# AC 2010-410: DEVELOPING GLOBAL COMPETENCE THROUGH CROSS-CULTURAL VIRTUAL TEAMS: PRELIMINARY OBSERVATIONS

**Alan Parkinson, Brigham Young University**

**C. Greg Jensen, Brigham Young University**

**Holt Zaugg, Brigham Young University**

**Spencer Magleby, Brigham Young University**

# Developing Global Competence through Cross-Cultural Virtual Teams: Preliminary Observations


## Abstract

A number of credible voices within the engineering community have expressed the need for engineering graduates to develop global competence. Many colleges of engineering have addressed this need by developing various technical study abroad programs. Typically these programs are resource intensive and only reach a fraction of students. However, it may be possible to develop some attributes of global competence without travel through cross-cultural, virtual design experiences which take place via video conferencing and internet-based collaboration and engineering software tools. This paper presents some of the issues associated with this approach. Preliminary observations are made about the effectiveness of an advanced CAD modeling course which involved virtual teams.


## Introduction

The NSF summit on the globalization of engineering education called on educators to "integrate global education into the engineering curriculum to impact all students, recognizing global competency as one of the highest priorities for all graduates."[1] The development of global competence for all (or even most) engineering graduates is a very challenging task. First, as discussed by Parkinson et al.,[2] the term "global competence" encompasses a broad range of attributes and skills. Second, a scalable blueprint is needed to guide the modification of engineering curriculum so that it combines engineering fundamentals and practice with global competence development. This second challenge may well be the greatest considering the constraints of a typically overloaded engineering program. Traditional approaches to developing global competence, such as faculty-supervised study abroad programs, while potentially effective are resource intensive as course sizes are necessarily small and faculty must be away from their normal duties. Thus scaling up or expanding these programs for more students is typically difficult due to the corresponding scaling of scarce faculty resources. Alternative approaches should be examined as a complement to traditional programs.

One alternative approach is cross-cultural, virtual design teams. These types of teams are usually defined as being geographically dispersed, spanning several different countries or cultures, being composed of team members with little prior association or common background, and communicating through electronic means. In the experiences we report here, the teams are composed of senior level engineering students from various universities who must complete a design project. Team members communicate using various software and hardware tools such as email, audio and video conferencing, shared design documents, and CAD design models.

For the past three years, faculty at Brigham Young University (BYU) have coordinated the efforts of student teams across the globe, including teams in Canada, China, India, Korea, Sweden, Germany, Brazil, Mexico and Australia, in a large scale design-and-build project. Building on those efforts, we recently initiated a National Science Foundation sponsored research program to develop and assess the effectiveness of global collaborative design experiences in developing attributes of global competence.

We believe the virtual teaming approach has the following potential advantages:

- The proposed format—virtual international design teams—scales relatively well. Students already take design courses. Faculty already teach such courses. Students would not be required to travel, although some may wish to travel at the beginning or end of the project. We are interested to learn if this format might be an efficient way to teach global skills.
- The process is similar to the process being adopted by industry. As tools for collaboration become more sophisticated, companies are conducting design and manufacturing process planning via Internet-based web tools. The authors recently experienced this first hand. At visits to Hewlett Packard and Cisco systems in Bangalore, India, both companies were using their own high end conference systems to conduct design meetings with teams in the U.S.
- It can potentially address some important elements of global competence. The specific attributes we wish to develop are having students gain proficiency working in or directing a team of ethnic and cultural diversity, and understanding how cultural differences affect how engineering tasks are performed. Global virtual teams, by their nature, involve activities which force students to address these issues.

Certainly this approach also has its challenges. Besides the regular challenges faced by a design team, virtual teams have the added challenges of bringing together a culturally diverse set of people who are not co-located and may not know each other. A virtual team must overcome the limitations of electronic communication. Developing individual commitment and trust among team members and establishing role definition may be more difficult in a virtual team.[3] Students will not have the rich, immersive experience associated with being physically present in another culture, as in study abroad programs. Each type of program to develop global competence has its own strengths and weaknesses. We view cross-cultural virtual teams as a complement to other kinds of programs.

