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# A Comparative Evaluation of an Educational Program Designed to Enable Mechanical Engineering Students to Develop Global Competence

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ABSTRACT

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The ‘flattening of the world’, using Thomas Friedman’s phraseology, is driving corporations to increasingly use collaborative engineering processes and global teams to operate on a global scale. Globalization of the traditional university engineering curriculum is necessary to help students prepare to work in a global environment. More scalable and economically sustainable program types are needed to enable the majority of students to obtain a globalized education.

The purpose of this research was to determine how effectively a global team- and project-based computer aided engineering course provided learning opportunities that enabled students to develop elements of global competence in comparison to existing engineering study abroad programs.

To accomplish this, research was necessary to identify, aggregate, and validate a comprehensive set of global competencies for engineering students. From a review of the literature and subsequent analysis, a set of twenty-three global competencies with an associated conceptual model was developed to group the competencies by contextual topics. Two surveys were then developed and distributed separately to academic and industry professionals, each of which groups largely confirmed that it was important for engineering students to develop these global competencies.

Next, the traditional ME 471 class was restructured into a Global ME 471 course. A pilot program was conducted from which lessons learned were incorporated into the global course. Selected global competencies were included as new learning outcomes. Course learning materials, labs, and lectures were also updated to reflect the new course emphasis. A survey was developed to be sent to BYU engineering study abroad students and the Global ME 471 course during 2010. A statistical analysis of responses was used to identify significant differences between the response groups.

In addition to the global competencies which were identified and validated, global collaborative project-based courses such as Global ME 471 were shown to be effective in enabling students to learn and develop selected global competencies. Study abroad programs and the Global ME 471 course were seen both to be complementary in their emphasis and supportive of global engineering. In addition, global collaborative project-based courses were shown to play an important part of a globalized engineering curriculum.

Keywords: Aaron Ball, global competence, global competencies, cross-cultural competence, cross cultural competencies, engineering education, global engineering education, ME 471, engineering study abroad, global virtual team, multicultural team, intercultural competence

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# 1 INTRODUCTION

Globalization has forever impacted the way that engineering and business is conducted. The number of multinational enterprises operating in global markets has exploded over the past decade. Increasing application of work sourcing practices such as offshoring, outsourcing, insourcing, and supply chaining continue to redefine the working environment of engineering professionals. In light of these increasing changes in the engineering profession, engineering education is being adapted to better prepare graduates to be successful in this new global work environment.

This chapter provides an introduction to the research conducted, described, and reported in this work. First, a discussion on the problem that exists and that is addressed by this research will be presented. Second, the objective of this study will be explained. Next, the delimitations, or defining limits and boundaries of this research will be described. Finally, several definitions will be provided for terms frequently used throughout this work.

## 1.1 Problem Statement

The 'flattening of the world', using Thomas Friedman's phraseology, is an ongoing process that was initiated by the convergence of political and technological factors. It is a process that continues to reshape and redefine the world as we know it (Friedman 2005). Cultures, societies, and economies alike are becoming more integrated through this process of globalization (Anderson 1982; Grudzinski-Hall et al. 2007; Lohmann, Rollins, and Hoey 2006;

Parkinson 2009; Parkinson, Harb, and S. Magleby 2009). Recognizing that this trend is likely to not only continue, but also become more pervasive in the future (Anderson 1982; S.A. Tirmizi 2008a), corporations throughout the world are increasingly using intercultural teams to meet the rising challenges and opportunities of operating on a global scale (Lohmann, Rollins, and Hoey 2006; Parkinson 2009; S.A. Tirmizi 2008a). Similarly on the academic front, scholars have followed these trends, and have recognized the need to globalize the traditional university educational curriculum (Anderson 1982; Borri, Guberti, and Melsa 2007; Hunter, White, and Godbey 2006; Downey et al. 2006).

Erik Bohemia suggested in his article in the 2008 Design Management Journal that "it is timely that design [and engineering] educators begin developing curricula that introduces future engineers and industrial designers to elements of designing in a global context" (Bohemia and Harman 2008). Evidence supporting Bohemia's claim that students need to be prepared to design products for a global environment are provided by Ray Almgren, the vice president of product marketing and academic relations at National Instruments:

> "The products [engineering graduates] design will probably be co-designed with someone in another region of the world, and then very likely be produced at yet another location. Today's engineers must be technically competent and skilled at working on and managing teams of engineers with diverse cultural backgrounds" (Almgren 2008).

Individual academic scholars and industrial leaders are not alone in noting the need for globalizing the engineering educational curriculum. The National Academy of Engineering stated in "Educating the Engineer of 2020: Adapting Engineering Education to the New Century":

> "[The] practice of engineering needs to change further . . . because of the changed professional environment in which engineers need to operate. That change must be encouraged and facilitated by change in engineering education" (National Academy Of Engineering 2005,37:; P.D. Galloway 2007).

The Academy further described the need for these educational changes by describing the altered environment in which engineers are currently, and in which they will find themselves operating in the future:

> "Many advanced engineering designs are accomplished using virtual global teams—highly integrated engineering teams comprised of researchers located around the world. These teams often function across multiple time zones, multiple cultures, and sometimes multiple languages" (National Academy Of Engineering 2005; Zappe, Litzinger, and Hien Nguyen 2010).

From the sample of statements shared above, the call for mechanical engineering departments to upgrade their curriculums to better prepare students to operate in a global environment is loud and clear. Although many universities are beginning to heed this warning and implement educational reform, there yet remains limited student participation in programs designed to provide global experience and training. In the Report of the National Summit Meeting on the Globalization of Engineering Education that was held in 2008, the statement is made:

> "Though the profession has reached general agreement that students must be prepared to work internationally, and though many engineering programs are now sending students abroad, the Institute for International Education reports that fewer than 3% of all engineering students are actually going abroad for educational experiences during their undergraduate years" (Grandin and Hirleman 2009).

The challenge of student participation in international programs is also noted by Dr. Gary Downey, professor of Science and Technology Studies at Virginia Tech, who suggested that alternative approaches that enable students to develop global competence should be developed:

> "To date, the most significant challenge to the methods of international enrollment, international project, international work placement, and international field trip is to increase their sheer scale of participation. . . . Given limited participation in these experiences, it makes sense to seek ways of expanding integrated class experiences, both to provide substitute experiences for those students who cannot afford or who are not inclined to undertake international travel, and to further enhance the learning of those who do travel" (Downey et al. 2006).

The need to develop alternative approaches to international programs is shared by Sarah Zappe, Research Associate and Director of Assessment and Instructional Support for the Leonhard Center for the Enhancement of Engineering Education at Pennsylvania State University:

> "Many universities and colleges offer international travel-based experiences, such as study-abroad, international co-ops or internships, and international humanitarian projects. However, most universities and colleges cannot require all undergraduates to participate, given the high cost and difficulty with scalability. International experiences that do not require travel provide an alternative that should be lower in cost and more scalable. . . . Therefore, universities need to work to develop scalable, cost-efficient alternatives for students to improve their global competence without traveling" (Zappe, Litzinger, and Hien Nguyen 2010).

The implementation of scalable and sustainable programs that allow for broader, more extensive student participation are not likely to negate the importance of more traditional international programs, such as study abroad experiences. Dr. Alan Parkinson, Dean of the Ira A. Fulton College of Engineering and Technology at Brigham Young University describes the complementary role that should exist among new and more traditional methods:

> "[A] scalable blueprint is needed to integrate the development of global competence within the existing engineering curriculum. . . . Traditional approaches to developing global competence, such as faculty-supervised study abroad programs, are often resource intensive. . . . Alternative approaches should be examined as a complement to traditional programs" (Parkinson, Jensen, and Spencer Magleby 2010).

As interest grows in developing alternative approaches that do not require students to travel, there is a need to understand the role, effectiveness, and comparative value of these programs. Offering these programs is simply not enough; there must also be evaluation and assessment. Few institutions are taking these important measurement steps as described by Dr. Darla Deardorff:

> "One meaningful outcome of internationalization efforts at postsecondary institutions is the development of [globally] competent students. Yet few universities address the

> development of [globally] competent students as an anticipated outcome of internationalization in which the concept of '[global] competence' is specifically defined. . . . Even fewer institutions have designated methods for documenting and measuring [global] competence" (D. K. Deardorff 2006).

Dr. Deardorff's claims are supported by Dr. Robert Todd, professor of mechanical engineering at Brigham Young University who suggests that additional program evaluation is needed:

> "Institutions around the country . . . have created a variety of courses and experiences aimed at developing global competence. While a few programs have been in operation for some time, many are new and just beginning to assess their effectiveness" (Todd et al. 2010).

Beyond the evaluation of the programs themselves, there needs to be a comparative evaluation of how these new alternative approaches fit with respect to their more traditional counterparts. This need is described by Dr. Zappe:

> "Although there are many articles addressing why engineering students need to be globally aware, few studies have . . . examined the effectiveness of various techniques designed to improve global competence. . . In addition, instruments are needed to measure students' global competence in order to assess the effectiveness of various international experiences" (Zappe, Litzinger, and Hien Nguyen 2010).

## 1.2 **Research Objective**

The primary objective of this study was to *determine how effectively a global team- and project-based computer aided engineering course provided learning opportunities that enabled students to develop elements of global competence in comparison to existing engineering study abroad programs.*

To support this principal objective, a set of global learning outcomes for an undergraduate mechanical engineering curriculum was identified. The process included reviewing literature that provided insight into: characteristics and challenges unique to multicultural or global teams, postulated learning objectives for global teams, global team studies and lessons learned, etc. Also, through participation in the Partners for the Advancement of Collaborative Engineering (PACE) program for over ten years, BYU had learned important lessons regarding global distributed teams. Important principles, topics, and learning objectives were identified through reviewed literature and knowledge captured through PACE.

From the collection of learning objectives, important topics, and principles resulting from this research, a set of important global competencies for an engineering curriculum was created. This set of competencies was refined by categorizing according to contextual topics. Hierarchical relationships were used to assist in identifying general and specific learning outcomes.

The set of global competencies were validated through a review conducted by working professionals in academia and industry. A survey was constructed and sent to a group of academic and industry professionals whereby the set of global competencies were reviewed and validated for comprehensiveness and appropriateness as determined by these academic and industry leaders.

Several elements of global competency were identified and added as course learning outcomes to the BYU ME 471 course, which in turn was reconstructed with added content focused on assisting students to develop the newly integrated competencies. New lectures, labs, and assignments were created as necessary. Existing lectures, labs, and assignments were reviewed and some course content was of necessity merged, condensed, or removed altogether. These changes were made through close interaction and approval of the professor teaching the course.

Finally, data was gathered from students in both the ME 471 course and in engineering study abroad programs from which a statistical analysis was conducted to comparatively evaluate the two types of approaches. To do this, another survey was created to assess the potential of different study programs in providing opportunities that enabled students to learn global competencies. Students who had participated in an engineering study abroad as well as students who had participated in the global virtual engineering team projects in ME 471 were surveyed.

## 1.3 Research Delimitations

This section establishes the defining limits, or bounds of this research. First, this study is undertaken with an emphasis in mechanical engineering education. Although there is much from this work that can be applied to other departments, or even colleges, the emphasis of the study is related to a mechanical engineering curricula. Because of this, the elements of global competency that are researched and discussed are done so through the lens of a mechanical engineer for a mechanical engineering program.

Second, the ME 471 course and five additional study abroad programs during the 2010 calendar year were identified for consideration in this study. While it is intended that the results of this study will provide inspiration and insight for educators at other universities, colleges, or departments in their efforts to improve the quality of their global programs, no attempt is made to include additional programs in this work.

## 1.4 Research Definitions

Several terms used in this work may have varied meanings for different audiences. To reduce confusion for the reader, terms repeatedly used throughout this work will be defined:

1. *global competence* – the set of knowledge, skills, and attitudes necessary to facilitate the successful interaction and communication of an individual with other persons of a

different culture. Chapter 2.1.2 provides a discussion of the variety of definitions associated with this term.

2. *global competencies, or elements of global competence* – a knowledge, skill, or attitude constitutive to global competence that can be acquired through experience, study, or training. Taken together, many global competencies provide a definition and understanding of global competence.

# 2 BACKGROUND

This chapter will provide an understanding of the most significant research that has been conducted relative to this work with the intent of providing a contextual knowledge base upon which this work can be understood. A review of the research in the following categories will be undertaken:

- Global Competence
- Elements of Global Competence
- Global Educational Engineering Programs

## 2.1 Global Competence

As defined in the Research Definitions section of this thesis (Chapter 1.4), 'global competence' is defined for use in this thesis as: the set of knowledge, skills, and attitudes necessary to facilitate the successful interaction and communication of an individual with other persons of a different culture. Although this is the definition of global competence that will be used in this work, a moderate review of the literature reveals that numerous terms and definitions related to global competence have been proposed and perpetuated. As Parkinson has noted, it is necessary to plainly define global competence in order for it to be taught, developed, and assessed (Parkinson, Harb, and S. Magleby 2009). The differing terminologies and definitions will be presented to show that the selected definition of global competence used in this thesis is in alignment (for all practical reasons) with those that have been presented in the literature.

However, no effort to amalgamate or demonstrate consensus among the terminologies or definitions will be undertaken.

In this section, several items will be discussed. First, other terms used in the literature that correspond to the definition of global competence used in this thesis will be considered. Second, other definitions of global competence will be related. Finally, the need for global competence among engineering students will be addressed.

### 2.1.1 Other Terms Used for Global Competence

The ability to work in a global environment has been described using many terms in the literature. More than six terms referring to the concept of global competence were used by college administrators as revealed by Deardorff in her study that sought to understand how intercultural competence was understood and incorporated in global educational programs at various colleges. Some of these include: intercultural competence, cross-cultural competence, global competence, and global citizenship (D. K. Deardorff 2006; DK Deardorff 2004).

In addition to Deardorff's use of the term intercultural competence, Jansen and Pudlowski as well as Fantini used the same term when describing the need and ways to educate and prepare engineers to operate globally (Jansen and Pudlowski 2009; Fantini 2000). Matveev and Milter discussed the importance of intercultural competence in multicultural team performance (Matveev and Milter 2004).

Cultural intelligence and cross-cultural competence are terms found in Tirmizi and Halverson's book "Effective Multicultural Teams: Theory and Practice", as well as in an article written by Del Vitto describing cross-cultural training materials that can be used in training engineering students to become global engineers (Halverson and S. Aqeel Tirmizi 2008,3:; Del

Vitto 2008). Richardson and Blackwell also use cross-cultural competence when describing their international educational team collaboration project (Richardson and Blackwell 2010).

Grudzinski-Hall et al. use global awareness to describe the formation and workings of the Global Citizenship program at Lehigh University (Grudzinski-Hall et al. 2007). Harb et al. also used this term in describing the implementation of a college-wide initiative to globalize an engineering curriculum (Harb et al. 2007). Parkinson et al. also noted that global awareness is a term used synonymously with other terms mentioned in this section (Parkinson, Harb, and S. Magleby 2009).

