Summary Findings on the Use of Global Virtual Teams to Achieve Selected Global Competence Learning Outcomes for Engineering Students

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Summary Findings on the Use of GV teams to Provide Meaningful Cross-Cultural Experiences for Engineering Students

As international enterprises expand their use of global virtual (GV) teams, educational institutions are taking steps to expand their capacity to provide students with cross-cultural experiences via GV teams. However, questions remain regarding the efficacy of GV teams to provide meaningful cross-cultural experiences similar to those on study abroad (SA) programs. Furthermore, questions arise regarding which type of team communication patterns are most efficient at producing strong trust and within team interactions.

This paper presents three findings from a study involving engineering students on SA and GV teams. First, evidence is presented indicating students on GV teams report similar significant increases in cross-cultural competence as students attending SA programs. Second, two team communication patterns were identified within GV team communications. Advantages and disadvantages of each pattern are explained. Finally, evidence is presented supporting the use of targeted lessons and activities to improve communication patterns on GV teams.

Globalization in the workplace requires that individuals from different cultural backgrounds collaborate with other cultures in a variety of settings [1]. Preparation for these collaborative opportunities occurs as students move through the rigors of engineering university courses prior to entering the workforce. Traditionally university programs focus on study abroad and cross-cultural internships to provide students with these global experiences [2]. However, the costs in terms of money and time prevent many students from participating in study abroad activities. In an effort to provide a cost-effective, meaningful, cross-cultural experience that models the real world trends, many universities are turning to global virtual (GV) teams [3, 4].

However, in using GV teams, students develop a modified set of interaction skills as virtual communication tools filter out key information during team contacts [5]. In addition students from different cultures have unique cultural understandings of the common language used by the GV team [6, 7]. Students interacting with other cultures need to be prepared to understand and deal with the cultural differences and virtual communication filters.

While study abroad (SA) programs have the distinct advantage of meeting and interacting on a face-to-face basis, GV teams do not have such a luxury. Instead team members need to find ways to virtually interact with their fellow team members. Adapting their behavior facilitates the social contact and cultural understanding of team members from a different culture [8, 9, 10]. Doing so allows trusting relationships to form and improves the collaboration and end product of the team.

To facilitate embedding GV teams into regular engineering classrooms, the Fulton College of Engineering and Technology at Brigham Young University (BYU) undertook a three-year study seeking to embed global virtual teams into advanced engineering courses. The three-year research helped to develop policies, materials, and practices that facilitate a cross-cultural, educational experience for students involved on GV teams.

This research had three distinct phases that provided greater understanding and insights into the use of GV teams in traditional classrooms. The first phase incorporated GV teams into an advanced engineering design course and capstone programs using international partner universities. The second phase included the development of educational materials to further facilitate the use of GV teams. This included a comprehensive list of global competencies [11], the creation of a cultural disposition index [12] to evaluate student's disposition towards working on cross-cultural projects, and a set of 10 lessons to help engineering students function better on GV teams (please see http://pgvt.groups.et.byu.net). The final phase of the study sought to compare the educational experience of GV teams with that of traditional study abroad programs. Experiences from each phase enabled greater understanding and refinement of implementing GV teams in traditional courses. This paper focuses on the findings from the final stage as researchers implemented understanding gained from the first two phases.

Participants

Participants in the final phase of the research included 71 engineering students participating in an advanced engineering design course. Half of the students attended BYU with the remainder attending universities in Mexico, Brazil, Canada, Korea, Taiwan, and China. The course, conducted in the Fall semester of 2011 at BYU, was broadcast (synchronously and asynchronously) to partner universities.

Also included in this final phase were 93 BYU students who participated in BYU study abroad programs primarily in Asia, Central America, and South America. Study abroad programs generally had course work in the Winter term with the travel in the Spring and Summer terms of 2012. Programs varied in length, time commitment prior to leaving, and intensity of interaction with indigenous peoples, but all involved engineering activities and some level of interaction with local cultures to complete assigned tasks.