**Sample Programs Using Virtual Teams**

This section reviews some of the on-going efforts to develop curriculum using virtual teaming approaches. However, we are quite certain that there is a lot of activity that we do not yet know about or that has not been reported in the literature. We are in the process of developing a more complete picture of what is going on relative to virtual teams in engineering education.

Syracuse and Cornell Universities are using a custom collaborative environment called “AIDE” (Advanced Interactive Discovery Environment for Engineering Education) to evaluate virtual design teams for engineering design education. They have found that with proper training and the right collaborative tools, some elements of virtual teams are better than face-to-face meetings. In particular, they indicate that for scheduling, brainstorming, document creation, confirmations, task assignments and distribution of outcomes, “computer mediated collaboration” is judged by participants to be superior to regular face-to-face meetings.[4]

Rice University has implemented a course, called “iDesign,” which involves pairing student teams from Houston, Paris, Tokyo and Abu Dhabi on projects involving oil well inspection and monitoring equipment.[5] The course was sponsored by Schlumberger Oil Services. At each location a faculty member and a Schlumberger liaison engineer advised the student teams. Students collaborated using audio and video conferencing, shared documents and CAD files. All students participated together in one lecture a week; the project lasted the entire school year. At the end of the project, students gathered at Schlumberger's Middle East Learning center in Abu Dhabi to assemble their hardware and present their projects.

The students dealt with challenges associated with "working in four different time zones, negotiating cultural differences, communicating across language barriers, dealing with incompatible school calendars and delivering functional prototypes under tight time constraints."

Penn State runs an international design and entrepreneurship course involving virtual teams from Penn State and Corvinus University of Budapest.[6],[7],[8] The experience begins with a four week class in international project management and engineering design. Students review case studies and discuss the challenges associated with cross-cultural project and team management. After four weeks the student teams make contact with each other (the four week offset is because the semester in Hungary starts one month later) using both in and out of class meetings. The projects focus on finding sustainable and economically viable solutions for business opportunities in the U.S., Hungary, or developing counties such as Morocco or Afghanistan. At the end of the semester, the teams meet for one week in Hungary to present their project recommendations.

Brigham Young has been heavily involved with several different national/international design-and-build vehicle projects.[9],[10],[11] The first project was a partnership between Virginia Tech, Kettering and BYU. The students worked ten months to design, analyze and prototype an off-road vehicle (see Figure 1). The following year, thirteen universities formed a global design team that touched 130+ students from eight different countries. Their ten month partnership resulted in the virtual creation and analysis of four concept cars. The resulting ¼ scale clay models were displayed in the lobby of GM's Vehicle Engineering Center, as shown in Figure 2.

**Figure 1: Off-road vehicle design-and-build project.**


**Figure 2: Sports car design-and-build project.**

During next three years, students from twenty universities, speaking eight different languages, and spanning sixteen time zones participated in the creation, testing, and analysis of a Formula-1 racecar, as shown in Figure 3.

**Figure 3: International Formula-1 design-and-build project.**

## Virtual Team Issues

This section reviews key issues associated with the operation of cross-cultural, virtual work teams. These include issues inherent in cross-cultural communication and understanding, issues related to teams which focus specifically on product design, and issues associated with using virtual teams as a paradigm for teaching students. Papers which include discussion of many of these topics include Powell et al.[12] and Martins et al.[13]

### Team Leadership

Because of the challenges associated with both the task (i.e. product design) and the virtual format, leadership in virtual teams is critical. Jarvenpaa and Leidner, in their seminal paper on communication and trust in virtual teams, mention that the leader in the high performance student teams they studied emerged "after an individual had produced something or exhibited skills, ability, or interest critical for the role. Moreover, the leadership role was not static but rather rotated among members, depending on the task to be accomplished."[3] In other words, the leader first demonstrated competence to lead the team and established some credibility. They further mention that leaders need to insure that team members have a clear understanding of their responsibilities and should be proactive in maintaining high levels of communication. Also, in successful, high trust teams, leaders were able to remain calm during "crises" and keep the team moving forward.

