals indicate percent of responses that did not change from pretest to posttest. Cells above the diagonal are percent increase. Cells below the diagonal are percent decrease.

The nPGVT participants reported 53% of students increasing one level in competence with another 16% increasing two competence levels. The Co-located group's increases are suspect due to the decreased response by participants on this item. However once again the PGVT reported 81% of students finishing in the competent or very competent ratings. This compared to the 69% of students in the nPGVT group finishing in these categories.

This may be explained by the PGVT instructions for students to take the time to share stories and interact with other team members. Several PGVT group's teams followed this instruction and scheduled time to visit about non-engineering topics. Jokes were shared. Stories were told about one another's lives. Overall language abilities were improved and, ultimately, trust was built along with strong team relationships.

For all competency ratings it is noteworthy that the PGVT reported significant increases from the pretest to the posttest on all competencies, while the nPGVT group reported significant differences in four of the five competencies. The Co-located group did not report any significant increases partially because of higher initial ratings on all competencies. This finding potentially reflects the GV students' better understanding of their initial level of competence having participated on a GV team experience. It also lends support to the concept that the Co-located group's students may not have truly understood their initial level of competence at the beginning of the project. This lack of understanding may be a result of students' lack of experience on GV teams or because students had past experience and positive relationships with team members.

Categorization of Email Conversation Topics

Each week all emails copied from team communications for all groups were sorted into communication incidents (CIs). Each email represented a conversation or a report of team activities that could be sub-divided into units that contained a word, a phrase, a sentence or a

paragraph referring to a team task, activity, or interaction. These units are CIs and became the means whereby emails could be examined to understand communication patterns among team members.

On a weekly basis two raters independently categorized each CI as described in the methods section. Initially raters had an agreement of 70% on the placement of CIs into specific categories. The categories were refined and developed as the raters discussed and categorized CIs each week. The percent agreement on the placement of CIs into categories increased to 94% agreement by the last week. The discussion and consensus of how to categorize CIs that did not have a common placement each week was critical in obtaining a high agreement of CI classification.

While students in each group chose and used virtual communication technologies that best suited their teams, it was important to examine the communication patterns of teams using a specific technology. In this case, email messages between team members of all groups were collected weekly and sorted into similar categories using a critical incident technique (Butterfield, et al., 2005; Flanagan, 1954; Gremler, 2004). Over the course of the engineering design course project, 747 emails were collected from all groups (PGVT = 254, nPGVT = 155, Co-located = 338). It should be noted that within each group one team was responsible for most of the emails collected, however, all emails collected from all teams were used in categorizing. While only the emails from the PGVT group are used to provide descriptions of the categories, emails from the other groups were used to highlight differences between the groups' email communication patterns.

Emails are divided into four broad categories with each category being further divided into specific subcategories. The broad categories include team protocols, trust building,

knowledge sharing, and scheduling. Team protocols included duties regarding who was responsible for specific team assignments, tasks that needed to be completed, and instructions on how to complete those tasks. Trust building referred to emails used to praise, encourage, or build a relationship with other team members. Knowledge sharing included emails that provided information and shared documents. This category also had problem solving examples where students asked for help or provided a solution. Finally, the scheduling category resolved calendaring issues and time zone differences. While these categories and their subdivisions are described separately, it should be noted that they are not distinct from one another. For example, asking for help to solve a problem or providing help to solve a problem helped to build or maintain trust. A summary of these relationships is provided in Figure 5.

Establishing protocols. The *establishing protocols* category is best summarized by team members stating who needs to do what and how. The duties sub-category refers to team members who self assign or accept team designated roles and duties. This includes taking a leadership role for a specific part of the project or assuming responsibility for completing a specific task such as modeling a part. The duties category serves to clarify who is doing what. Acceptance of a duty aided in commitment to team goals and individual responsibility and accountability. Knowing a team member's duty allowed him or her to emerge in a leadership role during a particular part of the project. Since all team members were aware of other team member's duties, there was quick acceptance when one team member emerged from the team as a temporary leader for a specific project task. This knowledge of roles also enabled team members to be held accountable for the successful completion of their duties.

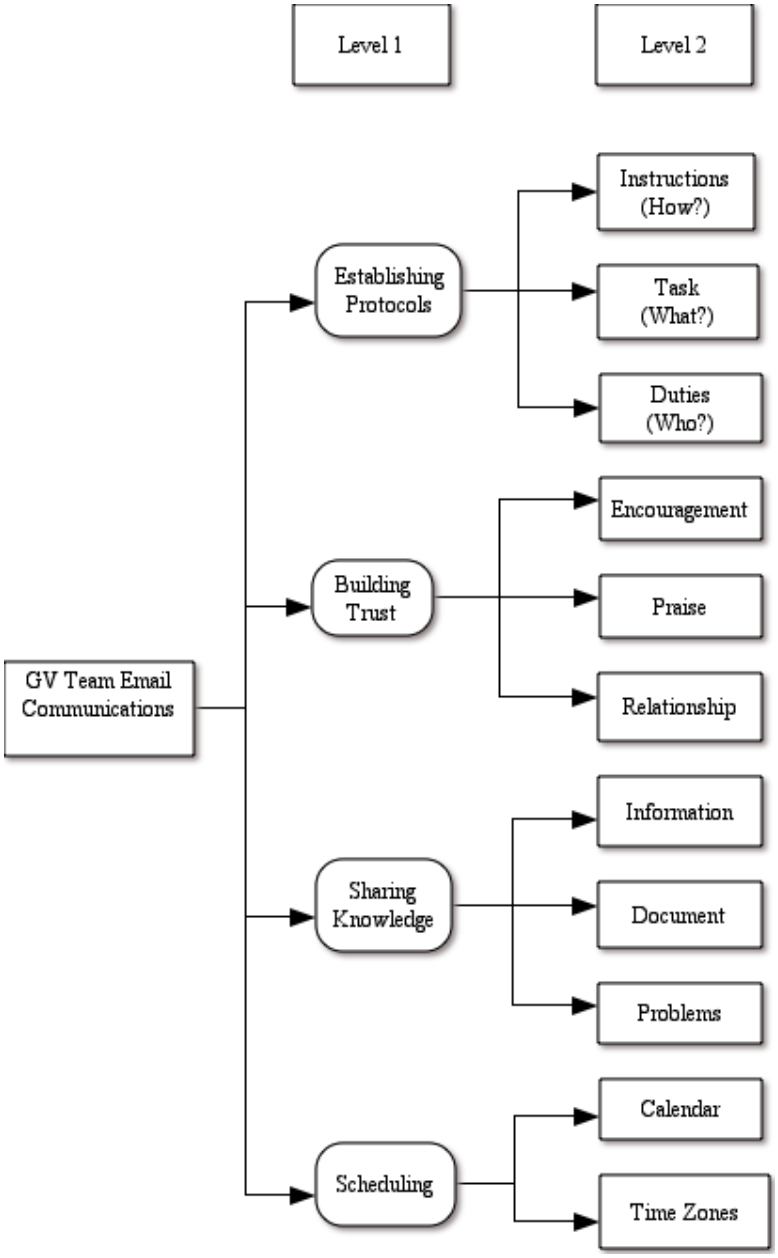

Figure 5. Summary of the GV Team Communication categories and subcategories.