Global citizens and global citizenship are used by Grudzinski-Hall et al. in describing the Global Citizenship Program at Lehigh University (Grudzinski-Hall et al. 2007). Hunter and others use this term when exploring the question "What does it mean to be Globally Competent?" (Hunter, White, and Godbey 2006; Hunter 2004). In a National Summit Meeting Report on the Globalization of Engineering Education, Grandin and Hirleman use the term Global Citizen to describe engineers that are prepared to operate in a global society (Grandin and Hirleman 2009).

Global competence appears frequently throughout the literature. Parkinson used the term in multiple papers in attempts to define the construct and its constitutive elements (Parkinson 2009; Parkinson, Harb, and S. Magleby 2009). Lohmann et al. also use this term while describing conceptual, curriculum, and assessment models related to global competence (Lohmann, Rollins, and Hoey 2006). Finally, Blumenthal and Grothus use this term (Blumenthal and Grothus 2008).

In summary, a sampling of recent, relevant literature has been reviewed wherein the authors have used varying terminology to describe global competence. Although subtle, and perhaps not-so-subtle theoretical differences exist among the definitions of the terminology used throughout the literature, the substance of the terms and their meanings are in line with the definition of global competence used in this work.

### 2.1.2 Definitions of Global Competence

Numerous definitions have been proposed for global competence throughout the years. Deardorff suggests that the topic has been considered for the past 30 years without agreement on the definition of the term (D. K. Deardorff 2006). Hunter also suggests that there is no consensus regarding what it means to be globally competent (Hunter, White, and Godbey 2006). This section will recount the various definitions of global competence that have been proposed in the literature. Some are general in nature, whereas others are more specific to engineering.

In a study conducted by Deardorff to establish consensus on the definition and elements of intercultural competence, several definitions received high ratings. One of the definitions for intercultural (global) competence was:

> "Knowledge of others; knowledge of self; skills to interpret and relate; skills to discover and/or to interact; valuing others' values, beliefs, and behaviors; and relativizing one's self. Linguistic competence plays a key role."

A second, highly rated definition was:

> "Five components: World knowledge, foreign language proficiency, cultural empathy, approval of foreign people and cultures, ability to practice one's profession in an international setting" (D. K. Deardorff 2006).

Hunter et al. shares a more pragmatic definition from the Swiss Consulting Group Global Competence Report that defined global competence as:

> "the capacity of an individual or a team to parachute into any country and get the job done while respecting cultural pathways" (Hunter, White, and Godbey 2006).

The Stanly Foundation, according to Hunter et al., provided a definition of global competence as:

> "an appreciation of complexity, conflict management, the inevitability of change, and the interconnectedness between and among humans and their environment. Globally competent citizens know they have an impact on the world and that the world influences them. They recognize their ability and responsibility to make choices that affect the future" (Hunter, White, and Godbey 2006).

After several days of debate among community college officials and government agency representatives during the Educating for the Global Community: A Framework for Community Colleges conference, a definition for a globally competent learner was reached that defines such a person to be one who is:

> "able to understand the interconnectedness of peoples and systems, to have a general knowledge of history and world events, to accept and cope with the existence of different cultural values and attitudes and, indeed, to celebrate the richness and benefits of this diversity" (Hunter, White, and Godbey 2006).

Grudzinski-Hall et al. recognize the extent to which there is ambiguity and wide ranging definitions for global citizenship by sharing several terms from the literature. First, from Oxfam:

> "a global citizen demonstrates an individual awareness and sense of his/her role in the world; respect and value for diversity; understanding economically, how the world works technologically, and environmentally; outrage at injustices; participation and contribution to politically, socially, culturally, the community at the local and global level; willingness to act to make the world a more sustainable place; and responsibility for taking personal action" (Grudzinski-Hall et al. 2007).

Next, a definition provided by the American Association of Colleges and Universities (AAC&U) in 1999 suggested that a global citizen is:

> "a citizen of the world experienced 'in the ways of diverse cultures' through which 'own frames of identity and belief [can be bracketed] enough to be comfortable with multiple perspectives [and] to suspend disbelief in the presence of new cultures and new ways of seeing'" (Grudzinski-Hall et al. 2007).

Finally, Grudzinski-Hall et al. recount a definition for global citizenship by the same association (AAC&U) in 2002, wherein global citizenship is defined as:

> "a sophisticated understanding of the increasingly interconnected but unequal world, still plagued by violent conflicts, economic deprivation, and brutal inequalities at home and abroad" (Grudzinski-Hall et al. 2007).

James Duderstadt, as quoted by Parkinson et al., provided an additional definition more closely related to engineering in the report "Engineering for a Changing World". Duderstadt, the former dean of engineering and president at the University of Michigan, described the need for engineering students to have 'global perspective':

> "Key is not only a deep understanding of global markets and organizations, but the capacity to work in multidisciplinary teams characterized by high cultural diversity, while exhibiting the nimbleness and mobility to address rapidly changing global challenges and opportunities" (Parkinson, Harb, and S. Magleby 2009).

Additional engineering-focused definitions of global competence are provided by Downey et al., who focus more on how engineers are 'problem solvers', and suggest that:

> "the key achievement in the often-stated goal of working effectively with different cultures is learning to work effectively with people who define problems differently than oneself" (Downey et al. 2006).

Lohmann et al. provide a definition of global competency when describing the assessment model used as a part of the Georgia Tech International Plan. Their definition emphasizes elements that are observable and measureable and lend themselves well to student assessment:

> "Basic global competence is the product of both education and experience, and it is characterized by a graduate's ability to (1) communicate in a second language via speaking, listening, reading, and writing (second language proficiency); (2) demonstrate substantively the major social–political–economic processes and systems (comparative global knowledge); (3) assimilate knowledgeably and with ease into foreign communities and work environments (intercultural assimilation); and (4) communicate with confidence and specificity the practice of his or her major in a global context (disciplinary practice in a global context)" (Lohmann, Rollins, and Hoey 2006).

In summary, a multitude of definitions of global competence have been proposed in the literature. Some definitions attempt to address global competence in a non-disciplinary way, whereas others are more specific to engineering. Some definitions are quite abstract and vague, whereas others are more precisely defined, measurable statements of knowledge or ability. This survey of definitions of global competence provides the context against which the definition of global competence used in this work can be understood. It is a working definition well-aligned in substance to the definitions of global competence found in the literature.

### 2.1.3 Need for Global Competence Among Engineers

The need to globalize the engineering education curriculum flows from an increasingly globalized world, a phenomenon described by Parkinson as being driven by four primary factors: advances in technology, geopolitical changes, economic policies which promote free trade, and the growth of multi-national corporations (Parkinson 2009). The need to globalize engineering education has also been vocalized for numerous years by a broad spectrum of industry and academic professionals. This section will provide a review of the need identified in the literature for universities to implement strategies that enable students to develop global competence. A discussion of the types of global programs being developed will be presented in Chapter 2.3.1.

The need to globalize American education was recognized as early as 1982 with a paper published by Lee Anderson. In his paper, Anderson proposed that education mirrors society and suggested that various social changes in the world would create a need to globalize the educational experience. For Anderson, the argument was not if the change would be necessary, but how soon and to what extent educational reforms would be needed (Anderson 1982).

Anderson's predictions regarding the effect of social changes on America have been substantiated by the realities of globalization. Merriam-Webster defines globalization as: "the development of an increasingly integrated global economy marked especially by free trade, free flow of capital, and the tapping of cheaper foreign labor markets" The topic, effects, and challenges of globalization have been discussed by numerous authors such as Thomas Friedman in “The World is Flat” (Friedman 2005). Related to engineering, Pisano and Shih discussed how globalization has affected American competitiveness in product design, innovation, and manufacturing, and suggest strategies that business and government need to adopt to remain competitive (Pisano and Shih 2009). The Committee on the Offshoring of Engineering established by The National Academy of Sciences further studied and reported on the facts, unknowns, and potential implications of offshoring engineering (Committee On The Offshoring Of Engineering 2008). The impacts of engineering and offshoring on engineering employment were further described by Dedrick et al. (Dedrick and Kraemer 2006,21:). Globalization’s growing influence on the engineering industry is readily recognized by scholars, government, and industry alike.

Numerous scholars have also noted that globalization is a factor driving the need to internationalize engineering education (Hill and Pena 2010; Mehta et al. 2010; Parkinson 2007; Todd et al. 2010). Borri et al. argue that the world economy and market are singular and that students need exposure to global industrial and educational experiences (Borri, Guberti, and Melsa 2007). Grudzinski-Hall et al. argue further that it is not possible for students to avoid the world outside of the United States (Grudzinski-Hall et al. 2007). Parkinson argues that global engineering challenges are a driving need in addition to globalization for engineering education reform (Parkinson 2009; Parkinson, Harb, and S. Magleby 2009). At the National Summit Meeting on the Globalization of Engineering Education, both the effects of globalization and global engineering challenges were noted as factors driving the need to globalize engineering education. Those in attendance at this meeting created and signed “The Newport Declaration” that both outlined the reasons and urgency for globalizing engineering education and called on educators, administrators, and others to support this type of reform (Grandin and Hirleman 2009).

Globalization has also affected the way that engineering work is accomplished, affecting in turn the need for engineering education to prepare students for this new work paradigm. Del Vitto suggests that students need to be taught cultural and linguistic skills to operate in international engineering environments (Del Vitto 2008). Hunter et al. suggest that students with global skills are becoming more needed by engineering companies (Hunter, White, and Godbey 2006). Bohemia et al. explain that engineering team organizations have shifted from traditional to concurrent workflows, that more companies are using virtual teams, and that suppliers are now being integrated into the design process (Bohemia and Harman 2008). Esparragoza et al. concur that concurrent engineering has become the de facto work paradigm and that international collaboration is not only a common, but also a necessary activity (Esparragoza, Mejia, and Rodriguez 2010). Numerous other scholars have noted that globalization has affected how engineering teams are organized and operate, that the use of virtual teams is increasing, and that students need to be able to work in global teams (Jansen and Pudlowski 2009; McNair, Paretti, and Kakar 2008; Halverson and S. Aqeel Tirmizi 2008,3:; Zappe, Litzinger, and Hien Nguyen 2010).

In summary, the need and urgency to globalize engineering education is legitimate. Globalization has been a hugely influential factor by affecting the operation and organization of business and engineering teamwork paradigms. Global engineering challenges are further being recognized as impetus for engineering education reform. The need for reform is recognized by many industry, government, and academic leaders, and the call for further support and recognition of this need continues to be extended.

## 2.2 **Elements of Global Competence**

Of the many definitions of global competence that have been put forth in the literature (described in the previous section), few of these definitions clearly identify what components, or elements, constitute the term. However, both elements and sets of elements describing global competence have either been proposed or identified through studies and have then been reported in the literature. Some studies have obtained academic and industry feedback in efforts to provide validation of the importance or consensus of the proposed components (Parkinson, Harb, and S. Magleby 2009; D. K. Deardorff 2006; Warnick 2010). Despite the extensive efforts found in the literature, there remains a lack of agreement on the constitutive elements of global competence (DK Deardorff 2004).

Notwithstanding the lack of agreement in the literature on what constitutes global competence, this section describes the review of the literature that was conducted to capture the breadth of the range of proposed, or otherwise identified competencies, that contribute to global competence and to organize the elements into a manageable set of global competencies. In addition, the elements of global competence and a hierarchical model defining the relationship among the competency categories are both described.

### 2.2.1 Identification and Categorization of Global Competencies

The literature describing global competencies is extensive. Some of the definitions are non-disciplinary in scope. Others are focused on identifying elements of global competence for business professionals. For this work, the primary interest was to identify global competencies pertinent to students studying engineering.

A review of the literature was conducted from which numerous global competencies were identified. Initial research of the literature examined 46 articles in 31 journals and five conference proceedings published within the past decade. Sources were picked based on their focus on international education, engineering education, or a combination of the two. Of these 46 articles, five were considered as seminal articles because of the extent to which they either examined international education in general, or investigated international engineering education in particular (D. K. Deardorff 2006; Downey et al. 2006; Hunter, White, and Godbey 2006; Lohmann, Rollins, and Hoey 2006; Parkinson, Harb, and S. Magleby 2009). The intent of this literature review was to synthesize global competencies which had been identified in previous research, yet remained fragmented throughout the literature.

Using these articles identified in the literature, key phrases (or statements) describing aspects of global competence were extracted by a team of three graduate research assistants. More than 100 descriptors of global competence (not all of which were unique) were identified and it became necessary to condense and categorize the list (This list of identified competencies with the corresponding parent article is included as Appendix A). The process for categorizing the competencies was as follows: First, similar competencies that had been mentioned by different authors using different terms were merged into one competency. Second, each researcher independently categorized the global competencies into categories and sub-categories. Next, the categorizations were reviewed among researchers and the discrepancies in terminologies were resolved. The number of categories was further reduced through an open debate and voting process until five broad categories remained.

The categorization process was completed when consensus was reached among the researchers that the list had been sufficiently condensed and defined such that the resulting categorizations were readily comprehendible, and that adequate preservation of the elements describing global competence had been maintained. The resulting categories of global competencies were re-worded so as to describe what a student would need to explain, describe, or demonstrate in order to be considered proficient in that area of global competence. The five categorical topics comprising global competence are listed below.

1. Cross-Cultural Communication
2. Cross-Cultural Dispositions
3. World Knowledge
4. Cross-Cultural Teams
5. Engineering Specific Cross-Cultural Competencies

### 2.2.2 Description of the Global Competencies

Each of the five categories that constitute global competence listed in Chapter 2.2.1 is comprised of specific knowledge, skills, and attitudes. These specific capabilities are directly related to those that were identified in the literature. Taken together, the global competencies support each of the global competency categories, respectively. A description of each of the five categories is provided by presenting the global competencies within each category, briefly describing their meanings, and providing related references to global competencies identified in the literature.

***Cross-Cultural Communication***

The student demonstrates knowledge and ability to communicate (speak, read, write, and listen) using a second language and cultural communication rules, while positively representing one's own culture, people, company etc.

1. Second Language

   *The student demonstrates the knowledge and ability to communicate (speak, read, write, and listen) using a second language.* This competency is based on competencies identified in the literature related to second language ability. Included is the ability to understand the mechanics and structure of a foreign language and the reflection of culture found in language. Further, this ability includes communicating through written and spoken forms of the second language (Lohmann, Rollins, and Hoey 2006; Parkinson, Harb, and S. Magleby 2009; Parkinson 2009; Mariasingam and Smith 2008; Eckehard Doerry, Karl Doerry, and Bero 2003; Yong Zhao 2009; Grandin 2006).

2. Cultural Communication Rules

   *The student demonstrates the knowledge and ability to appropriately apply cultural communication rules when communicating with people from different countries.* Cultural communication rules describe general guiding practices for interacting with individuals from another culture by appropriately applying cultural framework principles identified by various researchers such as Hofstede, Schwartz, Kluckhohn and Strodtbeck, House, Hall, and Trompenaars and Hampden-Turner (S.A. Tirmizi 2008b). These principles have application in both verbal and non-verbal communication. In addition, this competency addresses the ability to communicate in different social contexts through proper word choice, use of idioms and humor, manner of speech, and appropriate body language (Boehm and Aniola-jedrzejek 2006; Fruchter 2003; Jansen and Pudlowski 2009; Hofstede 2001; Kluckhohn and Strodtbeck 1976; Hampden-Turner and Trompenaars 1997).