All students participating in either program were in their second, third, or fourth year of engineering studies. Specific engineering programs were primarily mechanical, civil, and environmental engineering. In all programs students were primarily male and in their early to mid 20s.

Study Design

All students were administered a pretest and posttest survey designed to assess their experience with their respective program and changes from the beginning to end of the program. Pretests were administered within the first two weeks of the advanced engineering design course and in the first week of each study abroad program. Posttests were administered three weeks prior to the end of advanced engineering design course. Students in the study abroad program responded to the posttest on the final day of or in the week following the completion of their program. Where feasible, team leaders and designated students on the GV teams were also interviewed regarding their experience.

Eight key indices were used to determine change within each group from the beginning to the end of the program. The degree of change within each group was determined using the Bowker test of internal change. The Bowker test examines all possible 2 X 2 squares (including collapsed and uncollapsed categories) for significant change from the pretest to the posttest scores [13, 14]. The key indices included:

1. I am able to communicate on engineering tasks with people from different cultures.
2. I am able to complete engineering tasks while working with people from different cultures.
3. I am able to openly discuss engineering team differences before making a team decision.
4. I am able to build and maintain a working relationship of trust with engineering team members.
5. I am able to use different approaches to engineering design used by other cultures.
6. I am able to choose appropriate virtual communication tools by comparing the task with the media richness of the tool.
7. I am able to establish team rules, procedures, and protocols that consider cultural differences of team members.
8. I am able to 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.

Second, change patterns in the GV teams' use of virtual communication tools from the pretest to the posttest were also examined using the Bowker test of internal change. Virtual communication tools included email, personal, and group video calls, computer screen sharing,

on-line team calendaring, phone calls, text messaging via cell phones, instant messaging, on-line document or file sharing, on-line collaboration tools, and on-line team management tools.

Finally, team interviews were conducted in person or via virtual tools to examine the communication patterns and influences on GV teams. In particular, the communication patterns used by team members during weekly team meetings were examined.

Results

Three key findings supported the efficacy of using GV teams in a traditional classroom to provide a unique, cross-cultural experience. First, on key survey indices, comparison of student self-reported GV team competence with study abroad competence, saw positive shifts supporting the use of GV teams in instruction. Second, GV students were able to adjust their use of virtual communication tools to fit their team needs and personal preferences. Finally, two team communication patterns emerged in the weekly team meetings.

Students in both the GV teams and the SA groups reported a significant increase on each of the eight key indices (see Table 1). Students in both groups reported significant increases in their ability to perform on each key indicator from the start of their educational experience to the end. It is important to note that the change for the students in the advanced engineering design occurred over a semester of study and collaboration. The change for the SA students occurred over the few weeks of their educational experience.

Second, GV student reports of virtual communication tool use indicated a significant decline in use of six of the 11 tools used during the advanced design course (see Table 2.) Students also reported a non-significant trend increasing use for two tools with the remaining tool use virtual unchanged or split evenly between increased and decreased use.

Subsequent interviews with team members indicated two reasons for the corresponding increases and decreases. The first reason focused on utility. If a more efficient and effective tool was found to facilitate the team interaction, this tool was adopted and the other tool abandoned. The second reason focused on team task. If a student's responsibility or assigned task changed as the project progressed, one tool used by team members would be traded for another because of the nature of the task. For example, in the early part of the project students spent time communicating with one another to get to know each other's personality and abilities. However, as the project proceeded, this emphasis shifted to the team tasks of modeling, assembling parts, and preparing final presentations. Each task required different types of team interactions and communications. As a result there was a corresponding change in the type of tool used by team members.

Finally, interviews with team leaders and members revealed two types of communication patterns on GV teams. The first pattern indicated a network where each team member freely exchanged ideas, questions, and comments with fellow team members (see Figure 1). It formed largely because of students' common language abilities. The common language used by team members allowed students to spend time getting to know one another and to visit about non-engineering activities. It became a strong model for building trust and sharing information among team members.