Emails describing tasks, a sub-category, are reminders of assignments that need to be completed and reports of tasks that team members completed. In the initial part of the engineering design course project, BYU students clarified professor expectations for assignments to international team members, but as the international students became accustomed to the course expectations, these task reminders diminished. There were also requests from team members for assistance in completing tasks, but this usually focused on progress presentations due each week by each team or when a team member had fallen behind in a task completion because of extenuating circumstances. In the case of presentations, team members, responsible for the presentation, requested information (e.g., images or documentation) that highlighted what the team completed in the past week and stated goals for the next week. Other team members fulfilled this request by sending the needed information. If a team member had fallen behind in a task, he or she would explain why and recommit to completing the task or ask for help from team members.

Emails categorized as instructions clarified how to complete a task or provided an extensive list of step-by-step procedures. The step-by-step instructions typically occurred as team members had to combine individual work into a final product. The step-by-step instructions were intended to provide a uniform, seamless combination of work into a final product. However, the more detailed instructions were rarely sent and typically occurred only during significant transition points in the project.

The email communications in the establishing protocols category served the purpose to clarify and inform fellow team members of specific team actions and those accountable for those actions. The protocol categories modeled previous literature that indicated team members needed to be explicit in communications outlining and clarifying roles and responsibilities,

especially when different cultures are involved (Hung & Nguyen, 2008; Monalisa et al., 2008; Roebuck & Britt, 2002). This category also supported the findings of researchers describing emergent leaders who were given leadership roles that matched their expertise. While a single leader for the entire team and duration of the project was essential, the emergent leaders were responsible for specific parts of the project. The permanent and emerging leaders sent out the majority of emails to define, facilitate, and encourage team members' actions. This supports earlier research on emergent leaders and shared tasks on GV teams (Gavidia et al., 2004; Panteli & Tucker, 2009; Sudweeks & Simoff, 2005).

Building trust. Typical email communications in *building trust* included messages of praise (in the form of thanks and encouragement), comments meant to build relationships among team members, and statements of work related information. Throughout the emails, team members offered praise in the form of gratitude for work well done or encouragement to complete tasks. In the PGVT group most emails were generic messages of "thanks" tagged on at the end of the email. Occasionally individuals were singled out because of additional help or work that was exceptional. In one series of emails an international team leader commended a BYU team member for an exceptional job done modeling a part. However, for the most part, the emails were polite comments of appreciation for a job well done.

Relationship comments informed team members of impending absence from team meetings or apologies for missing a meeting without prior notification. Emails in the relationship category included team members offering to help team members on assigned tasks and accountability reports. The offers to help were typically simple questions asking fellow team members if they needed help completing a task by the assigned time or after the due date had passed. Accountability reports were statements that a task had been completed, a document

sent, or an image uploaded to a common cloud file. The statements served to build trust by indicating a team member's commitment to completing team tasks.

Although the trust building communications were work related and focused, they served to promote relationships by letting team members know what each team member was doing. The email communications served to indicate the level of commitment of the team member by how well he or she completed assigned tasks. This information became critical as all teams initially used this marker as the foundation for trust building. If a team member did not complete assignments or was late with assignments, trust was difficult to establish or was diminished. Those who completed assignments on time were able to build trust and moved to a higher level of trust built on personal relationships and communications. It should be noted that students in the nPGVT group did not move past this level of accountability in building trust with team members.

As the semester progressed emails from the BYU-Taiwan team became friendlier in their nature and levity. Team members started using emoticons, jokes, and vernacular phrases when emailing each other. The deeper personal sharing by the PGVT teams mirrored the research that emphasized the importance of team members seeking to build and increase friendships and working relationships to improve outcomes on each team (Brandl & Neyer, 2009; Hinds & Bailey, 2003; Roebuck & Britt, 2002).

Sharing knowledge. Three forms of *sharing knowledge* were evident in the emails. The first was information that described deadlines, clarified tasks, and notified other team members of progress. Information had a strong overlap with the protocols and trust building categories as the sharing of knowledge often followed a pattern prescribed in the protocols. As team members freely shared this knowledge and reported their progress with each other, trust was built. This

communication category provided notice of what the team member sending the email had completed and what he or she would do next. This component of knowledge sharing also helped establish the commitment of the team member to the project. These knowledge-sharing components connect to previous research that informs team members of the commitment of team members to the project (Barczak et al., 2006; Boule, 2008; Zhang & Chen, 2010).

The second component, problem solving, had two forms, asking for help or providing answers. Problems were often discussed in team meetings. The team leader either found a solution and shared it or referred team members to someone (on or off the team) with the needed expertise to solve the problem. This supports similar findings in previous literature where team members supported one another to solve problems (Carte et al., 2006; Tavčar et al., 2005; Zakaria et al., 2004). It also connected to the PGVT instruction on leadership. GV leaders needed to be aware of what forces are helping and hindering team progress. As such the GV leader became a resource to encourage team members and inform them who to contact for help.

The final component of knowledge sharing was that of document sharing. In this project document sharing largely involved notifying team members when modeled images were uploaded to a cloud storage system. It also identified the location of shared items for a specific team member, typically the team member who was preparing for a class presentation. Other documents shared were emails outlining team agendas and items that needed to be discussed at up-coming team meetings. This knowledge sharing helped team members prepare to discuss key items so group meeting time was not wasted. This type of knowledge sharing was analogous to previous research indicating the importance of sending out agendas and critical documents in advance of team meetings (Barczak et al., 2006; Laroche, 2002; May & Carter, 2001).

Scheduling. The category of scheduling referred to team members using email to request and/or schedule team meetings. For GV groups only, scheduling included reference to time zones of one or both sub-teams. Some GV team members also included which virtual communication technology to use for the meetings. One key difference between the PGVT teams and the nPGVT teams was stating reasons for meeting and scheduling changes. Individuals in the PGVT group, in addition to asking for a change of time or to be excused from a meeting, would offer reasons why. The reasons varied from schoolwork, to special lectures, national holidays, or personal pursuits. The PGVT teams also offered reasons why a meeting was not possible.

The PGVT group also asked team members for dates of national holidays, exams, or other important activities to be placed in a common schedule. While one team on the nPGVT group used an online scheduler to find a common meeting time, there was no mention of holidays or other dates where teams could not meet. While students in the nPGVT group would let team members know of an impending absence, they rarely if ever gave reasons for the absence or any detailed explanations.

Chapter 5

Discussion

The purpose of this study was to examine the ways and to what extent that PGVT instruction influenced the development of positive communication patterns for those participating on GV teams. In this chapter I interpreted the findings from the previous chapter. Following this I discussed the connections between the findings and the PGVT instruction. Finally, recommended practices and suggestions for future research are provided.

Interpretation of the Findings

The researcher examined five types of communication interactions among GV team members: (a) virtual communication technology use, (b) initiated contact communication patterns, (c) vernacular phrases in email communications, (d) GV communication competence, and (e) email conversation patterns. Each interaction is discussed in relation to the presented results. Each interaction provided evidence that PGVT instruction, combined with an engineering GV experience, supported the development of positive communication patterns on GV teams.

Virtual Communication Technology Use Across Groups. An initial step to determining whether positive communication patterns were established was to discern which virtual communication technology was best for team communication given the specific circumstances (Boule, 2008; Cho et al., 2007). Based on information from survey and interview responses, each group began with an exploratory attitude by trying familiar technologies and new virtual technologies introduced in the advanced engineering design course. Team members soon adopted a what-works-best stance given a particular team situation or attitude toward the technology. Team members seemed to use the virtual communication technologies that they

found to be useful in team interactions. Team members also adjusted the frequency of use of technologies depending on team member circumstances at a given point in the engineering project. For example, document-sharing technologies were critical towards the end of the project as teams collected and assembled parts. However, these technologies were not used as much at the start of the project.