3. Interpersonal Representation

   *The student demonstrates the ability to positively represent one's own culture, people, company, product, etc. in a foreign culture.* An individual with this ability understands that his actions affect a broad range of relationships. From making good first impressions, to long term ethical actions and positive representations of self, team, company, and country, this competency captures knowledge, skills, and attitudes related to the importance and principles of interpersonal representation (Hung and Mary Thi Thao Duyen Nguyen 2008; Keyzerman 2007; Anawati and Craig 2006; McNair, Paretti, and Kakar 2008; Cordery et al. 2009).

4. Communication Technologies

   *The student describes the availability and appropriate use of collaboration technologies in cross-cultural interactions.* Numerous technologies are available that provide synchronous and asynchronous worldwide communication possible. The multidimensional spectrum of technologies varies in the extent to which media richness is present, and the extent to which the communication is synchronous. Further, certain types of communication are better handled with a certain technology. This competency is related to using and making judgments regarding the use of collaboration technologies (Powell, Piccoli, and Ives 2004; Martins, Gilson, and Maynard 2004; McDonough III, Kahn, and Griffin 1999).

***Cross-Cultural Dispositions***

The student develops cross-cultural attitudes and beliefs (e.g. cultural appreciation, openness, and flexibility; a sense of cultural equality and global citizenship; a desire understand

and explore other cultures). The competencies listed below are quite similar, but are included separately to draw attention to the subtleties surrounding each competency.

1. Global Citizenship

   *The student demonstrates a desire to work with people from different countries to solve cross-cultural or global problems.* It is becoming more readily apparent that the difficulties faced by one nation or culture are inextricably intertwined with and impact the well-being of other global nations and cultures (Yong Zhao 2009). An individual that demonstrates global citizenship recognizes the interconnectedness of the world in which he lives. He recognizes that the challenges facing citizens of the world which do now and will yet exist can only be solved through global collaboration. Further, he demonstrates an interest in participating in efforts to address these global challenges (Hunter, White, and Godbey 2006; Parkinson 2009).

2. Global Exploration

   *The student demonstrates a desire to learn about different cultures, world events, and social issues of the world.* An individual that lacks an interest in other cultures and the greater world in which he lives has little impetus to understand or become familiar with foreign peoples, customs, and traditions. An interest in learning about foreign cultures, events, and issues is an attitudinal foundation that leads an individual to proactively seek to participate in global or intercultural exchanges. It also leads the individual to strive to ensure that these global or intercultural interactions are successful and positive experiences (Lohmann, Rollins, and Hoey 2006).

3. Cultural Equality

   *The student views all cultures without prejudice, stereotypes, and discrimination, and interacts with people from any culture as equals in social status (i.e. without ethnocentrism).* An attitude of cultural equality enables individuals to see beyond and withhold judgment about the most notable differences that exist between peoples of different culture. This capability enables individuals to become acquainted with and understand one another on a personal level—a level of understanding and familiarity that comprehends individual uniqueness within the culture of which the person is a member. Further, the capability provides the relational foundation upon which trust can be established and meaningful collaborations can occur (Jansen and Pudlowski 2009; Bray 2009).

4. Cultural Flexibility

   *The student tolerates and flexibly deals with cultural differences.* It is highly unlikely that individuals can find agreement upon all cultural differences, but rather it is almost certain that there will be elements that differ among cultures about which there is disagreement. It is in these situations that it is necessary for those involved to be tolerant and flexible such that differences in culture can be negotiated or addressed in both a civil and emotionally restrained manner. The knowledge related to this ability and its application is included in this competency (Bray 2009; Matveev and Milter 2004).

5. Cultural Appreciation

   *The student appreciates and respects cultural differences (e.g., language, social rules, political systems, arts, music, etc.).* There are always differences that can be found among cultures. These differences may be manifest in language, politics, music, the arts, etc. Different from cultural flexibility, one who demonstrates this capability *recognizes the advantage* that differences of perspective provide in solving problems and in collaborating as a team. Showing appreciation and respect for cultural differences builds a culture that facilitates global collaboration (Bray 2009; Parkinson, Harb, and S. Magleby 2009).

6. Cultural Openness

   *The student evaluates cultural differences from a perspective different from one's own cultural norms and takes advantage of the differences when appropriate.* Different from cultural appreciation, this competency addresses the attitude and ability to compare and evaluate cultures. A person with this capability recognizes that elements of his own culture have been influenced and likely adopted from those of another culture. In order to demonstrate cultural openness, not only must ethnocentric tendencies must be overcome, but also a *willingness to learn about and personally adopt* elements of another culture must be developed. This disposition leads an individual to not only interact well with those of another culture, but enables him to recognize that much can be learned from those of another culture and causes him to seek to learn from and adopt advantageous cultural practices (Bray 2009; Downey et al. 2006).

***World Knowledge***

The student demonstrates an understanding of the world in terms of values, geography, religion, language, culture, political and economic systems, including current and historical world events.

1. General Knowledge

   *The student demonstrates a general understanding of global history, events, public policy, politics, world organizations, geography, dominant religions, etc.* One demonstrating this competency not only has a general understanding of global facts, but understands the need to be aware of and knowledgeable about global topics and trends. An individual with this competency will recognize the influence that historical and current events, policies, organizations, etc have and will have on him personally and his surrounding society (Parkinson, Harb, and S. Magleby 2009; Anderson 1982; Hunter, White, and Godbey 2006).

2. World Cultures

   *The student identifies, compares, and contrasts beliefs, values, perspectives, practices, and products of his own culture with that of others.* Beyond general global knowledge and an understanding of its local impact, an individual with this capability also recognizes the differences and similarities among world cultures. A person with this ability further can make predictions about the behavior and preferences of an individual based upon that person's culture. Although such an individual can make reasonable predictions, he understands that cultural level factors do not supplant personal preferences, and expects to refine his understanding of another's person according to their individual behavior, experiences, and preferences (Del Vitto 2008; Bray 2009).

3. Global Interrelations

   *The student understands concepts of sustainability and globalization.* Related to the competency described by Global Citizenship, this competency emphasizes the topic of sustainability in a globalized world. Individuals with this ability recognize the interconnectedness of the world and its local, personal, and professional implications. They further understand that this trend will continue to influence the societies in which they live. As members of a global, inter-related community, persons with this ability understand sustainability in a global context and seek to appropriately apply principles of sustainability (Anderson 1982; Parkinson, Harb, and S. Magleby 2009; Patricia D Galloway 2007).

***Cross-Cultural Teams***

The student demonstrates the ability to work in an international team toward a common goal using strategies that encompass the team's cultural diversity.

1. Team Leadership

   *The student demonstrates the leadership skills needed to guide an ethnically and culturally diverse team toward a common goal.* An individual with this attribute has developed the skills to guide the completion of a project by a team composed of members from different nations or cultures. Such a person can build a cohesive team with a common understanding of leadership and team roles, vision, purpose, and goals. In addition, an individual with this capacity understands how cultural background influences the perception of the proper role, responsibilities, and style of team leadership. (Sheppard, Dominick, and Zronson 2004; Parkinson, Harb, and S. Magleby 2009).

2. Team Processes

   *The student understands the influence of culture on structuring team processes, developing team objectives, establishing team rules, building trust among team members, and establishing work values and practices.* An understanding of the way in which teams operate, make decisions, approach tasks, etc., is one of the abilities encapsulated by this competency. An individual that has developed this ability will also recognize that way in which people from different cultures approach and understand work can differ and that these differences need to be understood, particularly in an interdependent team environment. Also, an individual with this capability will both recognize the influence of culture on other team principles such as the development and understanding of objectives, rules, and trust, and also work to adopt adaptations to these principles that meet the needs of the team (Jarvenpaa and Leidner 1999; D. K. Deardorff 2006; Powell, Piccoli, and Ives 2004).

3. Conflict Resolution

   *The student identifies team conflicts arising from ethnic differences and implements culturally sensitive strategies to resolve these conflicts.* As noted by Halverson, a team progresses through several stages in its lifetime, including a 'storming' stage where conflict is high (Halverson and S. Aqeel Tirmizi 2008,3:). Resolving conflict among team members is important for any team. However, this competency is focused on resolving conflicts resulting primarily from cultural or ethnic differences. An individual with this ability understands and anticipates potential sources of conflict. As those differences are manifested and conflict occurs, he can act tactfully to resolve team member differences and enable the team to improve its working relationship (D. K. Deardorff 2006; Shuman, Besterfield-Sacre, and McGourty 2005; Halverson and S. Aqeel Tirmizi 2008,3:; Sheppard, Dominick, and Zronson 2004).

4. Cross-Cultural Team Experience

   *The student demonstrates the ability to collaborate effectively with cross-cultural team members to accomplish a common goal.* The literature suggests that one of the best ways to develop global team collaboration skills is through actual experience working in a global team environment. An individual demonstrates this ability through participation in a real collaborative project that involves persons from another culture and country. He demonstrates the ability to recognize and manage global team dynamics in an environment where his teammates may or may not be physically present (Jansen and Pudlowski 2009; Ball et al. 2007; Gonzalez 2008).

***Engineering Specific Cross-Cultural Outcomes***

The student demonstrates an understanding of the influence of culture on the engineering profession, engineering practices, product design, and cross-cultural engineering collaboration.

1. Cross-cultural Engineering Attitudes

   *The student appreciates, respects, and values the engineering contributions of another culture.* As an engineering specific manifestation of the more generalized form of the Cross-cultural Appreciation competency, an individual that has developed this ability is appreciative and respectful of the engineering work performed by of those of another culture. He values the insight that can be provided by global colleagues in an engineering environment (Downey et al. 2006).

2. Cross-cultural Engineering Interaction

   *The student demonstrates the ability to successfully interact with engineers (or engineering students) from another culture.* Representing an engineering specific manifestation akin to the Cross-cultural Team Experience competency, individuals that have demonstrated this ability can successfully communicate about technical engineering topics and documents. The individual with this ability understands how to use PLM tools to collaborate regarding engineering product design and development processes. In addition, such an individual has learned how to operate and successfully manage and complete a project in a global, distributed team environment (Grandin 2006; Gonzalez 2008; Sheppard, Dominick, and Zronson 2004).

3. Cultural Engineering Skills and Practices

   *The student understands how engineering skills and practices differ among the cultures of the world.* An individual that has developed this capability will understand that although engineering principles—principles based in the natural sciences—should not vary from culture to culture, engineering processes, skills, and practices may have wide variation throughout the world. An individual with this ability will understand that the problem solving approach and the way in which engineering tasks are defined and carried out are subject to cultural values. In addition, the standards used and the ethical practices followed may vary greatly according to national or cultural influences (Okudan et al. 2008; Downey et al. 2006).

4. Global Engineering Occupations

   *The student understands the cultural and business context surrounding occupations in global engineering.* Included in this competency is an understanding of the role of engineering work, and the cultural, or social, status of engineering professionals among different cultures. An individual that has developed this competency has an understanding of general principles of global business, collaborative engineering, and global intellectual property issues. Also, this individual will understand how globalization is influencing the engineering profession for different nations and cultures (Harvey and Griffith 2007; Pisano and Shih 2009; Wyndrum 2008; Hoppe 2006).

5. Culture-Centered Product Design

   *The student demonstrates an understanding of how culture influences product design.* An individual that has developed this capability understands that some products are more culturally sensitive than others, and can identify examples of products that are both culturally insensitive and culturally sensitive.  For culturally sensitive products, he also understands the extent to which culture can influence the evaluation and eventual adoption of a product or service.  In addition, an individual that has developed this competency has an understanding of the process for developing a globalized product and localizing it for regional or local markets (Moalosi, Popovic, and Hickling-Hudson 2008; Bohemia and Harman 2008; Chavan et al. 2009).

### 2.2.3 Hierarchical Global Competence Model

During the categorization process described in Chapter 2.2.1, a framework for describing and understanding the global competencies was identified.  The model provides insight into how each of the global competencies is contextually related.  In addition, the model provides insight into how competencies in a traditional engineering program and global competencies can be integrated together.  As this model is beneficial to understanding global competence, the model is described in this section.  Competencies encapsulated in the twelve learning outcomes for the BS in mechanical engineering degree at BYU, included as Table 2-1, will be referenced in this discussion to demonstrate the relationship among global competencies and traditional engineering program competencies.

**Table 2-1:** BYU BS in Mechanical Engineering learning outcomes

1. A basic understanding of fundamental physical phenomena and governing principles.
2. The ability to develop and solve mathematical models of fundamental physical phenomena and apply them to predict the behavior of engineering systems.
3. The ability to use engineering principles to design an innovative system, component, or process that meets human needs.
4. The expertise to plan and conduct an experimental program and evaluate the results.
5. The ability to use modern engineering tools and techniques in engineering practice.
6. An understanding of manufacturing processes and planning.
7. Effective oral and written communication skills.
8. The ability to work with and lead others to accomplish goals.
9. An appreciation of history, philosophy, literature, science, and the fine arts and how they influence the culture and behavior of societies.
10. Personal behavior demonstrating and practicing high moral and ethical standards.
11. The ability to practice engineering in a global environment.
12. A desire and commitment for lifelong learning and service.

Competencies range from general to specific. This is represented in the model (included as Figure 2-1) by three levels: general, organizational, and disciplinary (i.e. discipline specific). For example, some professional competencies are general in nature. Communicating respectfully and clearly often influences the effectiveness of an individual's personal relationships (Learning outcome 7 in Table 2-1. See also learning outcomes 9, 10, and 12). Other competencies are situated within a specific organizational setting. Knowing the best ways to both work on a team and to communicate with clients and colleagues are important (Learning outcome 8 in Table 2-1). Still other competencies are discipline specific. In a mechanical engineering setting, communicating engineering design details, performing analyses, and solving problems are each essential engineering specific competencies (Learning outcomes 1 through 6, and 11 in Table 2-1). However, introducing elements of cultural diversity can alter the nature of the competencies needed to be successful at each level.

Several of the competencies needed by students preparing to work in a globalized mechanical engineering environment will be either influenced or driven by culture. As noted in Figure 2-1, these competencies appear in the region described as 'Cultural Interaction' and have a presence in all levels. The model is constructed in this manner to indicate that certain competencies are unaffected by culture. For example, an understanding of physical phenomena and governing principles in mechanical engineering (Learning outcome 1 in Table 2-1) is exclusive of cultural effects. However, communication skills, or working with others to accomplish goals (Learning outcomes 7 and 8 in Table 2-1) can easily be influenced by culture.