The second pattern resulted when all team members did not have strong common language abilities or viewed the task as a business transaction (see Figure 2). Students did not take the time to visit with one another or get to know one another. Team communications,

especially during team meetings, had the sub-team leaders exchange ideas and information across local team boundaries before communication with other local team members. All interactions were filtered through the team leaders. While this pattern was effective, it did not produce the strong trusting relationships built on friendship found in teams using the first pattern. Instead students reported their trust being built solely on team members' ability to complete assigned tasks on time.

Table 1.
Summary of Study Abroad and Global Virtual groups' change from initial to end rating.

Question	Group	Percent Unchanged	Percent Increased	Bowker Test Statistic	df	p
1	SA	50	40	17.33	7	.015
	GV	18	80	32.00	6	< .002
2	SA	50	40	16.57	8	.035
	GV	25	63	24.50	8	.002
3	SA	55	26	19.00	6	.004
	GV	38	63	25.00	7	.001
4	SA	45	52	23.00	4	< .001
	GV	43	55	20.00	6	.003
5	SA	32	68	31.00	8	< .001
	GV	45	55	22.00	8	.005
6	SA	67	31	14.00	5	.016
	GV	15	85	34.00	8	< .001
7	SA	66	34	14.00	5	.016
	GV	23	78	31.00	9	< .001
8	SA	51	49	19.00	5	.004
	GV	43	57	21.00	7	.004

SA = study abroad. GV = Global Virtual

Table 2

Summary of GV group within group change from initial to end rating for each virtual communication tool.

Question	Percent Decreased	Percent Unchanged	Percent Increased	Bowker Test Statistic	df	p
Email	70	30	0	19.00	3	**> .001**
Personal Video Call	34	44	23	2.78	2	.249
Group Video Call	15	71	15	1.20	2	.753
Computer Screen Share	19	40	41	5.59	2	.061
Online Team Calendaring	41	59	0	11.00	2	**.004**
Phone Calls	82	15	4	21.00	3	**> .001**
Text Messaging via Cell Phones	74	26	0	20.00	3	**> .001**
Instant Messaging	59	33	8	11.33	3	**.010**
Online Document or File Share	4	67	29	6.33	3	.096
Online Collaboration Tools	34	56	11	10.00	3	**.019**
Online Team Management	30	63	8	3.67	2	.160

Boldface indicates significant results.

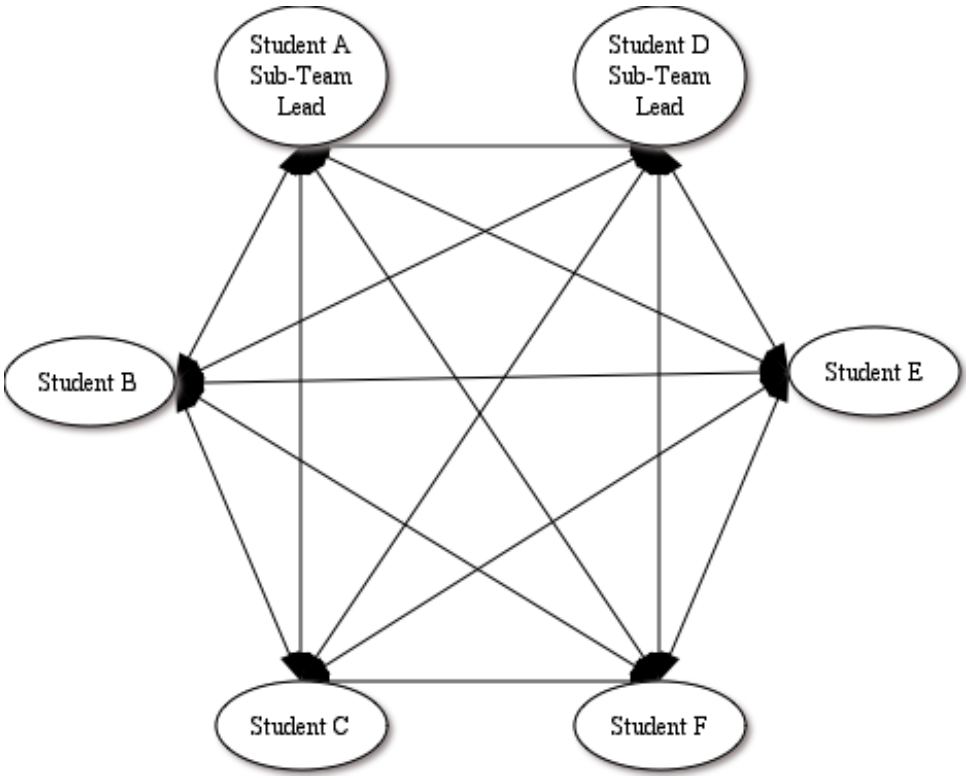

Figure 1. Social network of interconnected communication.