The type of group also influenced the use of virtual communication tools. GV teams used internet-based communication tools (personal video calls, instant messaging, computer screen share) on a more frequent basis than their Co-located counterparts (see Table 37). The use of virtual communication tools by the GV teams but not the Co-located teams was not unexpected. However this finding illustrated the fact that GV teams use these technologies out of necessity rather than convenience.

Table 37

Summary of Significant Within Group-Change in Communication Technology Use by Group.

Technology	PGVT	nPGVT	Co-located
Email	Decrease	Decrease	Decrease
Personal Video Call	-	Decrease*	Decrease
Group Video Call	-	-	-
Computer Screen Share	Increase*	-	-
Online Team Calendaring	Decrease	Decrease	-
Phone Calls	Decrease	Decrease	Decrease
Text Messaging via Cell Phones	Decrease	Decrease	Decrease
Instant Messaging	Decrease	Decrease	Decrease
Online Document or File Share	Increase*	Increase*	-
Online Collaboration Tools	Decrease	-	-
Online Team Management	-	-	-

Note. Asterisks (*) indicated non-significant trends. Dashes (-) indicate no significant change from the pretest to the posttest.

Two trends related to the groups appeared in the use of virtual communication technology. First, each of the changes indicated a refinement in the group's ability to choose which virtual communication technologies to use for a given task. For several virtual

communication tools, trends indicated students moving towards a common rate of use. For example, in Table 11 the PGVT members indicated that 33% of group members did not change their use of computer screen sharing tools. However, 30% of group members increased to a weekly use and 15% decreased to a weekly use. As a result the majority of team members moved towards a common rate of use for a given technology. Similar increasing or decreasing trends were indicated for other groups' communication tool use. This trend towards common team use suggests that students in all groups had the ability to discern which technology to use. In addition they were able to match the team task with appropriate communication technology and the frequency of use that was most effective.

Second, the analysis of technology rate of use reflected the project and group needs. For example, as one might expect, personal video call use for students in the Co-located group was lower than personal video call use by the GV teams. This finding was illustrated by the use of online collaboration tools. Towards the end of the project, GV teams decreased their use of this technology while Co-located teams increased their use. A plausible explanation was when GV teams used collaborative technology to teach one another how to use engineering design tools. The Co-located teams were able to do work with each other on a face-to-face basis. However, towards the end of the project, GV team members no longer needed to instruct one another and only needed the collaborative tools for sharing and assembling models. Conversely, the Co-located teams found the cloud tools a convenient way to collect and assemble modeled parts. As a result, one group increased use of this tool while the other two groups decreased use. The use of the tool related directly to the task of the team.

As another example of using a technology to fit the project activity is illustrated with the use of Skype. It became a common practice among most of the GV teams and some of the Co-

located group's teams to have Skype turned on while working on the project tasks. With this communication technology tool, local or international team members not present in the engineering design lab could be contacted to share their expertise. In one case, a BYU student commented that he would contact his Brazilian team members for help in modeling rather than personally visit the engineering course's teaching assistants because of expediency and the Brazilian's expertise.

When asked to explain the shift in technology use, individuals cited issues of facility and utility. The interviewed UBC students noted that their modeling lab was in the basement of their engineering building. While this did not allow for phone calls and text messages, it did provide for internet use to contact team members. Cost and time differences were also factors in which technologies students chose to use. The use of personal video conferencing was free via the internet as opposed to additional international charges for phone conversations and texting. Making a video call provided students the opportunity to immediately contact a fellow team member to ask or answer questions.

Each of these changes indicated flexibility within the GV team members' ability to adapt to the emerging team situation. Team members increased or decreased their use of specific technologies to communicate in their preferred mode. The choice of technology reflected the students' need and willingness to interact across time and distance. This finding paralleled previous research by Karpova et al. (2009) where students began a GV project using the same communication tools, but soon adopted additional technologies that facilitated team interactions. Like the students in Karpova et al.'s study, the GV teams developed skills in a repertoire of virtual communication tools to facilitate communications and interactions between local and

international team members. Students also developed a sense of how often technologies were needed and when to increase and decrease the use of these technologies as project tasks required.

Communication Patterns Based on Initiated Contacts. Being able to initiate contact with team members provided an indication of team members' willingness to communicate with one another. While there were no significant main effects or interactions found within or between the three groups, it is noteworthy that the PGVT group had more initiated contacts during the engineering design course project compared with individuals in the control groups. Previous research indicates that teams who have more contacts with team members form stronger more successful teams (Carte et al., 2006; Hou & Wu, 2011). The trend of more initiated contacts may indicate a greater willingness on the part of PGVT team members to open contact with fellow team members.

A willingness to communicate with other team members has been identified as a key component needed for successful GV team interactions (Boule, 2008; Cho et al., 2007; Cogburn & Levinson, 2003; Daim et al., 2011; Gibson & Gibbs, 2006). The PGVT group's slight decline likely happened for a variety of reasons, but an analysis of interview data and open-ended survey responses seem to indicate a refinement of team protocols and a greater recognition of when initiated contacts needed to occur. For example, several students commented that team protocols establishing when and how team members were to initiate and respond to communications initially helped in team communications. However, as the project advanced, these protocols were either replaced with more practical protocols or became redundant and were discarded. Likewise, the increase in initiated contacts for the nPGVT and Co-located groups also reflected an increased trust in team member's engineering skills and trustworthiness to respond to questions. For example, a Chinese student commented on how he was able to often contact his

BYU team leader with questions. As the project proceeded, the Chinese student gained confidence that his BYU counterpart would respond and he was more willing to initiate contact.

An interesting pattern of communication emerged from interviews regarding the initiated contacts and the willingness to communicate. In interviews, the PGVT and Co-located groups' team members reported the willingness to communicate with all team members on any issue. There was a give and take or open sharing of ideas both related to the engineering tasks and the broader personal and social context of team members' lives. However, the nPGVT group team members primarily relied on most communication occurring through a single communication conduit formed by the sub-group leaders. The sub-team leaders had considerable communication and interaction with each other, but there was not the open sharing and initiated contact with all team members. As a result all questions, answers, and suggestions where channeled through the sub-team leaders with the open sharing and contact only occurring on a local sub-team level (see Figures 6 and 7).

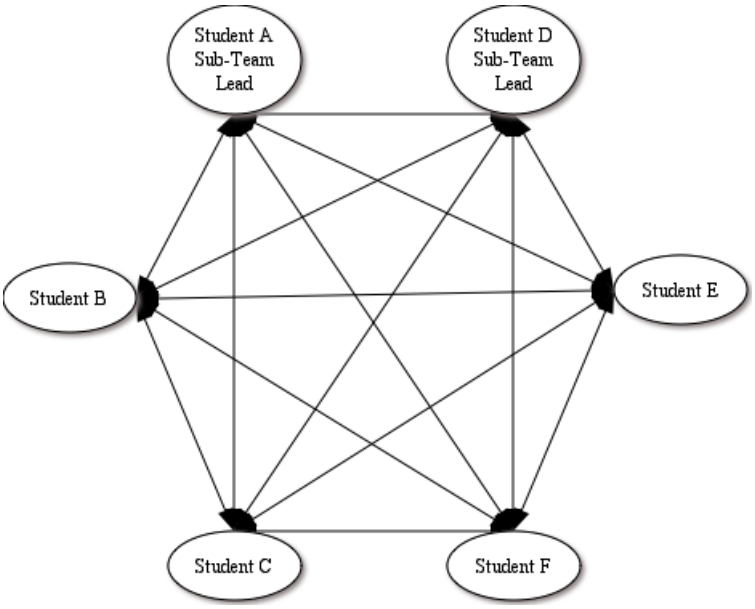

Figure 6. Social network of balanced communication.