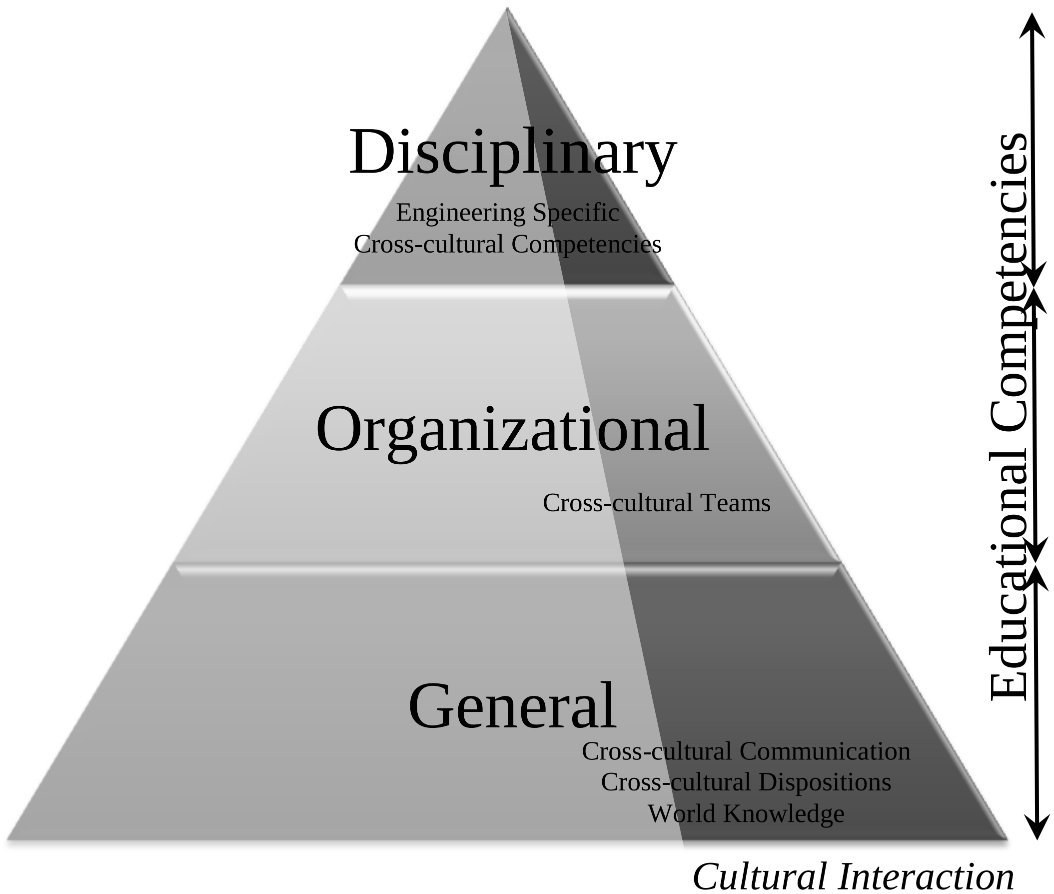


**Figure 2-1:** Hierarchical model describing both the breadth of global competencies from general to specific levels and the interaction of competencies with culture.

Several caveats that provide greater information about the model should be noted. First, there is nothing sacrosanct about the levels that were used to represent the specificity of competencies in this model. Other names, or more or fewer levels, might be just as appropriate. Second, the levels do not represent clearly defined boundaries. Rather, it is likely that more of a gradation exists moving from a completely general level to a highly disciplinary specific level.

In addition, it should be noted that competencies in more general categories may have more specific manifestations in more specialized levels. For example, the ability to communicate (Learning outcome 7 in Table 2-1) could be described and assessed on multiple levels: general or conversational, professional, and technical.

The set of identified global competencies are predominantly found within the region labeled ‘cultural interaction’, and are further described by this model in the following way: Global competencies found in the Cross-Cultural Communication, Cross-Cultural Dispositions, and World Knowledge categories generally represent general level competencies. However, more specific manifestations of those competencies can be found within the higher levels of the model. The competencies within the Cross-Cultural Teams category more appropriately fit in the organizational level. Lastly, the Engineering Specific Cross-Cultural Competencies, as apparent through the title, fit most appropriately in the disciplinary level of the model. The model provides an appropriate way to categorize and understand the relationships among the various global competencies.

In summary, the model described in this section was developed during the categorization of the global competencies that was undertaken as a part of this work. The model provides a way to describe competencies for any variety of programs, but was described through the example of a mechanical engineering program. Global competencies can be understood in relation one to another in addition to being understood in relation to more traditional educational competencies through the use of this model.

## 2.3 Global Educational Engineering Programs

Many universities have recognized the need to provide students with opportunities to gain international and intercultural experience. These institutions have participated and collaborated in the development of programs to support these educational goals. Although there now exists a multitude of different global educational engineering programs, few if any two programs are exactly alike.

In this section, a review of the various types of global educational engineering programs will be provided, including a brief description of programs corresponding to each program type. Because the objective of this work is to comparatively evaluate study abroad programs and global team project experiences in their effectiveness at enabling students to learn and develop elements of global competence, a brief review of the different study abroad programs and the BYU ME 471 class (global team project) that were evaluated in this research is also included in this section.

### 2.3.1 Review of Common Program Types

Numerous programs are currently being operated across the country and throughout the world to promote international and intercultural education among engineering students (Borri, Guberti, and Melsa 2007; Grandin and Hirleman 2009; Parkinson 2007). Some programs have been operating for a decade or longer, whereas others are more recent. These programs are offered in a variety of types. Each program type has advantages and disadvantages over other programs (Parkinson 2007). This section will provide a brief description of a representative sample of the types of programs that have been developed throughout the world and several of the tradeoffs involved among programs.

In a report of the National Summit Meeting on the Globalization of Engineering Education held in 2008, a discussion of the general types of educational programs provided for engineering colleges was held (Grandin and Hirleman 2009). Eight program types were suggested, and are included as Table 2-2. In this table, the type of program is indicated. In addition, several universities that offer programs that correlate to each type of program are provided. Other program types have been suggested, but since the objective of this section is to provide a representative overview of program types, a discussion based on this categorization will suffice.

**Table 2-2:** Sample of program types and universities offering those types of programs*

| Program Type | Universities Offering Program Type |
|---|---|
| Double Major or Dual Degree Programs | Pennsylvania State University, Iowa State University, and University of Rhode Island |
| Minors or Certificates | Georgia Tech, Iowa State University, Purdue University, University of Illinois, University of Michigan, University of Pittsburgh |
| International Internships, International Co-Op | Georgia Tech, MIT, University of Rhode Island, University of Cincinnati |
| International Projects | Worcester Polytechnic Institute |
| Study Abroad and Academic Exchange | University of Minnesota, Rensselaer, Global E3 |
| Collaborative Research Projects and Global Teaming with Partners Abroad | Purdue University, Harvey Mudd |
| Service Learning Projects Abroad | University of South Florida, Worcester Polytechnic University, University of Dayton, Duke University |
| Graduate-Level International Programs, including research experiences abroad, research collaborations with colleagues abroad, dual and joint degree programs with partner universities abroad | University of Rhode Island Dual Degree Master's and Doctoral Programs, NSF PIRE and IREE projects |

* Table adapted from list in (Grandin and Hirleman 2009)

### *Double Major or Dual Degree Programs*

Dual Major or Dual Degree Programs refer to programs in which the students complete coursework sufficient to satisfy the requirements for two separate programs that have been offered jointly. Programs of this type are significant in their duration, extending over the course of several semesters in the student's college career. Beyond regular coursework, other international experiences may be included, such as a mandatory study abroad experience. The two awarded degrees are often conferred by different colleges and are intended to strategically complement one another (i.e. A student may obtain a B.A. degree in German and a B.S. degree in Mechanical Engineering upon completion of the program) (Lohmann, Rollins, and Hoey 2006). The University of Rhode Island provides an excellent example of this type of program. Students admitted to this five-year program work towards a BA/BS combination degree in engineering and one of several foreign language programs. A semester length study abroad experience is required as part of this program. In addition, an internship lasting at least six months in a country that speaks the language corresponding to the language of study is also required (Grandin 2006).

***Minors and Certificates***

This program type is similar to, but generally less intensive than the dual major or dual degree programs. Programs of this type require students to take second language courses as well as some type of international coursework. In addition, students are required to complete either a study abroad or internship in another country (Lohmann, Rollins, and Hoey 2006). The University of Pittsburgh has established such a program where students arrange a customized set of courses including foreign language and area studies for a particular region. Students are also required to take at least a couple of classes from an allied department to support the interdisciplinary experience. A 'capstone' research project based on a global topic must also be completed to complete the certificate program (Brustein 2007).

### *International Internships and Co-Ops*

Programs of this type provide students with opportunities to work and live in a foreign country. International Internships and Co-ops can vary greatly in experience, and format depending upon the company and environment in which the student is involved. These types of programs may or may not be integrated with other curricular activities that emphasize global competence. Iowa State University has partnered with John Deere and the Fachhochshule Manheim in Germany in an arrangement whereby US students attend classes and experience an internship at John Deere in Germany and vice versa for students from Germany (Borri, Guberti, and Melsa 2007).

### *International Projects*

Generally of a short duration in comparison to the programs previously mentioned, international projects provide students with the opportunity to spend a limited amount of time in a foreign country working on a project. Often times these projects are for a local company or market. Students may experience cultural immersion to various degrees depending upon the experience provided. In addition, students may have the opportunity to work with international engineering students or professional engineers. Worcester Polytechnic Institute provides a program of this type in which students spend about two months with relatively high cultural immersion working on a project wherein they design a product to meet the needs of a localized problem (Lohmann, Rollins, and Hoey 2006).

### *Study Abroad and Academic Exchange*

Study abroad and academic exchange programs provide students with opportunities to learn and study in a foreign environment. These program types can vary greatly. Some programs may involve immersion in classrooms where the material is taught in a different language. Other programs may have courses taught by local faculty in the students' native language, but take place in the host country. Some experiences may be quite short, lasting of only a few weeks, whereas others may have a semester or year long duration. Examples of study abroad programs are described in greater detail in Chapter 2.3.3 where the BYU study abroad programs that were evaluated in this study are discussed.

***Collaborative Research Projects and Global Teaming with Partners Abroad***

Although it is recognized that collaborative research projects and global teaming with partners abroad may be very different activities requiring unique collaborative techniques, they are grouped here to remain consistent with the categorization scheme used in the literature (see Table 2-2). In general, programs of this type take advantage of communication technologies to enable students or teams of students to participate in research or other teaming projects with students at other universities. These programs can be small, consisting of only a few students at a couple of universities, to large-scale projects coordinated through multiple universities. Through collaborative research and global teaming projects, students have the opportunity to interact with students of another nation and culture. Depending on the program, students may or may not have the opportunity to meet face to face with their colleagues at other participating universities. Examples of this type of program include Partners for the Advancement of Collaborative Engineering (PACE) sponsored projects and programs and the ME 471 course taught at BYU, which will be further discussed in Chapter 2.3.4.

***Service Learning Projects Abroad***

Service learning projects are similar to international projects in that they provide students with the opportunity to work on a project where the end result yields a product or process that has a humanitarian benefit to a community in another nation. These projects vary in length, may include project work at the home institution, and may include collaboration with students or professionals from the host or target country. Programs of this type generally enable students to briefly visit the community that will benefit from the project, and experience short cultural interaction. As part of the Global Citizenship Program at Lehigh University, students participate in a roughly two week trip that takes place between semesters where students visit a foreign country and engage in service projects, cultural exchanges, and other extracurricular learning (Grudzinski-Hall et al. 2007).

***Graduate-Level International Programs***

Programs of this type may resemble many of the previous programs described except that they are offered to graduate level students instead of undergraduate students. Because these programs cater to graduate students, they are generally of a smaller scale and are designed to provide more individualized experiences. The University of Rhode Island, for example, offers dual masters degree and dual doctoral degree programs wherein students complete coursework from both the University of Rhode Island as well as from the Technical University of Braunschweig, and complete thesis work internationally (Grandin 2006).

### 2.3.2 Challenges for Global Educational Programs

Although numerous programs of various types are being offered in increasing numbers, there remain significant obstacles for engineering programs seeking to help students develop global competence, particularly through international programs. In the Report of the National Summit Meeting on the Globalization of Engineering Education, Dr. Janet Ellzey summarized challenges that are commonly faced by engineering programs when attempting to integrate global programs into engineering colleges and departments. She identified sixteen challenges to providing students with international experiences (Grandin and Hirleman 2009):

1. *Curricular rigidity* – The engineering curriculum is very full and lock-step, allowing little opportunity for students to experiment with things such as language learning, culture study or semesters abroad. In-depth experiences abroad often imply extra time for degree completion.
2. *Lack of tradition* – Study abroad has always been considered the prerogative of students in the humanities. Even though engineers are far more likely to have to work abroad or work together with colleagues from other nations, there has been no tradition of sending engineers to study or work abroad. This leaves a void of experience among engineering faculty and administrators, at a time when we now find it critically important to prepare engineering students for eventual work in the global sphere.
3. *Lack of support from study abroad professionals* – Study abroad or campus international offices are not engineering oriented and are seldom prepared to help engineering students who want to study or work abroad.
4. *Lack of support for cross-disciplinary activities* – Even though there is considerable expertise across any given campus to support international study, such as in language departments, there is little encouragement or incentive for faculty to cross the disciplinary divides in order to work together.
5. *Lack of support by departments, colleges of engineering or faculty* – Engineering programs often do not have advisors who are knowledgeable about study abroad opportunities and who are willing to commit the time to compare courses and determine credit.
6. *American monolingualism* – Americans, as native speakers of English, have always felt that language learning is for others. This means that Americans do relatively little serious language learning at any educational level and are thus restricted to experiences abroad where work can be done in English. This limits the extent of the cross-cultural experience.
7. *Academic rewards system* – Building successful international programs for engineering students is labor intensive and requires substantial time commitments from faculty and administrators. Since faculty are promoted and tenured by traditional teaching, publication, grantsmanship, etc. and not by sending students abroad, there is little incentive for faculty to work in this area.
8. *University financial restrictions* – Building program opportunities for engineering students abroad is labor intensive and expensive. In a time when many universities feel squeezed financially, such programs often fall from the priority list.
9. *Student financial restrictions* – Programs abroad are often arranged for summer when students need to work for precious tuition dollars. Students often do not understand the costs of the various programs. Semester programs may be less expensive on a per-week-abroad basis than summer programs but still might require a larger total financial commitment.
10. *Difficulty in transferring credit* – Credit systems vary around the world. In the U.S., credit is generally based on the number of contact hours. In many European countries,

this is not the case and defining an "equivalent" is difficult. Also, ABET needs to be part of this process to ensure that we are not risking our accreditation.

11. *Negative perception of study abroad* – Study abroad experiences are not uniformly regarded as worthwhile by either parents or recruiters. While some view study abroad as an important learning experience, others view it as a vacation.
12. *Disconnect in the corporate world between CEO and HR* – While CEO's often speak of the importance of global education, the message often does not reach the human resource departments. The message does not reach the recruiters who interact with students and do the hiring.
13. *Private vs. university-based programs* – Study abroad is now a big business and many private companies organize international educational experiences. Many of these enterprises are reputable but there is no well- established means of evaluating them.
14. *Lack of emphasis on total immersion for a significant length of time* – Evidence collected by IIE indicates that study abroad experiences are becoming shorter and sometimes have little cultural immersion. Students often seem to gravitate to these programs to "check a box" on their resumes. Universities also tend to boast about total number of students who have gone abroad and not student-months abroad.
15. *Difficulty in recruiting* – Students do not necessarily value the experience abroad or are hesitant about taking the risk. They also sometimes sign up for a program but do not end up going, thus creating administrative hassles in the agreements with partner institutions.
16. *Lack of cultural preparation* – Engineering students are often ill-prepared to accept the norms of another culture. Their educational experience is generally lacking in world history, art, and comparative politics thus often setting them up for a difficult transition.