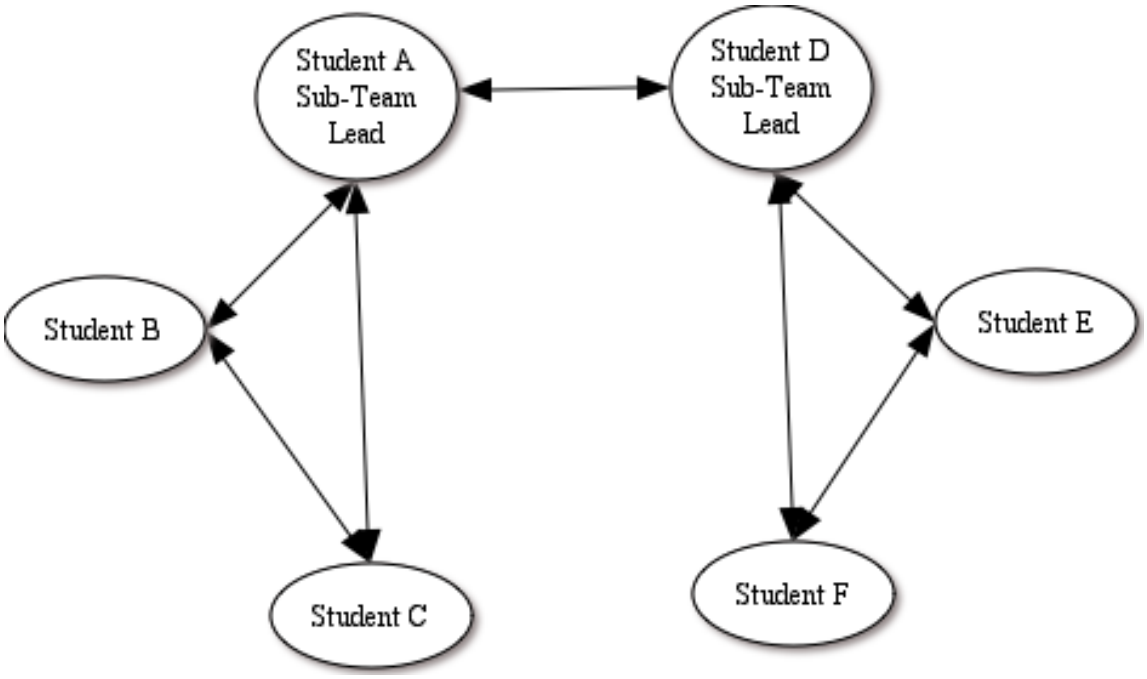

Figure 2. Social network of leader led communication.

Conclusion

Each part of this final stage of the study resulted in valuable findings for using GV teams embedded in classrooms. First, done properly, GV teams can provide students with a real-life opportunity to experience working with a different culture. The GV teams are, and will remain, inferior to the SA experience because of student immersion into the culture during the SA experience. However the GV experience does provide a time and cost effective means for students to experience a cross-cultural collaboration.

Second, when using GV teams, students should be well versed in the use of a wide variety of virtual communication tools. If they are not familiar with these tools students should be provided instruction on when and how to use the tools. This repertoire of tools enables the students to choose the most effective tool for the project task. A wide variety of tools augments communication and understanding among team members.

Third, while both team communication patterns provided effective results, the interconnected pattern allowed for stronger trust building and team sharing. This pattern depended on the strength of students' common language skills and their willingness to spend time visiting with each other about non-project activities. As teams strengthened their common language abilities and took the time to get to know one another, stronger communication and interaction occurred within the team. This effort resulted in better collaboration and a stronger end product.