Cross and Parker (2004) suggest that the social networks created by team members having contact with multiple team members creates a stronger team network. These ties support team interactions and allow for continued contact should one team member be removed from the network. For example, if either sub-team leader were removed from the social network illustrated in Figure 7, the respective sub-team members would be isolated from the remainder of the team. In the social network illustrated in Figure 6, a similar removal does not isolate team members. In this research, the PGVT teams reported more of a social network structure associated with Figure 6 while the nPGVT teams reflect a structure found in Figure 7. It should be noted that the lines connecting students on each team are illustrative of contacts between team members and do not indicate the weighted frequency of contacts between team members.

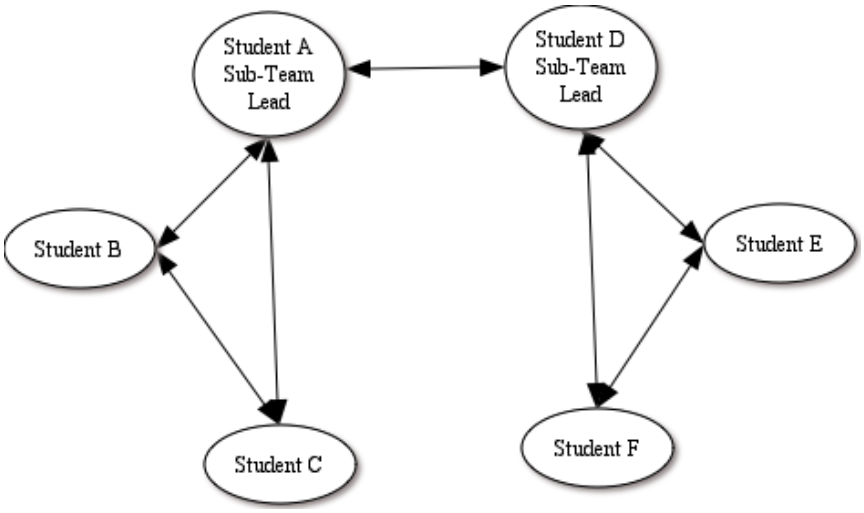

Figure 7. Social network of unbalanced communication.

The open social network (Figure 6) connected to the PGVT lessons that indicated all team members should participate on team tasks ranging from the establishment of team protocols to design assignments and decisions. Instruction specifically referred to drawing out those team members who came from a cultural background that was more reserved and quiet while

tempering those from a more emotional and verbose culture. In the team dissonance lessons students were taught that disagreements on how to best design a product or complete a task typically lead to a stronger product. PGVT teams indicated a common sharing of ideas and open discussion of how best to proceed with team tasks. Each of these processes related directly to the communication pattern in Figure 6. Here, team members had a free exchange of ideas with all other team members. This exchange resulted in stronger communication and interaction patterns for PGVT teams.

Vernacular Phrase Use in Email Conversations. Considerable evidence suggests that GV teams should avoid the use of vernacular phrases when working with team members using a second language as the potential for miscommunication and misunderstanding may occur (Barczak et al., 2006; Laroche, 2002; Panteli & Fineman, 2005; Ross, 2006; Anawati & Craig, 2006). However, others suggested that the use of vernacular phrases indicates a stronger understanding of international team members' culture and communication preferences. However, learning to use vernacular phrases in appropriate ways enhances team communication and relations (Brandl & Neyer, 2009).

An analysis of the qualitative data indicated key differences among all three groups. The use of vernacular phrases by the Co-located group may be explained by the UBC teams being allowed to self-select team members. The UBC students indicated in interviews, that they were able to choose their own team members. On each UBC co-located team, members had previously worked together. This familiarity is evidenced by the high use of vernacular phrases characteristic with individuals who are quite well known with one another and have a high level of trust. Since this familiarity was already present, the use of vernacular phrases began and remained consistently high throughout the study.

The PGVT group had a different pattern of vernacular phrase use. Initially the PGVT group showed a decline to zero use of vernacular phrases. However, the decline was followed by an upward trend. In interviews team members reported looking forward to the weekly meetings where they could discuss the project's progress and interact with their international counterparts. Typically the PGVT group's teams allowed the engineering conversation to digress to social conversations and humor. On two PGVT teams, time at each meeting was allotted for team members to tell jokes and visit about non-engineering social items. This planning for social interactions tied into the PGVT lessons that encouraged taking time to share stories, jokes and non-engineering social interactions. As advocated by Brandl and Neyer (2009), this planned visiting facilitated a greater understanding of one another's culture and communication differences. The sharing of stories and personal events allowed a greater trust to form between team members as group collegiality was created. It also altered the manner of communications as PGVT group's participants began using more colloquial phrases in team communications. However, the increased use of vernacular phrases may also be attributed to the second language ability of international students.

The sharing of culture and social visiting on the PGVT teams was also facilitated by several of the PGVT teams having strong second language or common cultural experiences. For example, all three members of NTU had lived for five to six years in either the USA or South Africa. This resulted in strong English language skills and some familiarity with American culture. Similar English language ability was evident with the UBC team members situated in Canada. In contrast, because some team members had weak language skills the nPGVT teams reduced their use of vernacular phrases and, except for a spike in week 7, maintained a low use of vernacular phrases throughout the study. In interviews with team members, the nPGVT

students reported that team members rarely, if ever, told jokes, laughed, or visited about non-engineering topics. With low English language skills, the team meeting conversations focused on what needed to be done and how to do each task. The interviews with the nPGVT students indicated limited trust between team members because of missed assignments due to communication errors. The nPGVT students did not develop the trust based on relationships that was formed on the PGVT teams.

Due to the lack of English language skills by some team members, communications were often more difficult. A BYU team leader described situations where he spent several hours helping an Asian team member learn how to model or perform specific engineering tasks. As a result of the weak language skills, communication often occurred between sub-group team leaders. The non-English leader would then explain the engineering procedures and messages to the other local team members. The Asian team members, who had regular contact expressed gratitude for the time taken by the American teammates, but they acknowledged their weak proficiency in English. Both the Asian and BYU team members indicated the lack of strong English language skills hampered communication with team members.

In interviews, PGVT students quickly indicated a strong trust with team members. They referred to strong relationships and friendships that had formed through virtual communications, but also cited student accountability and responsibility for task completion. Students on the nPGVT teams only referred to task accountability and responsibility as measures for building and maintaining trust.

This result supports Lee-Kelley et al.'s, (2004) assertion that having strong basic skills in a common language is essential for GV team communication success. This finding however runs counter to the advice of some experts who advocate not using vernacular phrases and humor in

any GV team conversations (Laroche, 2002; Panteli & Fineman, 2005; Ross, 2006). The benefits of using the vernacular in terms of team building is noted by Brandl and Neyer (2009) who advocated students getting to know one another and each other's culture at a deeper level to facilitate team communication. Apparently one way to improve the quality of team communication is by appropriate use of vernacular phrases but only when team members take the time to explain the vernacular phrases. In fact the scheduling or time for social interactions where team members shared humor and personal stories was encouraged by several researchers and was viewed as being important to establish a rhythm to the team interactions (Chen et al., 2009; Last, 2003; Lee-Kelley et al., 2004; Maznevski & Chudoba, 2000). As mentioned previously, the PGVT instruction encouraged students to take the time to visit socially and to share stories and experiences with one another to build trust and relationships.