### 2.3.3 Engineering Study Abroad Programs at BYU

As noted in Chapter 1.2, the main purpose of this study was to comparatively evaluate the extent to which study abroad programs provide opportunities for engineering students to develop elements of global competence relative to those given to students that participated in the BYU ME 471 course. This section provides brief background information describing five study abroad programs offered in the Winter 2010 and Spring 2010 semesters by the Ira A. Fulton College of Engineering and Technology at BYU from which data was collected.

#### *China Globalization*

Through the China Globalization study abroad program, students spent six weeks from 5 May 2010 to 16 June 2010 at Nanjing University in Nanjing, China. The emphasis of this program was to provide students with an understanding of the impact of globalization and technology on engineering, and to help students develop the skills to participate in and manage global engineering activities. Additionally, the course strived to help students understand the influence of culture on engineering and technology, the way people work and think, and on governments and economies. Several cultural excursions were taken throughout the trip to supplement this additional course emphasis. Students received six hours of course credit for participation in this program, three via EcEn 493R Globalization, Engineering, and Technology and three credit hours in either the Chin 345R or Chin 347 language course depending on the students Chinese language ability. Although students participated in courses taught by a BYU professor at Nanjing University, the students did not participate in design teams during the program (Kennedy Center for International Studies 2009a).

***China Megastructures and Megacities***

This study abroad program is directed primarily to upper- or graduate-level civil engineering students because of the 300 level civil engineering pre-requisites required for course participation. This course took place during Spring 2010 semester from 27 April 2010 to 14 June 2010. The emphasis of the program was to provide students the opportunity to study some of the world's largest and newest, in many cases, engineering solutions to many of the problems created and faced by enormous metropolitan populations. Students could take either one or both of the 500 level Megastructures and Megacities courses. During the course, students participated in a two week excursion to China where they interacted with Chinese engineering students, engineers, and professors. Students also had the opportunity to visit several Chinese cities (i.e. Beijing, Tianjin, Shanghai, Shenzhen, Hong Kong) as well as engineered structures such as the Three Gorges Dam. Upon returning to BYU, students reported on a structure or transportation system that they had studied during the visit to China. The students worked on individual projects rather than in engineering teams in this program (Kennedy Center for International Studies 2009b).

### *Global Product Development: Europe*

The focus of this study abroad program was to help students develop an "understanding of some of the important issues involved in globalization and to acquire skills needed to manage product development in a global environment" (Kennedy Center for International Studies 2009c). The program lasted about four weeks (27 April 2010 to 25 May 2010) in which a little over two of those weeks were spent in Europe. Students participating in this program visited about 18 companies as well as numerous cultural sites in five countries in Europe and the United States. The first week was a preparatory week with instruction and activities focused on globalization and global product design topics. After returning from the excursion to Europe, students spent several days finalizing and presenting individual and group reports as well as participating in a class debriefing. Students participated in group projects, but were not involved in engineering design teams, and received three hours of engineering elective credit via ME 579 Global Product Development (Kennedy Center for International Studies 2009c).

### *Global Projects in Engineering and Technology: Peru*

In this study abroad program, students participated in coursework locally at BYU in addition to travelling to participate in student design teams in Peru. During the Fall 2009 semester, students enrolled in a two credit hour engineering course with content focused on the design and engineering aspects of the course projects. The projects for the 2009-2010 year program dealt with "energy, water, and sanitation for implementation in two Peruvian villages" (Kennedy Center for International Studies 2009d). During the Winter 2010 semester, students enrolled in a one credit hour seminar course that prepared the "students for the trip to Peru through cultural, socio-economic, and logistics presentations" (Kennedy Center for International Studies 2009d). The students were organized into engineering design teams to work on the humanitarian-based projects, and travelled to Peru for several weeks during May 2010 (Kennedy Center for International Studies 2009d).

***International Product Development and Design: Singapore***

By working in co-located design teams composed of students from BYU, Penn State University (PSU), and the National University of Singapore (NUS), this study abroad program enabled students learn the basics of product design and development in a culturally diverse environment. The program is limited to sophomore through senior undergraduate engineering students. Students received three hours of engineering elective credit via ME 495R Fundamentals of International Product Development. This course included preparation sessions during the final weeks of the Winter 2010 semester in addition to several meeting times following the end of the semester and prior to traveling to Singapore, Singapore, where the students met and worked with their design teams for two weeks from 17 May 2010 to 5 June 2010. In addition to working on the global team projects, students also visited companies located in Singapore that design and/or manufacture various products (Kennedy Center for International Studies 2009e).

### 2.3.4 International Collaborative Project Team Program at BYU

The Computer Aided Engineering Applications course (ME 471) at BYU was modified to provide students with the opportunity to develop elements of global competence. Data collected from the students that participated in this course would be compared to the data obtained by students participating in the study abroad courses described in Chapter 2.3.3. In this section, the traditional ME 471 class is briefly described followed by an overview of what general changes would be made to the course to provide students with opportunities to develop global competencies.

### *Traditional ME 471 Class*

ME 471 is an advanced course in computer aided engineering applications that has been taught at BYU for 30 years. The emphasis of the course has always been to instruct the student on how to solve real world problems using available CAx tools; however, the specific tools and procedures that are taught are updated to be current with available, state of the art CAx technologies. In Fall 2008, principles taught related to concepts of: topology optimization, surface and advanced solid modeling techniques, parametric modeling approaches, assembly animation and kinematic analysis, manufacturing model preparation, and team based engineering.

The structure of the course is designed to provide students with ample opportunity to learn CAx tools and concepts through instruction and practice. The course consists of class and lab components: the classroom component facilitates instruction of the theoretical and mathematical basis of CAx tools, whereas lab activities emphasize learning advanced practical CAx skills. Student assessment is based on homework assignments, quizzes, lab assignments, design reviews and final project presentations, and midterm and final exams.

Students in ME 471 are organized into teams to work on a 16 week design project. The design projects require significant student effort, necessitating complete team member participation. Design projects are also chosen such that they require students to apply advanced CAx principles that have been taught in the course. To best facilitate student application of these skills on the design projects, topics in ME 471 are sequenced to be taught throughout the semester when the teams will most benefit from the instruction.

Students are provided with multiple sources of learning materials to help them master ME 471 course content. An English language text that emphasizes CAx theory and mathematics is required from which reading assignments are given and homework problems are assigned. Laboratory materials are provided to assist students in learning advanced practical CAx skills. The course professor is available to provide assistance to students outside of class, and a teaching assistant (usually a graduate student) is also available to meet with students to mentor them on course topics.

***Globalized ME 471 Class***

International programs of the 'Collaborative Research Projects and Global Teaming with Partners Abroad' category type—such as the ME 471 course—while not considered a sole solution to improving student participation in international programs, are scalable programs that can provide students with international and intercultural experiences. Collaborative global teaming projects are less costly for the college, and generally are less costly for students as well. They still, however, require significant faculty oversight and involvement. Also, more students can be accommodated through this method than through many of the other program types. Because of the recognized advantage, it was hypothesized that the students could develop certain elements of global competence through a course of this type.

The intent of the transformation of the traditional ME 471 to the global ME 471 course was to retain as much of the scope of the traditional course as possible while integrating instruction and opportunities that would support the learning and development of global competencies through a 'Global Teaming' program type. Additional course content in the form of lectures, reading materials, assignments, and labs would be introduced. Partnerships would be formed with other universities throughout the United States, and throughout the world that would provide students with an opportunity to participate in global team projects with the BYU students. Through working together in a global team, and by receiving instruction focused on topics pertinent to selected elements of global competence, students would be provided with opportunities to develop certain global competencies.

# 3 RESEARCH METHOD

This chapter details the methodology that was employed while conducting this research. As noted in Chapter 1.2, the primary purpose of this study was to evaluate the effectiveness of the learning opportunities provided in the ME 471 course to enable students to develop elements of global competence in comparison to those that were afforded by existing engineering study abroad programs at BYU. To address this purpose, three research phases were executed and are described in the following three sections. The first section describes the process of validating the global competencies that were identified and described in Chapter 2.2. Next, the process of integrating selected global learning outcomes for the ME 471 class will be discussed. Finally, the process of comparatively evaluating the ME 471 class to selected study abroad programs at BYU will be detailed.

## 3.1 Validation of the Set of Global Competencies

The lack of a widely agreed upon comprehensive set of competencies that constitute global competence in the literature led the researchers to obtain expert evaluation of the identified competencies so as to provide validating evidence of their importance and comprehensive scope. To validate the set of global competencies resulting from the literature review and categorization process (described in Chapter 2.2), two electronic surveys—one for each response group—were developed and administered to academic and industry professionals.

The two surveys were very similar, with primary differences resulting from different demographics questions. This section describes the two validation studies that were performed.

### 3.1.1 Academic Evaluation of Global Competencies

The first survey was developed for administration to a group of academic professionals who participate in the Partners for the Advancement of Collaborative Engineering Education (PACE) program. PACE is an industry sponsored organization that promotes the student development of engineering product lifecycle management (PLM) skills learned through a global collaborative environment (Anon.). BYU is one of over 50 universities worldwide that has been strategically selected to participate in the PACE program, and has been involved in the program since its inception over ten years ago. Academic participants in the PACE program have been involved in past collaborative projects such as building a full-size, fully-functional formula one race car, and research and development work on an emerging market vehicle concept.

A request to distribute this survey among PACE program affiliates was provided to and approved by the PACE program manager for academic programs. Administrators, faculty, and staff members involved with the PACE program comprised the entire sample of respondents for this survey. This population of respondents is not a sample that is representative of the academic community as a whole, but represents a collection of individuals with a demonstrated interest in and experience with global collaborative engineering and design education. Several noted leaders in research related to the need for engineering students to develop global competence were also among those in the survey sample. The academic sample totaled 439 academic professionals.

Using a Likert-type response scale ranging from “Unimportant” to “Very Important”, respondents were directed to evaluate the how important each of the global competencies was when considering the global competence of a student preparing to work as an engineer in a global workforce. Respondents were asked to provide any additional competencies not identified in the survey.

The process of developing, administering, and reviewing the results from the academic validation study was composed of several steps. Each of the steps is described below:

1. *Survey Development* – The survey was developed and refined through a drafting and collaborative revising process. Question items were constructed and critically reviewed by several collaborative researchers.
2. *Electronic Instrument Design* – The survey was designed and tested using the Qualtrics online survey program (Anon.). Qualtrics is web-based service that specializes in survey design, distribution, and analysis and reporting capabilities with hundreds of corporate and academic clients.
3. *Think-Aloud Prototyping* – In person 'think alouds' were conducted with a couple of mechanical engineering professors. The intent of these sessions was to observe a representative respondent that was instructed to vocalize their thoughts as they responded to the survey items. Notes were made of the actions and thoughts of the observed individuals as well as comments that the individuals provided. Revisions to the survey were made to clarify question wording and improve the understandability of the survey.
4. *Pilot Test* – A pilot test was conducted using faulty members of the mechanical engineering department at BYU. 9 of 22 (41%) faculty completed the survey, with several faculty members providing additional comments or feedback.

5. *Survey Administration* – The survey was administered to the 439 academic professionals affiliated with the PACE program and was open from July 19, 2010 to August 9, 2010. The survey administered to the academic professionals is included in Appendix B.
6. *Survey Reminders* – To encourage additional respondents, email reminders were sent to the group of academic professionals that had not completed the survey. Two reminders were sent—one on July 26, 2010, and the second on August 2, 2010.
7. *Data Analysis* – After the survey was closed, the data was exported from Qualtrics to Microsoft Excel 2007 where it was formatted for descriptive and inferential analysis that was performed using SPSS, a statistical analysis software program provided by IBM (Anon. 2010a). Survey results are reported in Chapter 4.1.

The survey consisted of 47 questions in five sections. Respondents were prompted to provide: acknowledgement of informed consent to participate in the study, employment information, an evaluation of the set of global competencies, a self assessment of global competency, and personal global demographics. Each of the five categories is described below:

1. *Informed Consent* – This introduction page to the survey provided respondents with a description of the study, anticipated length (10 min), benefits, compensation, confidentiality, and information for contacting the researchers. Respondents were required to either select "Yes" on this page to continue with the survey, or to select "No" to exit. Survey branching logic was used to control the path of survey respondents at this point of the survey.
2. *Employment Information* – This section (Questions 1 through 6) prompted the respondent to provided information related to his or her employment type, duration of employment in academia, and involvement in education or research activities with a global emphasis.

3. *Global Competency Evaluation* –Respondents provided their evaluation of each of the 23 global competencies using a five point Likert-type scale with responses ranging from "Unimportant" to "Very Important" (Questions 7 through 29). If the respondent felt that an important competency was omitted, additional competencies could be suggested (Question 30).
4. *Personal Global Competence Evaluation* – The survey prompted respondents to rate their level of personal global competence using a five point Likert-type scale from "Poor" to "Excellent" (Question 31). Then, they provided self-evaluations for selected specific manifestations of global competence that corresponded to several competencies from Chapter 2.2.2 (Questions 32 through 41).
5. *Global Demographics* – Finally, a few remaining global demographics (Questions 42 through 47) were collected, such as country of residence and other countries in which the responded had previously visited or lived. Survey respondents who had never lived in another country were redirected past two follow-up questions using survey skip logic.

### 3.1.2 Industry Evaluation of Global Competencies

Similar to the academic survey that was described previously, a survey was developed for administration to a group of working mechanical engineering professionals. The survey was administered to industry contacts held by one of the professors involved in this research, collected over the course of his academic career. The set of industry contacts included individuals from 30 states in the USA and 10 additional countries worldwide. 106 companies were represented in the sample group, which totaled 391 individuals. The sample is not a random sample that represents workers from the mechanical engineering industry as a whole; rather, the industry contact sample represents a pilot group of individuals. Despite this, response data is helpful in understanding and characterizing the views of the mechanical engineering industry related to elements of global competence.

Using the same Likert-type response scale as in the academic survey, respondents indicated how important each of the constitutive competencies was when considering the global competence of a mechanical engineer at their company. Once again, survey respondents were instructed to provide any additional competencies not identified in the survey.

The process of developing, administering, and reviewing the results from the industry evaluation study was composed of several steps, similar to that of the academic study. Each of the steps is described below:

1. *Survey Development* – The survey was developed and refined through a drafting and collaborative revising process. Question items were constructed and critically reviewed by several collaborative researchers.
2. *Electronic Instrument Design* – The survey was designed and tested using the Qualtrics online survey program (Anon.).
3. *Think-Aloud Prototyping* – An in person 'think aloud' was conducted with an engineering manager at a local company that produces products for a worldwide market. The intent of the session was to observe a representative respondent that was instructed to vocalize his thoughts as he responded to the survey items. Notes were made of the actions and thoughts of the engineering manager as well as comments that the manager provided. Revisions to the survey were made to clarify question wording and improve the understandability of the survey.
4. *Survey Administration* – The survey was administered to 391 industry professionals and was open from August 12, 2010 to September 12, 2010. An email message with a link to

the survey was sent to each individual. The survey that was administered to the industry professionals is included in Appendix C.