Future Research

It would be informative to broaden the key indicators used for comparison of GV and SA groups. This would provide a clearer picture of what SA programs do best and where GV programs could be used effectively. Second, it would also be of interest to determine how long the positive interactions remained with the students. Does the short, but intense, SA interaction have a longer effect on students' willingness to work with other cultures, or does the more drawn out process of the GV teams produce a longer-term impact on students' willingness to work with other cultures? Third, it may be useful to examine how GV practices be integrated into SA programs to produce a stronger, more effective learning and interaction experience for participants. Finally, it would be important to identify methods whereby students can strengthen their common language and virtual interactions during the GV experience. For example, would participation in common language instruction facilitate the students' cultural interactions? If so, what methods would work best for students participating on GV teams?

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References

[1] G.P. Ferraro, "The cultural dimensions of international business", Pearson Prentice Hall, Upper Saddle River, 2006.

[2] M. Grudzinski-Hall, H. W. Stewart-Gambino, K. L. Jellison, & R. N. Weisman, "Engineering students in a global world: Lehigh university's global citizenship program", *Online Journal for Global Engineering Education*, *2*(1), 1-8, 2007.
[3] D. Starke-Meyerring & D. "Andrews, Building a Shared Virtual Learning Culture: An International Classroom Partnership", *Business Communication Quarterly*, *69*(1), 25-49, 2006.
[4] L. Hasler-Waters & W. Napier, "Building and Supporting Student Team Collaboration in the Virtual Classroom", *Quarterly Review of Distance Education*, *3*(3), 345-352, 2002.
[5] T. U. Daim, A. Ha, S. Reutiman, B. Hughes, U. Pathak, W. Bynum, & A. Bhatla, "Exploring the communication breakdown in global virtual teams", *International Journal of Project Management*. Elsevier Ltd and IPMA, 2011. doi:10.1016/j.ijproman.2011.06.004.
[6] N. Zakaria, A. Amelinckx, & D. Wilemon, "Working Together Apart? Building a Knowledge-Sharing Culture for Global Virtual Teams". *Creativity and Innovation Management*, *13*(1), 15-29, 2004. doi:10.1111/j.1467-8691.2004.00290.x
[7] L. Hasler-Waters, & W. Napier, "Building and Supporting Student Team Collaboration in the Virtual Classroom", *Quarterly Review of Distance Education*, *3*(3), 345-352, 2002.
[8] B. Abedin, F. Daneshgar, & J. D'Ambra, "Enhancing non-task sociability of asynchronous CSCL environments", *Computers & Education*, *57*(4), 2535-2547, 2011. Elsevier Ltd. doi:10.1016/j.compedu.2011.06.002
[9] M. Boule, "Best Practices for Working in a Virtual Team Environment", *Context*, *44*(1), 28-31, 2008.
[10] H. Cho, G. Gay, B. Davidson, & A. Ingraffea, "Social networks, communication styles, and learning performance in a CSCL community", *Computers & Education*, *49*(2), 309-329, 2007. doi:10.1016/j.compedu.2005.07.003.
[11] A. Ball, H. Zaugg, R. Davies, I. Tateishi, A. Parkinson, C. G. Jensen, & S. Magleby, "Identification and validation of a set of global competencies for engineering students", *International Journal for Engineering Education*, 28(1), 1-13, 2011.
[12] R. Davies, H. Zaugg, and I. Tateishi, "The Design and Development of a Cross-Cultural Disposition Inventory", *Journal of Engineering Education*, in review.
[13] SAS/STAT User's Guide, The FREQ procedure, Tests and Measures of Agreement retrieved from http://v8doc.sas.com/sashtml/stat/chap28/sect26.htm on 6 April 2013.
[14] A. Krampe and S. Kuhnt, "Bowker's Test for Symmetry and Modifications Within the Algebraic Framework", *Computational Statistics & Data Analysis*, 51(9), 4124-4142, 2007.