Changes in GV Communication Competencies. The initial and end reports of communication competence provide some of the strongest evidence for the difference between GV and Co-located teams and between GV teams with and without the PGVT instruction. It is noteworthy that, from the pretest to the posttest, significant improvement was reported by the PGVT group on all of the five competencies, while the nPGVT group reported significant improvement on four of the five competencies. The Co-located group did not report any significant change on any of the communication competence items. While this may have been an effect of students not really knowing what they don't know or the result of previous team member relationships, it may also suggest a key difference in how GV teams and Co-located teams communicate with each other.

How team members were placed on teams and the opportunity to interact with those team members influence team communications. The UBC Co-located teams self-selected team

members based on previous teaming experiences. However, the GV participants were placed on teams using a different set of criteria. This resulted in half or less of the team members having previously worked with each other. Also working with team members via virtual communication technologies was a novel experience for most participants in the GV groups. Both factors may have influenced the lower ratings of initial competence and also provided for the opportunity for increases in competence on GV teams. This might also help explain the result that both GV groups reported significant increases from the pretest to the posttest in their ability to discuss engineering tasks with culturally diverse team members and establishing culturally sensitive team protocols. It is logical to assume that this occurred with and without instruction simply because of the need to communicate and interact with team members to accomplish the project. The significant increase in competence suggests a commensurate effort with team members for these gains in competence to occur.

However, the lessons, combined with team experiences, provided only the PGVT group's team members the opportunity to significantly increase their competence in their ability to hold non-engineering conversations with team members via virtual technologies. This competence was considered a key competence provided the opportunity for trust to grow through the development of personal relationships. This finding supports previous research on the importance of building trust through sharing social and emotional information and building friendships to establish trust among team members (Bailey, 2003; Monalisa et al., 2008).

The PGVT lessons may have assisted student learning in the competencies related to discussing engineering tasks and establishing team protocols with culturally diverse team members. However, since the nPGVT group also had significant gains in competence without

the PGVT instruction, it was felt that these gains in competence were more of a factor of the team experience and language abilities of team members than the PGVT instruction.

Email Conversation Patterns. Communication patterns found in emails also provided support for the GV Leadership lessons and knowledge sharing instruction in the PGVT lessons. Leaders in the PGVT group's teams were willing to allow emergent leaders to assume control of the team for brief periods where the emergent leader's expertise afforded the team an advantage to completing the team project. Leaders also demonstrated team-building efforts by informing team members of what was currently happening on the team and focusing efforts on what needed to be completed. They also took the time to praise and encourage fellow team members for completed and outstanding work. Finally, the GV leaders served as a resource for either providing information or directing team members to an appropriate resource. Each of these aspects of a GV leader was presented in the PGVT Leadership lesson.

The emails also provided evidence of a strong knowledge sharing aspect encouraged in the PGVT instruction. When students in the PGVT group were going to be absent, they not only informed other team members, but also provided an explanation for the absence. While the nPGVT group's participants informed team members of absenteeism, typically they did not give an explanation for the absence. In addition to this the PGVT group's participants also asked about and scheduled upcoming events and holidays unique to their international team members as instructed in the PGVT lessons. While this type of scheduling also occurred on the nPGVT teams, it typically did not occur until sub-team members missed a meeting without prior notice or explanation. In this case the PGVT lessons appeared to accelerate PGVT students' learning. This instruction accelerated students' learning and helped the team's function better.

Observed Connections Between Communication Patterns and PGVT Lessons

The research question sought to determine the ways and extent that the PGVT lessons facilitated positive communication patterns among team members. While all findings do not connect directly to the PGVT lessons, several findings link directly to concepts presented in the asynchronous instruction. The following discusses those findings with connections to the PGVT lessons.

Using Vernacular phrases. Increased use of vernacular phrases corresponded to the PGVT lessons. Initially students were taught to reduce the use of vernacular phrases to increase the clarity of communications. However, in lesson three, Building and Maintaining Trust, students were encouraged to gain a deeper cultural understanding of their international team members and team members' communication preferences. Since team members could not meet in person, this deeper understanding was facilitated through communication tools. Using the vernacular phrases common in one culture increased the clarity of the message as team members began to communicate in familiar terms and phrases. For example in several emails the Taiwanese team members would use a vernacular phrase and then seek clarification with their BYU team members as to whether the phrase was used correctly. Such use and clarification allowed the Taiwanese members to build communication patterns familiar to BYU students. Learning and using vernacular phrases by the PGVT participants was an indication that deeper learning of one another's culture took place.

Establishing protocols. Each of the categories described above is connected to lessons taught in the PGVT instruction. Team leaders were encouraged to communicate clearly with team members and share leadership roles to make full use of team members' abilities and skills. When team members assumed and performed team duties, trust was built among team members.

Conversely, if a team member did not follow through with an assigned duty trust was diminished. Each of these actions indicated a student's level of commitment to the team. Finally, the procedures established in the protocols were expressly taught in the PGVT instruction where students were told to be as explicit as possible with any communications. The PGVT lessons also indicated that all team members needed to discuss the team protocols and agree to follow them. As students followed this direction, communication and team interactions improved.

Building trust. Deeper cultural sharing was presented as part of the PGVT instruction. Although students were initially instructed to limit vernacular phrases and humor, later instruction encouraged students obtain a deeper cultural understanding of team members. As team members scheduled visits, told stories, exchanged humor, and shared current experiences the use of vernacular phrases increased. The lessons encouraged team members to understand cultural communication patterns of team members and adopt those patterns to facilitate team communication. The PGVT teams scheduled such interactions and built trust on relationships.

Scheduling. The scheduling findings also linked to PGVT instruction. The Team Processes lesson provided instruction on finding holidays and events unique to each international sub-group on the team. It asked students to clarify meeting times with time zones and provide fuller explanations to team members. This occurred on the PGVT teams, but not the nPGVT teams. The PGVT lessons provided team members the understanding to explain how they could or could not contact team members and provide deeper explanations why they could not attend.

Recommended Practices

One of the key findings from this research, not related to the PGVT lessons, was the importance of second language skills. Strong common language skills are essential to establish

relationships and trust. Where English was used as the language of interaction, a minimum standard of English should be required for team participation. Similarly, where possible, students with second language abilities should be paired with team members who have a similar native language. Team members with weak English skills can greatly hampered team communications and interactions. Additional instruction in creating common language tools (e.g. a lexicon of terms unique to the project) can be helpful to students using a second language. Introducing the opportunity for engineering students to couple second language instruction and a GV team experience in the same language would likely benefit the students' experience.

The timing of the presentation of PGVT lessons may also be critical. Since some lessons focus on establishing team protocols or specific team interactions, it may benefit students to complete the PGVT lessons in a timely manner. Requiring lessons to be completed in the first four to six weeks of the engineering design course would provide students with the instruction on how to interact with team members before the opportunity to use that knowledge presents itself. It would also be helpful to indicate the importance of the PGVT lessons by making them part of the overall course grade.

Future Research

Where study abroad students interact with international team members prior to travelling to the international location, future iterations of this research might examine how PGVT instruction and GV team interaction influences the experience of the study abroad students. Of particular interest would be how the establishment of trust and relationships between local and international team members prior to the study abroad travel. If the PGVT instruction combined with GV contact prior to the trip is positive it should positively influence the final product and overall interactions between local and international students during the study abroad experience.