5. *Survey Reminders* – To encourage additional respondents, email reminders were sent to the group of industry professionals that had not completed the survey. Two reminders were sent—one on August 18, 2010, and the second on August 24, 2010.
6. *Data Analysis* – After the survey was closed, the data was exported from Qualtrics to Microsoft Excel 2007 where it was formatted for descriptive and inferential analysis that was performed using SPSS. Survey results are reported in Chapter 4.1.

The survey consisted of 38 questions in four sections. Each respondent was prompted to provide: acknowledgement of informed consent to participate in the study, demographic information regarding their employment, demographic information about the company in which they were currently employed, and an evaluation of the set of global competencies identified in this study. Each of the four categories is described below:

1. *Informed Consent* – This introduction page to the survey provided the respondents with a description of the study, anticipated length (5-10 min), benefits, compensation, confidentiality, and information for contacting the researchers. Respondents were required to either select "Yes" on this page to continue with the survey, or to select "No" to exit. Survey branching logic was used to control the path of survey respondents at this point of the survey.
2. *Employment Information and Global Demographics* – Questions in this section (Questions 1 through 9) prompted respondents to provide information related to their employment, global demographics, and determined if respondents met the criteria to complete the remainder of the survey. Question 2 was designed to enable only

individuals that were currently working in industry, or who had in the past worked in industry to complete the survey. Respondents whom indicated that they were either students, not currently employed, or a stay at home parent were prompted to indicate if they had previously worked in industry (Question 3). If they had, they were allowed to continue the survey and were directed to consider their most recent work experience when responding to all the remaining questions. Respondents whom indicated they were retired were allowed to continue with the survey with the same added direction to consider their most recent work experience for the survey questions. Questions 6 through 9 were global demographics questions collected primarily for describing the survey sample that completed the survey. Questions 7 and 8 were only shown to respondents who had lived in another country other than the country that they indicated in Question 1.

3. *Company Information* – These questions (Questions 10 through 14) were collected to provide descriptive data regarding the size and global composition of the company with which the respondent was associated. Number of employees, approximate annual company revenue, and the extent to which the company catered to a global market are examples of the topics of these questions. Respondents who were not aware of the information asked for in this section were allowed to indicate that they didn't know.

4. *Global Competency Evaluation* –Lastly, respondents provided their evaluation of the 23 global competencies using a five point Likert-type scale with responses ranging from "Unimportant" to "Very Important" (Questions 15 through 37). The scale was identical to the scale used in the academic survey; however, slight wording changes were made to improve the applicability of the statements regarding engineers rather than students.

Also, as was done in the academic survey, if certain important competencies were omitted, additional competencies could be suggested (Question 38).

## 3.2 Globalization of the ME 471 Course

Preparatory to performing a comparative evaluation of the opportunities provided for students to develop elements of global competence between the ME 471 course and traditional study abroad programs offered at BYU, the traditional ME 471 class needed to be transformed into a globalized course. This section describes this transformative process and resulting structure of the globalized ME 471 course. First, a description of a pilot version of the ME 471 course and the lessons learned will be provided. Second, the identification of global competencies for inclusion and emphasis in the Fall 2010 ME 471 class will be discussed. Finally, the resulting changes made to the Fall 2010 ME 471 class including lectures that were added and labs that were modified to support the globalized course outcomes, will be presented.

### 3.2.1 ME 471 Pilot Program

During the Fall 2009 semester at BYU, a pilot version of the global ME 471 course was offered to test the feasibility of offering a globalized course that incorporated the use of student global virtual design teams. Portions of the course objectives, structure, content, and logistics were modified to accommodate the new international emphasis while research identifying the set of global competencies reported in Chapter 2.2.2 was being conducted.

#### *Description of Pilot Program*

Several course outcomes were added to the course to reflect its global emphasis. These new global outcomes are listed in Table 3-1. In a previous study, Parkinson, et al. proposed thirteen elements that together comprise global competence (Parkinson, Harb, and S. Magleby 2009). From this list, three global competencies were identified that could be integrated into the ME 471 course. This decision was reached by considering the ease with which the elements could be incorporated in the course and their natural fit related to the traditional course emphasis.

**Table 3-1:** Added Pilot ME 471 learning outcomes

The student will:

- Experience working in or directing a team of ethnic and cultural diversity.
- Understand cultural influences on product design, manufacture and use.
- Understand how cultural differences affect how engineering tasks are performed.

The structure of the course remained largely unchanged. Classroom instruction, laboratory training and exercises, as well as reading and homework assignments, and examinations all remained integral parts of the course. The major change in the structure of the course was the integration of international teams. Students from five other universities participated in the course, including the following universities: University of British Columbia (Canada), University of Toronto (Canada), Universidad Iberoamericana (Mexico), ITESM-Toluca (Mexico), and the University of Sao Paulo (Brazil). Table 3-2 lists the number of students that participated from each university.

**Table 3-2:** Student distribution by university in pilot program

| | BYU | UBC | Toronto | UIA | Toluca | USP |
|---|---|---|---|---|---|---|
| Number | 21 | 14 | 2 | 4 | 4 | 5 |
| Percentage | 42% | 28% | 4% | 8% | 8% | 10% |

Each of the students in the course was asked to respond to a short questionnaire wherein they provided information about their previous engineering experience, CAx and team skills, foreign language(s) fluency, and personal interests. Using this information, the course professors strategically organized the students into teams according to language ability, engineering experience, and geographical location. Four international teams were created. The student teams were relatively large, with an average size of 12 members. Table 3-3 shows the distribution of students in each team by university.

**Table 3-3:** Student team composition by university in pilot program

| Team | BYU | UBC | Toronto | UIA | Toluca | USP |
|---|---|---|---|---|---|---|
| Team 1 | 5 | 4 | - | - | 4 | - |
| Team 2 | 6 | 4 | - | 4 | - | - |
| Team 3 | 5 | 2 | 2 | - | - | 3 |
| Team 4 | 5 | 4 | - | - | - | 2 |

The processes used to grade student work varied by assignment type, necessitated by the ways in which the participating universities offered the course (i.e. not all of the students participating in the course were receiving university engineering credit for the course). Individual homework assignments were submitted to local faculty members. Team project presentations, reports, and other deliverables as well as lab assignments were graded by the BYU professor or TA. Although assessment and student performance was discussed among all of the professors, ultimately, the local university professors had responsibility for determining grades for their own students.

Course content and learning materials were added, modified, or in some cases, removed to meet the altered set of course learning outcomes and objectives. Two new lectures focused on global topics were developed. The first new lecture introduced the idea of and the need for global competence, also discussing the need to avoid ethnocentrism. The second lecture focused on principles of intercultural communication. Material for these lectures was based on topics published throughout the literature. To make room for the new lectures, several lectures that focused on IGES/STEP and data exchange were merged. In addition, some of the manufacturing content was dropped.

Several new technologies were integrated into the course to support virtual student team interactions. Siemens Teamcenter Community (TcC) was selected and used to accommodate each team's work-group needs (i.e. calendaring, task assignments, asynchronous discussions, application sharing). TcC was also used as the teams' primary secure file hosting and file sharing utility. It also hosted course presentations, assignments, and other materials posted by the course professors. TcC was selected because it was readily available to the participants and had been successfully used in past PACE projects. Other free web-based tools to supplement team processes were used as well, including Skype and the online Google Docs Suite.

A new laboratory exercise was also developed to introduce technologies that students would use to collaborate with their distributed teammates. Instruction was provided on how to use TcC, Skype, and Google Docs. In addition, instruction on how to interact with teammates in a distributed team environment was provided. The existing team-building lab was augmented to accommodate the newly developed material that would prepare the students to work in a distributed team environment.

Numerous other logistical challenges were addressed to ensure that the course operated smoothly. First, collaborative technologies were integrated into the course to support three primary logistical areas: faculty correlation, class lectures and lab instruction, and team activities. Video conferencing equipment was utilized as the primary technology to support faculty, class, and lab communication. This decision was made based upon the availability of such equipment at each of the participating universities, and the high level of audio and video quality provided by these systems. Table 3-4 lists the video conferencing systems that were used at each university.

**Table 3-4:** Video conferencing hardware used by university in pilot program

| University | Equipment Used |
|---|---|
| BYU | Tandberg 880MXP Endpoint<br>Tandberg Edge 95MXP Endpoint<br>Tandberg Codian MCU conferencing 'Bridge' |
| UBC | Tandberg 990MXP Endpoint |
| Toronto | Tandberg Edge 95MXP Endpoint |
| UIA | Tandberg 880MXP Endpoint |
| Toluca | Polycom Endpoint |
| USP | Polycom V500 Endpoint |

Course lectures and lab instruction were provided by professors and teaching assistants at BYU and made available via video conferencing technology to the other universities. BYU used two different video conferencing endpoint units to facilitate communication activities throughout the course. The first system was in a small conference room in the PACE ParaCAD Lab, and served as the primary collaboration area (at BYU) for weekly faculty meetings. Because the ME 471 lecture and laboratory activities at BYU were not available in a common classroom that supported video conferencing, a second mobile video conferencing unit was designed that could be used in any of the classrooms in which the ME 471 course was scheduled. This mobile unit supported the conferencing needs for both classroom and laboratory instruction.

In addition to endpoint video conferencing units, a multimedia conferencing bridge ('bridge') accommodated videoconferencing between the more than three partner universities. The bridge (pre-existing video-conferencing hardware at BYU) supports up to high-definition video conferencing capability for up to 40 different conference participants and was an invaluable, readily available hardware component that was necessary to support multi-university participation.

Student team members at BYU were provided (through a checkout system) with headsets and web cameras to support just-in-time team collaboration activities. Teams at BYU had the flexibility to schedule the video conferencing room for team use as well as the ability to collaborate via Skype.

Additional logistical challenges included differences in university course calendaring and time-zones. Recognizing that semester (term) beginning and ending dates, holidays, and other breaks did not perfectly align, plans were made to ensure that lectures, lecture materials, laboratory instruction, and assignments were available both through synchronous and asynchronous communication methods. Lectures and labs were recorded and posted on YouTube so that they could be reviewed at any time. This was beneficial for students that were unable to connect synchronously for class. Planning and coordinating schedules in advance helped to mitigate, but did not eliminate all problems incurred because of calendaring and time differences.

Reasons for participation in ME 471 varied among institutions. BYU was interested in providing a scalable, low cost opportunity for local students to develop global competence by interacting with students from another country in an engineering design team context. UBC does not teach an advanced CAx applications course, so the course topic was an incentive for participation. When coupled with an opportunity to learn collaborative tools and practice those skills, it was recognized as a great fit. Faculty members at USP were excited to participate because one of the school's current objectives is to increase the internationalization of its undergraduate courses. Also, the students were motivated by the possibility of working with fellow students abroad, and had worked with BYU on previous PACE global projects. As a final example, UIA elected to participate because of the ambitious ME 471 syllabus and the opportunity provided for students to use internet and videoconferencing communication tools.

Students at each university were recruited in different ways. At BYU, student interest in the ME 471 class had always been considerable and offering the international version of the course did not adversely affect student interest. All interested students were invited to participate. At UIA, students were selected from the four credit "Computational Product Simulation-IN041" course. Twenty students typically participate in this course. The four best students in this course were selected to participate in ME 471. These students were in the top ten "best students of their generation 2007-2010". Additionally, they had excellent written and oral proficiency in English. Students at USP were recruited from the group that was working on the PACE Global project and were already familiar with Dr. Alves' laboratory. Students attending UBC's MECH 328 (a third year design project course) were provided with the option of applying to take the Global ME 471 class and use its design project to fulfill the requirement for their MECH 328 project. Students applied via an e-mailed letter explaining why they would like to participate and why they should be selected. The selections were based on their letters and their grades.

***Pilot Program Lessons Learned***

Many lessons were learned from the pilot course. The lessons learned presented here are qualitative in nature, and are the result of the following feedback methods: student surveys, student and faculty interviews, and faculty observations.

1. *Calendaring and Daylight Savings Time Preparation* – The logistical aspects of integrating a course among multiple universities internationally present significant challenges. Advanced preparation is essential to successfully operate a course of this nature. Planning for differences in calendaring (including holidays, semester schedules, etc.) and time zone differences is critical. The adjustment away from and on to daylight

savings time was a particular challenge in the course. For example, at the beginning of the semester USP was 3 hours ahead of BYU. As the USA ended the daylight savings period, this difference went to 4 hours. Later in the same semester when Brazil moved into its daylight savings period, the difference increased to a total of 5 hours. In one case, one of the universities had a staff member attend the lab sessions so that he could re-teach the lab to his local students who were unable to attend the lab concurrently. Although scheduling conflicts with students, faculty, and video conferencing facilities were mostly avoided, additional planning and advance student notification would alleviate problems that were encountered.

2. *Prior Distribution of Learning Materials* – The importance of providing instructional materials to all students prior to class was another lesson that was learned. Internet bandwidth varied among universities and throughout the duration of course (some universities were affected more than others) and had a direct effect upon the quality of the presentations, lectures, and labs. Providing electronic copies of course materials in advance ensured that all students could clearly see and better understand course material.

3. *Redundant Communication Protocols* – Having redundant communication technologies in place was found to be important. It was learned that if one of the universities had difficulty connecting to the video conference, there was little that could be done to correct the problem during class. Establishing videoconferencing connections ten to fifteen minutes prior to each class period would decrease potential disruptions during class. Also, conferencing disruptions would be mitigated by having a faculty or staff member at each institution online via Skype, which would function as a standby backup communication and troubleshooting medium.

4. *Required Course Commitment by Faculty* – A high level of faculty commitment is required for a successful international course experience. Frequent faculty correlation regarding lectures, student comprehension and assessment, and calendaring was necessary. Faculty at UBC noted that much more faculty time was required than was originally expected. Each university provided varying mentoring resources for their local students as well. Although a teaching assistant at BYU was available to help students at each of the universities via Skype, few students took advantage of this opportunity. It was learned that it is important that faculty are provided with information to help them best understand the commitment involved, and that students are provided with local as well as remote mentoring resources.
5. *Need for Streamlined Course Credit, Educational Incentives* – Course credit for the students participating in the ME 471 course needed to be streamlined. Only some of the partner universities provided their students with some type of equivalent mechanical engineering course credit for participating in ME 471. For example, USP enrolled students in PME2596– Special Topics in Mechanical Engineering. In contrast, UBC provided ME 471 as an option to students in MECH 328, a third year design project course. The lack of uniformity in offering engineering credit to students participating in the course had deleterious effects on team operations. Whereas some students were overloaded by attempting to fulfill the requirements of the ME 471 course as part of another course in which they were enrolled, other students participated in more of an extracurricular way. Ensuring a more uniform credit offering would help to provide equal motivation for students to participate in the team projects.