Susan Bray, a consultant on virtual teams, gives some "habits of highly successful globally distributed team leaders."[14] These include modeling an intercultural mindset, creating a shared vision and alignment to common goals, facilitating agreement about roles and responsibilities, adopting effective collaboration tools, establishing communication protocols, building a sense of team spirit and community, and attracting resources for the team.

### Communication

Communication strategies are inextricably tied to communication technology. We have separated them here for the purposes of discussion. Communication strategies refer to two main concepts: matching the message to the technology, and explicitly addressing protocols and commitments for team interaction.

Effective communication is a foundation stone of any team's success and can be challenging for a regular, co-located team. On a design project of any size, hundreds if not thousands of decisions must be made and coordinated. Besides these normal challenges, virtual teams have their own set of communication issues which must be addressed. Further, one of the most effective forms of communication—face-to-face—is often not available to virtual teams.

*Strategies and Behaviors*

Jarvenpaa and Leidner identify several communication behaviors that help virtual teams build trust and work effectively.[3] Early in the team formation and task initiation it is helpful if teams engage in social communication (e.g., discussion of hobbies and families), and convey enthusiasm for the work. Later on, their research suggests successful teams have predictable and regular communication patterns and give substantial and timely responses to each other's work. Some have suggested that teams execute a communications "contract" which spells out expectations for communication, such as "Everyone will check and respond to emails within 24 hours."

*Mechanics*

Effective communication includes learning how to match both the *immediacy* and *compatibility* of the message to the communication method. Immediacy refers to the psychological closeness associated with a communication method. High immediacy occurs in a rich environment that includes words, tone of voice, facial expressions, opportunity for immediate feedback, and appropriate physical contact (e.g., a handshake). Face-to-face discussions represent an environment of high immediacy. Low immediacy implies a very limited communication environment; an example would be a memo physically circulated one-by-one to the group.

The immediacy of the message should match the immediacy of the method. For example, decisions about a crisis situation should usually be made in a high immediacy environment. Resolving conflict between team members would usually best be done in a high immediacy environment. Students need to understand the immediacy associated with common virtual team communications. Some messages are better communicated through a video link than through an email.

Compatibility refers to matching the data communication capacity of the method to the message. Engineering design often involves large data sets, particularly in the form of CAD models or analysis results. When discussing a design issue, the communication method must have the data transmission capacity to allow team members to quickly understand the data. This often implies ability to transmit graphical images (e.g. 3D models).

<u>Internal Cultural Issues</u>

Internal cultural issues refer to cultural issues that affect team operation. Bray[14] identifies six major cultural orientations team members need to master. Many of these overlap with the five contrasting cultural dimensions given by Ferraro[15] and as discussed by Hofstede.[16] We have combined information from these three sources into the five dimensions given here.

All of these dimensions are built on a foundation of high "cultural intelligence," i.e. the ability to interpret actions of team members in terms of their own culture. This foundation of cultural intelligence has to be built before these other skills can be mastered. The dimensions include understanding: 1) how communication styles are affected by culture (high context vs. low context), 2) how reckoning of time is affected by culture (precise vs. loose), 3) the hierarchical structures of a culture (formal vs. informal), 4) the group/individual orientation of a culture, and 5) the competitive/cooperative orientation of a culture.

These dimensions are obviously not always mutually exclusive but represent useful constructs for understanding cultural differences. All of these dimensions influence how team members interact with each other and how they interpret and will execute tasks.