Also, it would be interesting to understand how second language acquisition is benefited through GV team interactions. It would be of interest to better understand how GV interactions affect the development of second language abilities, especially in the use of colloquial expressions. It would also be of interest to understand how native pronunciation and cultural explanations affect language acquisition that interpersonal communications and relationships.

Conclusion

Combining a course designed to teach students the principles of global virtual teams with a GV experience enhanced the learning of students. As students developed a repertoire of virtual communication tool skills, they also developed a sense of which tool to use and when to use it. Initiating practices such as planned social interactions during weekly team meetings, helped develop team members' use of communication practices that facilitated team interactions. Increased language ability, in the form of vernacular phrase use and humor, enabled team members to form strong trust based on personal relationships. Adapting leadership styles to support team interactions and the emergence of activity specific leaders facilitated positive communication and interactions. In each case there was evidence that the PGVT lessons provided students with the knowledge needed to recognize when a communication and interaction unique to GV teams occurred. The lessons also provided insights and best practices to help students navigate through these interactions. The result was a stronger GV team communication.

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Appendix A

Pretest

Title of Research Project. Development of a Scalable and Sustainable Infrastructure for Global, Collaborative Engineering Design Education
Purpose of this Study. This research is seen as a necessary first step towards the possible development of a network of U.S. teams partnered with international teams to work as global virtual teams in engineering.
Procedures. Completion of this survey will take approximately 20 minutes to complete. Questions in four (4) sections relate to general information about your background and team experience, cross-cultural disposition, virtual communication skills, and engineering team work skills.
Benefits. A premise of the research is that students can develop several global engineering skills by participating in a well-crafted international design experience. The specific attributes being focused on in this study are,
1. Proficiency working in or directing a global virtual team of ethnic and cultural diversity.
2. Understanding cultural influences on product design, manufacture and use. 3. Understanding how cultural differences affect how engineering tasks are performed.

Compensation. No compensation will be provided for participating in this study.
Confidentiality. While participants are asked to enter their name, this is only to link pretest survey responses to posttest responses to aid in statistical analysis. No responses will be linked to any identifying information. All information obtained during this study will be kept strictly confidential.
Opportunity to Ask Questions. You may ask questions regarding this research at any time. If you have questions about this study, you may contact:
Holt Zaugg, Graduate Student, Educational Inquiry, Measurement and Evaluation, McKay School of Education, Brigham Young University. Tel: 1 (801) 857-0182; Email: zauggh@gmail.com
Dr. Allan Parkinson, Dean, Fulton College of Engineering and Technology, Brigham Young University. Tel: 1 (801) 422-4327; Email: parkinson@byu.edu
Freedom to Withdraw. Participation in this study is voluntary. You may withdraw at any time without penalty or refuse to participate entirely without harming your relationship with the researchers or Brigham Young University. Leaving the study will not cause a penalty or loss of any benefits to which you are otherwise entitled.

Please select "Yes" to provide your informed consent to participate in this survey, or select "No" if you choose not to participate. To confirm your response, please select the "Next" button at the bottom right.

- ❍ Yes, I will participate.
- ❍ No, I do not wish to participate.

Q2.1. First Name:

Q2.2. Family Name:

Q2.3. Which course are you participating in?
- ❍ ME 471 with Partner Universities
- ❍ International Capstone with BYU, NUS & Penn State

Q2.4. What university do you attend?
- ❍ Brigham Young University - ME 471
- ❍ ITESM - Toluca
- ❍ Honjik University
- ❍ Tongji University
- ❍ University of British Columbia
- ❍ Universidad Iberoamerican
- ❍ University of Sao Paulo
- ❍ Wayne State
- ❍ National Taiwan University
- ❍ Other- Please Specify _____

Q2.5. Which School was on your design team?
- ❑ Brigham Young University - ME 471
- ❑ ITESM - Toluca
- ❑ Honjik University
- ❑ Tongji University
- ❑ University of British Columbia
- ❑ Universidad Iberoamerican
- ❑ University of Sao Paulo
- ❑ Wayne State University
- ❑ National Taiwan University
- ❑ Other- Please Specify _____

Q2.6. What Type of team are you participating on?
- ❍ GV Team with PGVT Lessons
- ❍ Co-located
- ❍ GV Team with NO PGVT Lessons
- ❍ Virtual Only

Q2.7. What is your gender?
- ❍ Female
- ❍ Male

Q2.8. What country do you consider to be your native country?
(Scroll down list provided electronically)

Q2.9. How many years have you lived inside of the country where you currently live?
- ❍ Less than 1 year
- ❍ 1 to 5 years
- ❍ More than 5 years

Q2.10. How many years have you lived outside of the country where you currently live?
- ❍ 0 years (None)
- ❍ Less than 1 year
- ❍ 1 to 2 years
- ❍ More than 2 years

Q2.11. Please select any of the following experiences in a foreign country that you have participated in:
- ❑ Vacation
- ❑ Study abroad
- ❑ Student exchange
- ❑ Internship
- ❑ Service abroad (i.e. mission, etc.)
- ❑ None
- ❑ Other - Please Specify _____

Q2.12. What is your native language?

Q2.13. Do you speak a language other than your native language?
- ❍ Yes
- ❍ No

Q2.14. Please list the language(s) other than (native language specified in Q12) that you speak.
Second Language
Third Language
Fourth Language

Q2.15 Please indicate your level of fluency for second language.

	Poor	Fair	Good	Excellent
Reading	❍	❍	❍	❍
Writing	❍	❍	❍	❍
Speaking	❍	❍	❍	❍

Q2.16 Please indicate your level of fluency for third language.

	Poor	Fair	Good	Excellent
Reading	❍	❍	❍	❍
Writing	❍	❍	❍	❍
Speaking	❍	❍	❍	❍

Q2.17 Please indicate your level of fluency for fourth language

	Poor	Fair	Good	Excellent
Reading	❍	❍	❍	❍
Writing	❍	❍	❍	❍
Speaking	❍	❍	❍	❍

Q3 Please indicate the extent to which each statement describes your behavior, values and beliefs.

	Almost Never True	Sometimes True	Usually True	Frequently True	Almost Always True
I take opportunities to learn about other cultures.	❍	❍	❍	❍	❍
I adapt my actions when working with other cultures.	❍	❍	❍	❍	❍
I like to learn about foreign cultures.	❍	❍	❍	❍	❍
I love learning new languages.	❍	❍	❍	❍	❍
I have close friends from different cultures.	❍	❍	❍	❍	❍
I think a lot about the influence that society has on other cultures.	❍	❍	❍	❍	❍
Community and government are stronger with diversity of ethnic representation.	❍	❍	❍	❍	❍
Government should make policy to make a positive global impact.	❍	❍	❍	❍	❍
Leaning about foreign cultural practices builds a better community.	❍	❍	❍	❍	❍
Incorporating foreign cultural practices is beneficial to our society.	❍	❍	❍	❍	❍
I donate money for or participate in international humanitarian causes.	❍	❍	❍	❍	❍
I feel more comfortable living in a neighborhood with similar ethnic backgrounds to my own.	❍	❍	❍	❍	❍
I read or watch world news.	❍	❍	❍	❍	❍
Learning about world events is important to me.	❍	❍	❍	❍	❍
I respect ideas and beliefs of people from foreign cultures.	❍	❍	❍	❍	❍

Q4 How often do you use the following technologies?