6. *Improved Communication of Student and Team Responsibilities* – Students felt that there needed to be a better delineation of the responsibilities and expectations required of them and their teams in labs, assignments and projects. A higher level of uncertainty and ambiguity can be felt by students participating in a distributed team environment over a co-located team. Providing additional instructional materials and teaming requirements may help students to better operate in this environment. Also, the sequencing of some of the course lectures needed to be altered to provide students with the skills they needed for their design projects in a timelier manner.
7. *Establish A More Participatory Environment* – Ensuring student involvement and interaction proved to be challenging. It was noted that at times it was hard for remotely-located students to hear questions asked by BYU students. Also, students suggested that it was more difficult to ask questions as a remote student to the lecturing professor at a different university. Some students at universities participating through video conferencing did not feel that they understood completely what was being taught in the lectures. From this, it was learned that concerted effort must be taken to create an environment and processes such that students participating through video conferencing are involved in lectures and that their understanding of the material can be better understood.
8. *Decreased Team Size* – Decreasing student team size was a suggestion made by multiple students and an observed need made by faculty members as well. It was quite difficult for the teams to schedule their meetings such that everyone could synchronously participate. This was not only true because of the size of the teams, but also because several teams were composed of students from more than two universities. Coordinating

student schedules in addition to time zone differences proved to be very challenging. Despite the challenges, each international student team performed well and produced high quality project deliverables at the end of the course.

9. *Improve Team Member Interaction* – Providing opportunities for students to become better acquainted with teammates was another important lesson learned. A large majority of students responded in a survey that they wanted more interaction with the students at the other universities. The students noted that it was challenging to get to know their colleagues in the virtual environment. The need for student incentives to associate with and learn about their distributed team members should not be underestimated.

### 3.2.2 Designing the Global ME 471 Course

Learning from the ME 471 pilot program, plans were made and work began to improve the ME 471 course for its global launch in Fall 2010. This section describes the modifications that were performed to create a global virtual team based educational experience intended to provide students with opportunities to learn and develop global competencies. First, the new global learning outcomes that were selected and integrated into the course will be recounted. Second, changes to course structure and logistics will be described. Finally, modifications to course lectures and labs and the addition or modification of learning materials will be described.

***Incorporation of Global Competencies***

From the list of global competencies described in Chapter 2.2.2, several competencies were identified for inclusion in the Fall 2010 ME 471 course offering. This process was undertaken by working in close collaboration with Dr. C. Greg Jensen, the professor that would be teaching the ME 471 course. The global competencies that were identified for inclusion as additional learning outcomes for the class were selected based upon the ease with which they naturally fit with the envisioned structure of the global course, and the extent to which the competencies would support the students in succeeding in the soon-to-be created global engineering environment. The learning outcomes that were added to the ME 471 course were based on global competencies and are shown in Table 3-5:

**Table 3-5:** Global competencies incorporated into the ME 471 course

The Student will:

- Collaborate and work towards a common goal as a team member on a multicultural team.
- Develop multicultural team leadership skills.
- Interact with engineering students (or engineers) from a culture different than their own.
- Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies).
- Understand how to design a product for different cultures.

***Course Structure and Logistics***

The Fall 2010 ME 471 course incorporated improvements based on the lessons that were learned from the ME 471 pilot program as well as what was learned through the literature review and identification of the global competencies. The structure of the course (i.e. balance of course lectures, labs, and global team project, etc.) remained largely consistent with that which was described for the pilot program (see Chapter 3.2.1). However, changes that were made to the structure and logistics of the Fall 2010 ME 471 course are enumerated below.

1. *New Global Team Paradigm* – A new paradigm was used to structure the student teams wherein the teams were composed of six students in total, reducing the team size from the Fall 2009 pilot course by about 50%. Three students from BYU were paired with three students from another university. With a student enrollment of 24 at BYU, 8 additional universities were recruited to participate in the global course, each providing a group of three students that would be paired with three BYU students. Participating universities included: Hongik University (Korea), Toluca – ITESM (Mexico), Tongji University

(China), Universidad Iberoamericana (Mexico), University of British Columbia (Canada), University of Connecticut (USA), University of Sao Paulo (Brazil), Wayne State University (USA). This new paradigm reduced the number of time zone, calendaring, and other scheduling difficulties that the students in the Fall 2009 course had experienced when working in their teams because the teams were smaller and because only two universities were represented in each team.

2. *Improved Course Calendar* – An improved course calendar was developed to help the students and faculty at each university to be aware of not only the academic calendars for the participating universities, but also to be aware of and plan for changes in daylight savings time which would impact the relative time differences between BYU and many of the other participating universities. For example, the course calendar for October 2010 is included in Appendix D.
3. *Institutional Participation Agreement* – To guarantee that the resources and commitment necessary to ensure the success of the collaborative course, an institutional participation agreement was created that specified the expectations of both the institutions as well as faculty seeking to participate in the course. Topics covered in the agreement included such things as availability of software resources for students, hardware resources, local student mentoring resources, expected faculty commitment, and department commitment. The agreement that was developed is included in Appendix E.
4. *Student Participation Agreement* – Similar to the institutional agreement described above, a student participation agreement was developed to provide students with an improved understanding of what to anticipate regarding the ME 471 global team project as well as what was expected of them as participants on a team. Topics covered in this

agreement include prerequisites for participation, time expectations, and communication expectations. The student participation agreement is included in Appendix F.

5. *Improved Collaboration Protocols* – A document describing the processes used for class and lab videoconferencing that could also be applied to student team meetings was developed. This document described both procedures to follow while in the videoconference as well as steps to take to participate and communicate with BYU should videoconferencing fail or be temporarily unavailable.

### *Lectures and Labs*

Changes to a couple of lectures and several labs were made to provide instruction on and opportunities for students to practice developing the global competencies that had been integrated into the Fall 2010 ME 471 course. The modifications and integration of new lecture and lab material are described below.

1. *Global Product Design Lecture* – Additional improvements and modifications were made to the lecture which was used during the pilot course. Topics discussed in the lecture included the definition and rational for studying cross-cultural design, the process of designing a global product, and the influence of cultural values on design. A supplementary pre-lecture reading assignment—"The Washing Machine That Ate My Sari—Mistakes in Cross-Cultural Design" (Chavan et al. 2009)—that correlated to the lecture was added as well to provide the students with greater exposure to this topic.
2. *Rationale for and Introduction to Global Competency Lecture* – This second lecture that was integrated into the ME 471 class during the pilot phase was modified slightly for reuse during the Fall 2010 course offering. The general topics discussed in this lecture included: events and drivers increasing the need to develop global competency, examples

of products produced through globally distributed networks, global challenges facing the world, and an introduction to global competency and its constitutive elements. In addition, a supplementary pre-lecture reading—"The Global Toothbrush" (Hoppe 2006)—was provided to enhance student understanding and improve in class discussion.

3. *Communication Tools and Teambuilding I (Lab 1)* – The collaboration tools lab that was developed for the pilot course was revamped to better enable students to get to know their non-local teammates and to enhance their understanding of good virtual team practices. Several forms were either adapted or created to gather information from the students to assign them into teams and to facilitate Lab 1. These forms collected information regarding the students and their past engineering experience as well as Skype and Google account contact information that could be distributed when team assignments were made.

   The lab introduced the students to Skype, the Google Docs suite, and TcC, and provided opportunities for them to practice using and become familiar with the capabilities of these tools. Homework activities related to the lab exercise required the students to use Skype to interview and get to know one of their teammates one-on-one and to work together on a software tutorial. In addition, the team as a whole was to get together to discuss team communication strategies and create a team communication contract. Supplementary materials included a sample team communication contract and a handout describing principles of effective intercultural communication. Other materials related to videoconferencing equipment and procedures were distributed on a local university level.

4. *PLM tools and Teambuilding II in Lab 2* – The second lab was revamped to teach the students to use TcE and to provide further team instruction. Although the emphasis of

the in-class portion of the lab was to originally demonstrate using TcE and to enable the students to practice additional tutorials that were developed to enable them to learn to use the PLM software, the TcE environment was not ready for the Fall 2010 ME 471 offering. Instead, instruction and learning materials designed to help students use other file-sharing programs (such as TcC and Dropbox (Anon. 2010b)—a free web-based file storage and sharing service) were provided. Homework activities associated with the lab again required the students to interview a second non-local team member. Another supplementary document was adapted from the pilot course that provided instruction on team organization, team roles, and ways to improve team performance. Each team member was to read this document and then as a team, get together to discuss what they learned, how they would organize their team, and establish roles for each team member.

5. *Teambuilding III in Lab 3* – The homework portion of Lab 3 was revised to include further emphasis on team instruction. For a final time, each team member was instructed to interview a third (last remaining) non-local team member. A supplementary document describing ways to make team meetings effective was provided to students to review and use to guide a discussion on what they would do to ensure that their meetings were productive. The team submitted their agreed upon plan for this assignment and were encouraged to adhere throughout the course to the principles upon which their team had agreed.

6. *Teambuilding IV in Lab 4* – Similar to the changes made in Lab 3, only the homework aspect of Lab 4 was modified to once again incorporate some team based instruction. By this time, the team had been working together for about a quarter of the length of the course. To help the student teams overcome points of conflict and consider the extent to

which their team interactions were positive and productive, two team assignments were introduced. First, the team was to appoint a team member to perform a process evaluation in which a team meeting would be observed by the selected individual. Notes were to be made on how well the team communicated, made decisions, and interacted with one another. The second assignment was for each team member to complete a short online form wherein they anonymously evaluated several dimensions of their team (such as goals, procedures, relationships, etc.). The results of the process observation and the team assessment would afterwards be discussed by the team and necessary changes made. A second evaluation using these same two metrics was planned to be completed after week 10, marking the point in the course in which about two-thirds of the project time had elapsed.

### 3.3 Comparative Evaluation of Global Educational Programs

As described in Chapter 1.2, the primary purpose of this study was to perform a comparative evaluation of the ME 471 course, which was designed (Chapter 3.2.2) to enable mechanical engineering students to develop global competencies. Because of the great need to provide opportunities for students to develop global competence in the engineering curriculum, and the lack of programs that can currently and effectively reach a significant portion of the mechanical engineering student body, the advantages provided through a course-based global team project warranted this comparative investigation through which the relative strengths and weaknesses of the various programs in enabling the students to develop global competencies could be better understood. This section is described in three parts: first, the educational programs considered in the study will be reviewed, second, the method of performing the comparative evaluation will be discussed, and third, the method of analyzing the survey results will be described.

### 3.3.1 Educational Programs that were Evaluated

In this study, the global ME 471 course was compared against the collection of study abroad programs offered by the BYU Ira A. Fulton College of Engineering and Technology during the Spring 2010 semester. Each of the study abroad programs that were included in this study was described in Chapter 2.3.3. As a reminder to the reader, data from each of the following programs was collected for use in this study:

1. China Globalization
2. China Megastructures and Megacities
3. Global Product Development: Europe
4. Global Projects in Engineering and Technology: Peru
5. International Product Development and Design: Singapore

In addition to the study abroad programs mentioned above, a pilot survey was sent to students participating in Winter 2010 Mexico Engineering Study Abroad (MESA) study abroad program. Also, data was collected from the Fall 2010 course offering of the ME 471 course, against which the aggregated study abroad program data would be compared.

### 3.3.2 Method of Performing the Comparative Evaluation

A survey was developed and administered to students enrolled in each of the seven programs previously identified, enabling them to provide an evaluation of the extent to which the program of which they were a part enabled them to develop the global competencies that were identified in Chapter 2.2. A survey instrument was chosen primarily to obtain qualitative data from each program that would facilitate a comparison between the ME 471 course and the aggregated study abroad programs. Using a six point Likert response scale ranging from "Strongly Agree" to "Strongly Disagree", students could indicate their level of agreement with which the program of which they were a part taught and enabled them to develop global competencies.

The survey was administered to students in each of the seven programs, each of which varied from the others in enrollment size. Table 3-6 displays the number of students involved in the study categorized by their program enrollment. Students varied in academic standing; although a significant majority of the students were undergraduate students, a few graduate students were enrolled in several of the programs. All of the students that were enrolled in the study abroad programs attended Brigham Young University, whereas only half of the students in the ME 471 course were BYU students.

**Table 3-6**: Student enrollment by program type

| Program Name | Enrollment |
|---|---|
| China Globalization | 14 |
| China Megastructures and Megacities | 23 |
| Global Product Development: Europe | 11 |
| Global Projects in Engineering and Technology: Peru | 19 |
| International Product Development and Design: Singapore | 8 |
| Mexico Engineering Study Abroad (MESA) | 28 |
| Global ME 471: Computer Aided Engineering Applications | 48 |

The process of developing, administering, and reviewing the results from the comparative program evaluation study was composed of several steps. Each of the steps is described below:

1. *Survey Development* – The survey was developed and refined through a drafting and collaborative revising process. Question items were constructed and critically reviewed through a collaboration process by several researchers. Because the survey would be

administered to students, the necessary legal paperwork was completed with the university such that the research could be performed.

2. *Electronic Instrument Design* – The survey was designed and tested using the Qualtrics online survey service. Qualtrics was chosen as the survey method of choice because it was readily available for use to graduate students at BYU, and because of the ease with which students could respond to the survey and the ease of collecting, tabulating, and formatting data for analysis. The same survey was used for each of the study abroad programs, although not all of the questions were pertinent to this research study. The survey that was administered to the BYU ME 471 students differed only in questions not pertinent to this research study that were deleted, added, or otherwise modified.
3. *Think-Aloud Prototyping* – In person 'think alouds' were conducted with several BYU students that were peers to the researcher directing this study. During these sessions, the students were instructed to vocalize their thoughts as they responded to the survey items. Notes were made of the actions and thoughts of the observed students as well as comments that they provided. Revisions to the survey were made to clarify question wording and improve the understandability of the survey.
4. *Pilot Test* – A pilot test was conducted using students in a winter offering of the traditional ME 471 course and to students in the MESA program. 13 of 17 (76%) students enrolled in the traditional ME 471 course and 15 of 28 (54%) students enrolled in the MESA program completed the survey. Several revisions were made to the survey after analyzing the results from the pilot studies.
5. *Survey Administration* – The survey was administered to the 123 students in the remaining six educational programs either shortly before or after the completion of the

program in which the student had participated. In general, the survey was open to the students in each program for three weeks. Table 3-7 shows the dates indicating when the survey was opened for each program.

**Table 3-7:** Survey opening dates for each global engineering program

| Program Name | Date Open |
|---|---|
| China Globalization | 21 Jun 2010 |
| China Megastructures and Megacities | 9 Jun 2010 |
| Global Product Development: Europe | 28 May 2010 |
| Global Projects in Engineering and Technology: Peru | 28 May 2010 |
| International Product Development and Design: Singapore | 8 Jun 2010 |
| Mexico Engineering Study Abroad (MESA) *[Pilot]* | 15 Apr 2010 |
| Global ME 471: Computer Aided Engineering Applications | 8 Dec 2010 |

An email message with a link to the survey was sent to each student. The emails sent to the students varied only in the content that was specific to identifying which course with which the student was affiliated. The survey that was administered to the study abroad students as part of the final study is included in Appendix G, with the similar survey sent to the ME 471 students in Appendix H

6. *Survey Reminders* – To encourage additional responses, email reminders were sent to the group of students that had not completed the survey. One to three reminders were sent, depending upon the rate of response from the students. Again, the reminders were largely the same with only minor differences that personalized the message to the program in which the student was involved.
7. *Data Analysis* – After the surveys were closed, the data was exported from Qualtrics to Microsoft Excel 2007 where it was formatted for descriptive and inferential analysis that was performed using SPSS. Survey results are reported in Chapter 4.2.