## External Cultural Issues

Engineering teams doing product development will often also face *external* cultural issues as well as internal ones. External cultural issues refer to cultural issues that affect achieving the team objective, such as bringing a new product to market. Products developed by international product teams are often designed to be sold in international markets. The influence of culture on product design must then be understood and accounted for. One example is the automobile. A number of companies have attempted to build a "world car," i.e. a vehicle of a particular type such as a mid-size sedan that can be sold in many different world markets. However, the set of ideal vehicle characteristics which are most important to Europeans is different from the set valued by Americans or the Japanese. Design teams need to understand the impact of culture on target markets—they must understand how to approach *cross-cultural product design.*

Product design teams must also address other questions unique to this particular focus. What set of units (SI or English) should be used? What tolerance standards should be adopted? How do local drafting or modeling standards vary from one company subsidiary or country to another?

## Course Management Issues

A class using global virtual teams invokes its own set of issues. We note some of these here.

### *Semester Mismatch*

One of the greatest impediments to matching virtual student teams from around the world is semester mismatch. The beginning and ending dates for semesters can be off by weeks or even months. Along similar lines, holidays for students (which can last from a day to several weeks) also do not line up. Various solutions, none of them ideal, have been proposed. These include scheduling make-up sessions for students who begin later than others, having the project run only during the intersection of all schedules, having students enroll via independent study and continue on after their semester ends, etc. Some schools have used the "non-intersecting" time as an opportunity to cover preparatory material unique to their own students. The problem of semester mismatch is mitigated to some degree by keeping teams in the same (northern or southern) hemisphere: then, at least, summer vacations are not completely out of phase.

*Working Across Time Zones*

Although most virtual teams must accommodate various time zones, this represents a relatively new challenge for universities. Team meeting times can usually settled by compromise: students take turns getting up early or staying up late to talk to each other. Although lectures, etc. can be posted on the web, it is usually helpful in terms of building community to have some lectures attended by everyone. For this situation lecture times need to be adjusted to "spread the inconvenience" around equally. The governing principle is to try to be fair to all.

*Curriculum*

It is perhaps obvious to state but has been borne out by research that virtual teams that are trained in cultural sensitivity, communication strategies, etc. are more successful than those which aren't.[12,13] This implies new curriculum is developed and the course is modified to teach new topics associated with virtual design.

## Virtual Class Description

Since 1978 BYU has offered a suite of design courses that deal with principles and procedures of advanced computer-aided engineering applications. The intermediate course (on which we will focus here), Computer Aided Engineering Applications, is numbered as ME 471. This course teaches students how to approach real world engineering problems using the capabilities of commercial CAx tools and systems. Students use advanced parametric skeletal assembly modeling in conjunction with parametric surface and solid modeling to construct virtual conceptual models of cars, planes, watercraft, etc. Students apply topological optimization to components to determine optimal structures and cross-sections. These results are further analyzed and transformed via mass properties and finite element analyses. Ultimately the students learn to visualize their components and an assembly through photo-realistic rendering and rapid prototyping. Students are organized into teams for a project to allow them to model, analyze and prototype larger and more complex products.

Previously, the teams were formed only among BYU students, and the lectures and labs were available only to students enrolled in the course at BYU. In the fall of 2009, benefiting from our previously-developed relationships with other universities, we offered our first global Computer-Aided Engineering Applications course. This was done with cross-cultural, virtual teams. Students from the Universities of British Columbia (UBC) and Toronto in Canada, as well as students from Universidad Iberoamericana and ITESM-Toluca in Mexico, and students from University of São Paulo joined the ME 471 lectures and labs via an Internet link to our video conferencing bridge. These universities were selected based on prior relationships and also because time zone differences were manageable. During the second week of the class, teams were organized so as to promote cultural exposure. Of the eight BYU teams, four teams were kept as local teams only in order to have a control group. The remaining four teams had BYU and Canadian students; two of these teams also had Brazilian students and the other two teams had Mexican students. A typical virtual team size was 12: six BYU students, three students from Canada and three from Mexico or Brazil. To help with communication we assigned BYU students who spoke Spanish as a second language to the teams having Mexican members and the BYU students who spoke Portuguese to the Brazilian teams.