	Never	Less Than Monthly	Monthly	Weekly	Once a Day	More Than Once a Day
Email	❍	❍	❍	❍	❍	❍
Phone Calls	❍	❍	❍	❍	❍	❍
Text Messaging via cell phones	❍	❍	❍	❍	❍	❍
Instant Messaging (i.e. Google Chat, etc.)	❍	❍	❍	❍	❍	❍
Personal Video Conference (i.e. Skype, iChat, etc.)	❍	❍	❍	❍	❍	❍
Group Video Conference (i.e. Tandberg, etc.)	❍	❍	❍	❍	❍	❍
Computer Screen Share (i.e. Skype, Adobe Connect, etc.)	❍	❍	❍	❍	❍	❍
Online Document/File Share (i.e. Dropbox, etc.)	❍	❍	❍	❍	❍	❍
Online Collaboration Tools (i.e. Google Docs, CAEDM, TcC, etc.)	❍	❍	❍	❍	❍	❍
Online Team Calendaring	❍	❍	❍	❍	❍	❍
Online Team Management	❍	❍	❍	❍	❍	❍

Q5 Indicate how competent you are in each of the following areas.
• I am able to:

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
a) communicate on engineering tasks with people from different cultures.	❑	❑	❑	❑	❑
b) complete engineering tasks while working with people from different cultures.	❑	❑	❑	❑	❑
c) openly discuss engineering team differences before making a team decision.	❑	❑	❑	❑	❑
d) build and maintain a working relationship of trust with engineering team members.	❑	❑	❑	❑	❑
e) use different approaches to engineering design used by other cultures.	❑	❑	❑	❑	❑
f) choose appropriate virtual communications tools by comparing the task with the media richness of the tool.	❑	❑	❑	❑	❑
g) establish team rules, procedures and protocols that consider cultural differences of team members.	❑	❑	❑	❑	❑
h) have a non-engineering conversation (i.e. share stories, tell jokes, feel comfortable speaking and listening) with a person from a different culture via virtual technologies.	❑	❑	❑	❑	❑

Appendix B

Posttest

Q2.1 First Name:

Q2.2 Family Name:

Q2.3 Which course are you participating in?

- ❑ ME 471 with Partner Universities
- ❑ International Capstone with BYU, NUS & Penn State
- ❑

Q2.6 What type of team are your working on?

- ❍ GV Team with PGVT Lessons
- ❍ Co-located
- ❍ GV Team with NO PGVT Lessons
- ❍

Q2.4 Which university do you attend?

- ❍ Brigham Young University - ME 471
- ❍ ITESM - Toluca
- ❍ Honjik University
- ❍ Tongji University
- ❍ University of British Columbia
- ❍ Universidad Iberoamerican
- ❍ University of Sao Paulo
- ❍ Wayne State University
- ❍ National Taiwan University
- ❍ Other- Please Specify _____

Q3 Please indicate the extent to which each statement describes your behavior, values and beliefs.

	Almost Never True	Sometimes True	Usually True	Frequently True	Almost Always True
I take opportunities to learn about other cultures.	❍	❍	❍	❍	❍
I adapt my actions when working with other cultures.	❍	❍	❍	❍	❍
I like to learn about foreign cultures.	❍	❍	❍	❍	❍
I love learning new languages.	❍	❍	❍	❍	❍
I have close friends from different cultures.	❍	❍	❍	❍	❍
I think a lot about the influence that society has on other cultures.	❍	❍	❍	❍	❍
Community and government are stronger with diversity of ethnic representation.	❍	❍	❍	❍	❍
Government should make policy to make a positive global impact.	❍	❍	❍	❍	❍
Leaning about foreign cultural practices builds a better community.	❍	❍	❍	❍	❍
Incorporating foreign cultural practices is beneficial to our society.	❍	❍	❍	❍	❍
I donate money for or participate in international humanitarian causes.	❍	❍	❍	❍	❍
I feel more comfortable living in a neighborhood with similar ethnic backgrounds to my own.	❍	❍	❍	❍	❍
I read or watch world news.	❍	❍	❍	❍	❍
Learning about world events is important to me.	❍	❍	❍	❍	❍
I respect ideas and beliefs of people from foreign cultures.	❍	❍	❍	❍	❍

Q4.1 Briefly describe a technology you used to communicate and interact with a team member and how well it worked.

Q4.2 How often do you use the following technologies when communicating or interacting with team members on your group project?

	Never	Less Than Monthly	Monthly	Weekly	Once a Day	More Than Once a Day
Email	❍	❍	❍	❍	❍	❍
Phone Calls	❍	❍	❍	❍	❍	❍
Text Messaging via cell phones	❍	❍	❍	❍	❍	❍
Instant Messaging (i.e. Google Chat, etc.)	❍	❍	❍	❍	❍	❍
Personal Video Conference (i.e. Skype, iChat, etc.)	❍	❍	❍	❍	❍	❍
Group Video Conference (i.e. Tandberg, etc.)	❍	❍	❍	❍	❍	❍
Computer Screen Share (i.e. Skype, Adobe Connect, etc.)	❍	❍	❍	❍	❍	❍
Online Document/File Share (i.e. Dropbox, etc.)	❍	❍	❍	❍	❍	❍
Online Collaboration Tools (i.e. Google Docs, CAEDM, TcC, etc.)	❍	❍	❍	❍	❍	❍
Online Team Calendaring	❍	❍	❍	❍	❍	❍
Online Team Management	❍	❍	❍	❍	❍	❍

Q4.3 What factors would you use to decide which virtual tool to use when communicating or interacting with an international team member?

Q5.1 Refer to your experience on the current engineering project to answer the following questions. Indicate your level of competence in each of the following areas and briefly respond to each open-ended question if asked to do so.

Q5.1a I am able to communicate on engineering tasks with people from different cultures.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.2 Explain how your communication (speaking, talking, listening, writing) changed when you talked with international team members.

Q5.1b I am able to complete engineering tasks while working with people from different cultures.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.3 Explain how and when you reported to the team leader on your assignments and tasks. (If you are the team leader, explain how and when you received reports from team members on assignments and tasks).

Q5.1c I am able to openly discuss engineering team differences before making a team decision.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.4 Think of one team decision. Describe how the decision was reached and how team members interacted to reach the decision.

Q5.1d I am able to build and maintain a working relationship of trust with engineering team members.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.51 Describe a team situation where trust was built on your team.

Q5.52 Describe a team situation where trust was damaged on your team.

Q5.1e I am able to use different cultural approaches to engineering design.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.6 Describe how culture affected the final design and product of your team.

Q5.1f I am able to choose appropriate virtual communications tools by comparing the task with the tool's media richness (how much information is transmitted through the virtual communication tool).

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.1g I am able to establish team rules, procedures and protocols that consider cultural differences of team members.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Q5.7 Describe how your team established team rules, procedures and protocols.

Q5.1h I am able to have a non-engineering conversation (i.e. share stories, tell jokes, feel comfortable speaking and listening) with a team member from a different culture via virtual technologies.

	No Relevant Experience	Little Competence	Moderate Competence	Competent	Very Competent
Beginning of the project	❍	❍	❍	❍	❍
End of the project	❍	❍	❍	❍	❍

Appendix C

Student Interview Questions

The initial interview questions included the following statements and questions. Rounded parentheses indicate wording that was added for interviews with students on GV teams. Square brackets indicate changed wording for team leads.

1. How was your experience on this current (GV) team in terms of the team interactions, technology use to facilitate team interactions and the (cultural) diversity of the group?
2. How did you & your team choose technologies to communicate with each other?
3. How often did you communicate & interact with team members (international & local)?
4. (Did you alter your communication, speaking, talking, writing, listening, with international team members? If yes, how?)
5. Did your team experience any communication challenges? If so, what? How did you overcome those challenges?
6. Which (international) team members did you visit with the most about non-engineering interests? What were the broad topics?
7. Did your team often use humor? If so, please provide an example.
8. How did your team establish team: a) duties, b) leadership, c) rules, d) procedures, and e) meetings?
9. Which team members were the most influential on team interactions? How did they influence the team interactions?
10. How accessible were your (international) team members?
11. How did you report [receive reports of] team progress on tasks and assignments?
12. Did your team experience differences of opinion or conflict?

13. Walk me through one of those differences and how you resolved it.
14. To which (international) team member were you likely to turn to in order to discuss a new or innovative idea? Briefly describe one of these situations?
15. Did you gain engineering insights from your team members? If yes, describe one.
16. Do you trust your (international) team members? Please give examples why.
17. Do you trust your (international) team members?
18. What events from your team experience helped/hindered you to trust your (international) team members?
19. How much did you look forward to communicating and interacting with (international) team members?
20. How confident were you that your (international) team members would help you?
21. Is there any other aspect of your team experience that I have not asked about that you want to comment on?

Secondary questions and statements such as, “Would you please elaborate further”, “Can you please be more specific about . . .”, or “Can you please tell me more about who was involved” were used to gain greater detail and description of the story told by the interviewee. Relevant information from the copied emails was also used, where appropriate, in asking students to discuss or elaborate situations discussed in the interview.

Appendix D

Potential Validity Threats

Several potential threats to the validity of the conclusions of the quasi-experimental design were addressed.

1. A pretest-posttest model has the potential for a reactive effect due to pretesting where participants remember and are influenced by their original responses. However, several factors helped to mitigate this effect in this study. First, there was an interval of three months between the start and end of teamwork so no memory recall effect was anticipated for the administration of the surveys. Second, all students were also taking a full load of classes over this period. This course load required focused efforts by each student including the rigorous efforts for and requirements of the engineering design course. Third, once submitted, responses to the pretest were not available to students and students were not given any feedback regarding the adequacy or correctness of their pretest responses. For these reasons any reactive effect from the TE pretest was considered minimal. Since the IC pretest and posttest merely reported initiated contacts no reactive effect was anticipated.
2. Instrumentation differences were minimal. Procedures were identical for each group for each survey administration. The TE pretest and posttest used identical questions with the exception that the posttest had open-ended responses allowing for student comments and several demographic questions in the pretest were eliminated on the posttest. All students provided their team initiated communication contacts for the same week using the same virtual communication tools and submitted the report at the same time. Identical reminders, to encourage students to copy emails to the researcher, were sent to all students. The initial interview questions were identical for all students unless clarifications were needed or

related experiences needed to be explored and further clarified. Any variations only occurred when individual students were asked to clarify or explain answers either during the interview or as part of a follow-up interview for specific students. In two interviews, questions were simplified and texted to international students to aid in their understanding of the questions. As these procedures only added understanding to the student's response, the addition of texting the question to the student was considered to be more helpful than problematic. Little or no instrumentation effect was expected.

3. Attrition effects were negligible because of the high value associated with the engineering design course and the team organization occurring after the add/drop deadline. Students were highly motivated to remain in the engineering design course. Although no students formally withdrew from the course, one BYU student was absent for two weeks due to illness, one UBC student caused conflict on his team by refusing to work on the engineering design course project, and the three UIA students stopped communicating with their BYU team members. While these made things more difficult on the engineering teams, they replicated similar circumstances on real life teams and were not deemed as critical enough to affect results.
4. Low statistical power was anticipated since there were 20 students in the nPGVT group and 20 students in the Co-located group. Although no student formally withdrew from the study, not all students in each of these groups responded to all surveys in spite of efforts made to encourage participation by the researcher and local professors. On the TE posttest the majority of the non-responses came from UBC students in the Co-located group. It is believed this may have affected the analysis of data as only half of the Co-located group's participants completed the posttest.

Efforts to encourage response included the researcher introducing him to as many local and international students as possible and explaining the research to the students in a one-on-one basis. He attended all classes and labs to make periodic requests for compliance, and solicited the help of local and international professors to encourage student response to the surveys. Results may not be generalizable to other engineering schools at other universities, but should offer key insights to the functioning of GV teams.

5. Trustworthiness issues with regards to the qualitative data were mitigated because of the three data sources used. This allowed for triangulation of data and student responses. As mentioned earlier, inter-rater agreement and the use of an arbitrator rater was used to establish trustworthiness of the qualitative data and analyses.
6. Reliability issues of placement of communication incidents within each category were mitigated by the raters categorizing and placing communication incidents separately. Comparison of communication incident categorization between the two raters and the consensus process used when categorization of communication incidents differed, served to increase the reliability as indicated by the increased common categorization of the raters. Clear understandings of each general category also aided in the reliability of identification and categorization.

For the identification of vernacular phrases a system of three raters was used. Two raters initially identified the phrases. Where there was disagreement on the identification of vernacular phrases between the initial two raters, the third rater arbitrated the phrase. This system was used because the identification was conducted post-hoc and raters did not have the advantage of weekly discussions to help identify vernacular phrases.

7. Periodic checks of the qualitative procedures were conducted by a qualified outside source to verify that outlined procedures were followed. For example, the outside source listened to a sample of interviews to ensure that the questions used were the same for each student and any divergence was part of the prescribe protocols for interviews or provided greater clarity or insights into the communication process on GV teams.

Appendix E

Limitations

Although efforts were made to reduce limitations and effects of biases in this study several biases persisted or were beyond the scope or ability of this research. First, although response rates for TE pretest and posttests were high (90% and 76% respectively), most of the non-responses on the posttest came from the Co-located group's members attending UBC. Efforts to encourage participation in the posttest through email and local professor encouragement, was not sufficient to get students to complete the posttest survey. As a result a full post project understanding of Co-located groups was not available. This lower rate of response by the Co-located group on the posttest may have influenced analyses.

Second, language limited the type and kind of response participants were able to make on data collection instruments. While all participants of the research had varying degrees of English language competence and most team interactions were conducted in English, it would have been helpful to have both the PGVT lessons and survey materials translated into the native language of the participants. However, this was beyond the financial and time abilities of this research.

Third, selection of team membership was not uniform. While students at BYU were placed on teams based on specific criteria (language ability, technology, and engineering experience), students at UBC were allowed to self-select team members. Self-selection allowed UBC teams to select familiar team members.

Fourth, although emails were used extensively in previous iterations of the course by both GV and Co-located teams, only one Co-located team used emails to any great degree. Even the GV teams switched from using emails to using virtual communication technologies that provided for immediate contact such as Skype. The lack of a common platform to automatically collect

all emails or other communications between team members (as a group and individually) limited the scope of the communication pattern descriptions. Communication with team members may differ in significant ways when students use more immediate, synchronous tools.

Finally, the efforts to collect data coupled with the demanding course requirements may have influenced the degree to which students completed information. Students frequently commented on the lack of time and rigorous demands to complete tasks in the engineering design course. Adding research tasks to the course requirements may have lessened the efforts by some to complete surveys accurately. Completion of self-ratings may have been influenced by the Co-located group's students' lack of understanding of their true initial competence as evidenced by the correlations between the initial competence ratings at the start and finish of the project.