Curriculum changes that were essential to the success of this collaborative class included:

- modification of all existing lectures to remove US (English) stereotypical references, units, ethnocentric examples, etc.
- additional lectures and labs on collaborative methods and tools. These included Skype, video conferencing via the BYU bridge, Google documents, Teamcenter Community and Teamcenter Engineering (NX CAD products).
- additional lectures on ethnocentrism, communication across cultures, and cross-cultural product design.

"Discourse" changes that proved to enhance the lecture and lab sessions included:

- involving the remote schools in class discussions (although we can still do better here). For example, in discussing cultural misunderstandings, we asked the remote students to discuss some common misunderstandings regarding their culture or country. Having this happen in real time was very enlightening for the BYU students.
- having remote students take the lead in making presentations.
- weekly faculty meetings with representatives from the non-BYU schools.
- providing all lecture and lab notes in advance of the lectures.
- Video capture and posting of lectures.

All students (those in local and international teams) received the additional lectures on cultural issues.

**Preliminary Observations**

End-of-course surveys, cultural questions on the final exam, observations of team interaction and interviews with students in the local and international teams were the assessment methods used for the preliminary observations. Over 95% of the students in the international teams felt they had learned key skills in working in a global, cross-cultural team. Another encouraging finding is that the students in the international group also expressed a strong desire (85%) to work again in a similar international environment.

Students in both the local and international teams reported a greater appreciation of other cultures (local 71%, international 78%). Students in both groups reported a greater understanding of cultural influences on product design (local 90%, international 82%). Students in the international group felt that course materials and learning activities greatly improved their ability to communicate across cultures (83%). This was considerably higher than that reported by the local students (56%).

On final exam questions dealing with culture, students demonstrated some awareness of cultural solutions to international team problems. When asked about communication or language mirroring culture, for example, students provided clear examples of language interpretation/misinterpretation, appropriate methods to communicate with other cultures and communication concepts such as “saving face” when resolving disputes.

Team observations and student interviews provided specific examples of intercultural awareness in product design and team communication. As an example, a UBC student reported looking up both Canadian and US safety standards for the brake assembly for his team’s assignment. He compared and chose the higher standard to make the car acceptable in Canada and the U.S. Another student reported recognizing ethnocentric attitudes in a different engineering class. He reported using strategies from the ME 471 class to deal effectively with the issue.

Final team projects were graded by faculty, students in the class, and the virtual participation of several experts from industry (who participated in the project presentations remotely). The average project score for the international teams was 152 points as compared to 138 points for local teams. Thus the virtual teams, on the whole, did somewhat better on their final projects than the local teams.

## Concluding Remarks

In 2009 BYU sent about 100 students on engineering study abroad programs. This was accomplished at a very significant expense, both in terms of money and faculty time. In the virtual team project course described here, 24 students also had an international experience. The students in the international teams did have to put forth additional effort to complete their projects, and the faculty teaching did have to prepare and teach some new materials. The course was more complex to administer than it was previously. However, overall, the addition of virtual teams was accomplished at only an *incremental* cost relative to the regular mode of teaching the class. We estimate the virtual team students spent an additional 2-3 hours per week on the class. Faculty time is somewhat harder to judge because some of the additional time was associated with one-time activities, such as preparing new lecture material. In steady state operation, additional faculty time would be on the order of three hours per week. Thus we feel this was an efficient way to enrich the learning experience for the students.

Certainly the kinds of experiences students get from a virtual teaming experience and an in-country study abroad program are different. However, we believe this was a significant international experience for the students. Indeed, we started out with the objective of determining whether this would be a valid means of obtaining some elements of global competence which are common to other types of programs, such as learning how to communicate across cultures. Our viewpoint has started to shift to where we now feel that learning how to work in virtual teams is *itself* an important dimension of global competence.

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