With exception of a few demographics questions pertinent to program type and additional questions included in the surveys not pertinent to this research, the two surveys sent to the study abroad and Global ME 471 programs were identical. Both survey instrument used to perform the comparative evaluation was composed of 86 questions in six categories, although only the first 35 questions in the first three categories of each survey were used in this research. Because of this, only the first three categories of questions will be described. The three categories for all programs surveyed included: educational demographics, linguistic capability, and incorporation of instruction on global competencies. Each of the three categories is described below:

1. *Educational Demographics* – The first questions in the survey (Questions 1 through 5 and Question 8) gathered general educational and geographical demographics information. Information gathered included such things as: the university the student was attending, educational program in which the student participated, academic department, and years spent living inside and outside of the current country in which the student lived. If the student indicated that they had lived for any number of years outside of the country in which they currently resided (Question 5) they were allowed to select the countries in which they had previously lived (Question 8). The purpose for gathering this information was primarily to describe the sample of students surveyed.
2. *Linguistic Capability* – The next section (Questions 6 and 7 and Questions 9 through 12) primarily dealt with student linguistic capability. The student was prompted to provide their native language and was asked if they spoke any additional languages (Question 7). If the student indicated that they did speak more than one language, then they were prompted to list the additional languages that they spoke (up to four total languages – Question 9). For each of the languages provided, the student would then be presented with a question prompting him to indicate his level of fluency in that language in reading,

writing, and speaking (Questions 10 through 12, as needed). If the student did not speak an additional language, questions 9 through 12 were skipped.

3. *Incorporation of Global Competency Instruction*–The students next provided their evaluation of the extent to which the program of which they were a part taught and enabled them to develop 23 global competencies using a six point Likert scale with responses ranging from "Strongly Disagree" to "Strongly Agree" (Questions 13 through 35). Students were informed that because of the variation among programs that not all of the competencies would of necessity have been incorporated into their educational program.

### 3.3.3 Method of Analyzing the Survey Results

Analysis of the results of the comparative evaluation between the Global ME 471 course and the selected engineering study abroad programs offered by BYU consisted of performing descriptive and crosstab statistical analyses. Descriptive statistics were utilized primarily to describe survey response groups for each program type. Descriptive statistical analysis included general statistical measures such as calculations of variable means, standard deviations, and category frequencies.

Two options were available when considering the comparative statistical analysis to be conducted: independent samples t-test and Pearson's Chi-square analysis. Pearson's Chi-square crosstab analysis was chosen to provide further insight into the response patterns of student respondents. Several factors were considered when making this determination, including sample size and sample distribution type. Although response patterns could be normal, or Gaussian distributions, it was considered unlikely that this would be the case for this response data. Because of this, a non-parametric test such as the Chi-square test would be preferable.

Considering sample size, for large samples, both t-tests and Chi-square analyses perform well. With small samples, however, each tool has certain limitations. For example, t-tests tend to perform better with smaller samples, but fail to provide accurate P values with small samples that do not follow a Gaussian distribution. Chi-square analyses on the other hand are challenged by small samples in that each of the numbers in the contingency table may not be above the minimum required by the analysis. Because of this, the Chi-square may lack statistical power (Anon. 2009). Although small sample sizes were expected, the advantages offered by the Chi-square analysis is identifying differences in distribution patterns was noted as more valuable in the analysis; hence, this analysis type was used.

Using the Chi-squared analysis, differences in responses provided by students participating in study abroad programs and those provided by students in the global ME 471 course were identified. In addition, by controlling for demographics, program, and other categorical variables, important differences in responses were identified. The crosstab analysis centered on the question items in the surveys related to the assessment of the effectiveness of each program in enabling students to develop global competencies. Through performing Pearson's Chi-square analysis, any statistical differences between the study abroad program type and the global ME 471 program type would be identified, thus addressing and answering the primary research objective of this thesis, as was described in Chapter 1.2.

# 4 ANALYSIS AND RESULTS

This chapter details the analysis of and results from the surveys that were administered in connection with this research. First, an analysis of and results for the academic and industry validation research described in Chapter 3.1 will be presented. Second, an analysis of and results for the study relating to the effectiveness of the Global ME 471 course (described in Chapter 2.3.4 and Chapter 3.2) in comparison to other BYU study abroad programs (described in Chapter 2.3.3) in enabling students to learn and develop global competencies will be discussed. For a review of the method of performing this comparative analysis, consult Chapter 3.3.

## 4.1 Academic and Industry Evaluations of Elements of Global Competence

As described in Chapter 3.1, two surveys were created and administered to academic and industry professionals to obtain a validation of comprehensiveness, appropriateness, and importance of the global competencies which had been identified from the literature as a part of this research (described in Chapter 2.2). In this section, the two response groups will be described and the survey results will be provided and described.

### 4.1.1 Response Group Demographics

For the industry professional group, the survey was sent to individuals located in 30 states in the USA and 10 additional countries worldwide. A total of 106 companies (e.g. Boeing, Caterpillar, Ford, General Motors, Honeywell, Pratt & Whitney, and Siemens) were represented in the sample group, including 390 individuals.  Only 37 individuals responded for a response rate of 9.5%.  Thirty of the respondents (82%) were located within the USA.  The remaining individuals (18%) were from 5 additional countries.  Most of the respondents (94%) had been employed in industry for over 10 years, with 53% of the sample holding management or director positions.  Most of the respondents (70%) worked at companies employing over 10,000 people, with 49% of respondents indicating that their company had annual revenues of over 10 billion US dollars.  Additionally, 49% of respondents indicated that more than half of their company's business was for international markets.

For the academic professional group, the survey was electronically administered to 439 individuals located at one of more than 50 universities worldwide.  The response rate was 9.6% (42 individuals), with 43% of the respondents located within the USA. The remaining 57% of respondents were located in 7 additional countries.  Most of the respondents (57%) had been employed in higher education for over 10 years.  The majority (69%) of respondents held full-time faculty status.  Most of the respondents (95%) were employed in engineering departments, of which 45% were in mechanical engineering departments.  Almost half (48%) of the respondents had been involved in teaching or supervising global curricular activities for more than four years, with 36% of respondents having directed or facilitated extracurricular global activities.  Additionally, 29% of respondents had been involved in researching topics related to global or cross-cultural issues for more than four years.  A large majority of the respondents (88%) provided a self-rating of good, very good, or excellent when describing their personal global knowledge, skills, and abilities.

### 4.1.2 Survey Results

The results from the two surveys regarding the importance of specific global competencies were collected and analyzed. Responses indicating how important each of the 23 identified competencies were when evaluating an individual's global competence were aggregated and are reported in order of importance in Table 4-1. Each competency is listed in this table, along with its associated competency grouping (i.e. COMM-Communication, DISP-Dispositions, WRLD-World Knowledge, TEAM-Teamwork, and ENGR-Engineering Specific). The industry and academic group means are provided as well as overall means and standard deviations for each competency. The 1 to 5 point scale corresponds to the 5 point Likert-type response scale used in the survey. A rating of 1 indicated that the competency was "Unimportant"; 2 – "Of Little Importance"; 3 – "Moderately Important"; 4 – "Important"; and 5 – "Very Important". An asterisk next to the overall mean for specific competencies indicates where there was a significant difference in the responses between the two groups that were surveyed.

**Table 4-1:** Validation of global competencies by academic and industry respondents ordered by overall importance

| Cptcy. Group | Global Competency | Response Group | Group Means | Overall Mean | Overall Std Dev | |
|---|---|---|---|---|---|---|
| DISP | Appreciate and respect cultural differences. | Industry | 4.5 | 4.6 | 0.6 | Very Important |
| | | Academia | 4.7 | | | |
| DISP | Practice tolerance and flexibility when involved in intercultural interactions. | Industry | 4.3 | 4.6* | 0.7 | |
| | | Academia | 4.8 | | | |
| TEAM | Collaborate and work towards a common goal as a team member on a multicultural team. | Industry | 4.4 | 4.5 | 0.7 | |
| | | Academia | 4.6 | | | |
| DISP | Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices. | Industry | 4.3 | 4.4* | 0.7 | Important |
| | | Academia | 4.6 | | | |
| COMM | Use collaboration technologies in intercultural interactions. | Industry | 4.4 | 4.2 | 0.9 | |
| | | Academia | 4.1 | | | |
| TEAM | Identify, resolve, and minimize conflicts resulting from cultural differences. | Industry | 3.8 | 4.2* | 0.8 | |
| | | Academia | 4.5 | | | |

**Table 4-1:** (Continued)

| Cptcy. Group | Global Competency | Response Group | Group Means | Overall Mean | Overall Std Dev | |
|---|---|---|---|---|---|---|
| TEAM | Develop multicultural team leadership skills. | Industry | 3.9 | 4.2* | 0.8 | Important |
| | | Academia | 4.4 | | | |
| ENGR | Interact with engineering students (or engineers) from a culture different than own. | Industry | 4.0 | 4.1 | 0.9 | |
| | | Academia | 4.2 | | | |
| ENGR | Understand and respect engineering practices and contributions that are foreign. | Industry | 3.8 | 4.1* | 0.8 | |
| | | Academia | 4.4 | | | |
| TEAM | Describe how culture influences team processes. | Industry | 3.9 | 4.1 | 0.8 | |
| | | Academia | 4.1 | | | |
| WRLD | Understand concepts and principles of sustainability and globalization. | Industry | 3.7 | 4.0* | 0.9 | |
| | | Academia | 4.3 | | | |
| COMM | Apply principles of intercultural communication. | Industry | 3.8 | 4.0* | 0.8 | |
| | | Academia | 4.3 | | | |
| DISP | Develop a desire to interact with people from different countries to solve global problems. | Industry | 3.8 | 4.0 | 0.8 | |
| | | Academia | 4.1 | | | |
| ENGR | Describe how culture influences engineering product design. | Industry | 3.6 | 3.9* | 1.0 | |
| | | Academia | 4.2 | | | |
| ENGR | Explain basic principles of global businesses. | Industry | 4.0 | 3.9 | 0.8 | |
| | | Academia | 3.8 | | | |
| WRLD | Understand and compare world cultures. | Industry | 3.6 | 3.9* | 0.9 | |
| | | Academia | 4.1 | | | |
| ENGR | Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes. | Industry | 3.7 | 3.8 | 0.9 | |
| | | Academia | 3.8 | | | |
| ENGR | Describe how culture affects the perception of engineering work and the engineering profession throughout the world. | Industry | 3.6 | 3.7 | 0.9 | |
| | | Academia | 3.7 | | | |
| DISP | Objectively evaluate and adopt advantageous cultural practices and values. | Industry | 3.2 | 3.6* | 0.9 | |
| | | Academia | 4.0 | | | |
| DISP | Develop a desire to learn about different world cultures, events, and social issues. | Industry | 3.2 | 3.6* | 0.9 | |
| | | Academia | 3.9 | | | |
| COMM | Represent own culture, social group, company, nation, etc., in a foreign culture. | Industry | 3.2 | 3.5* | 1.0 | Somewhat Important |
| | | Academia | 3.7 | | | |
| COMM | Communicate in a second language. | Industry | 3.1 | 3.4* | 1.1 | |
| | | Academia | 3.7 | | | |
| WRLD | Increased general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc. | Industry | 3.1 | 3.4* | 0.9 | |
| | | Academia | 3.6 | | | |

* Differences in means between the two groups were statistically significant at the 95% confidence level.

### 4.1.3 Discussion of Survey Results

In general respondents indicated that all of the competencies were at least somewhat important. However, academics tended to place higher importance on each of the competencies than industry experts did. Many of these differences were statistically significant. As indicated in Table 4-1, significant differences for 14 of the 23 competencies were found between the two response groups. In each of these cases, academia considered the competencies to be of higher importance than did industry respondents. Still, there was a strong correlation between the ratings of the two groups ($r = .75$).

These results suggest that the large majority of identified global competencies are important, but that they are not all equally important. Only three of the competencies were considered to be “very important”. The most important competencies involve attitudes and abilities focused on working effectively with individuals in a culturally diverse team setting. Dispositions regarding cultural respect, tolerance, flexibility, and equality were seen as being most important. The ability to work collaboratively as a member of a multicultural team, to resolve cross-cultural conflicts, and to use collaboration technologies in intercultural interactions were also quite important. In contrast, it was found that knowing a second language, representing your culture or company, and developing a desire to learn about world cultures were considered only somewhat important.

The five competencies rated most important by the industry group (listed in order of importance and included as Table 4-2) were: appreciate and respect cultural differences, collaborate and work on a multicultural team, use collaboration technologies in intercultural interactions, practice tolerance and flexibility, and practice cultural equality. Academic respondents considered the five most important competencies to be: practice tolerance and flexibility when involved in intercultural interactions, appreciate and respect cultural differences, collaborate and work towards a common goal as a team member on a multicultural team, practice cultural equality, and identify, resolve, and minimize conflicts resulting from cultural differences, respectively.

**Table 4-2:** Highest rated competencies by response group

| | Industry | Academia |
|---|---|---|
| Appreciate and respect cultural differences | 1 | 2 |
| Collaborate and work as a team member on a multicultural team | 2 | 3 |
| Use collaboration technologies in intercultural interactions | 3 | 13 |
| Practice tolerance and flexibility in intercultural interactions | 4 | 1 |
| Practice cultural equality by eliminating personal cultural prejudices | 5 | 4 |
| Identify, resolve, and minimize cross-cultural conflicts | 11 | 5 |

With the exception of the ability to use collaboration technologies in intercultural interactions (ranked as only thirteenth by academics in terms of importance), the most important competencies identified by academics were similar to those identified as most important by industry respondents. This seems to indicate that positive cross-cultural attitudes and practical collaborative personal and teamwork skills are of paramount importance.

### *Differences by Geographic Location*

Geographic influences tended to significantly affect several response patterns. Respondents from the US considered communicating in a second language to be only 'Moderately Important' whereas respondents from all other countries tended to rate this competency as 'Very Important' ($\chi^2(4) = 22.2$, $p < .001$, ES V=.53). This strong disparity in response patterns is likely explained by the fact that English is widely accepted as the international language of engineering. Native English speakers likely would tend to consider communicating in a language other than English to be of less importance than non-English speakers considering it to be very important to learn to communicate in English, a second language. Also, USA respondents tended to rate the desire to learn about different world cultures as only ‘Moderately Important’ whereas all other respondents provided a rating of ‘Important’ ($\chi^2(3) = 9.0$, $p < .029$, ES V=.34). The USA has for many years been a dominant market in the world economy. It is possible that those living in the US have not found it to be as critical to understand the cultures of countries in which they have little interaction as compared to those in other countries who have significant interaction with individuals within the USA.

Several other significant insights were also noted in the results that appear to be location dependent. Comparing responses of professionals in the USA to those in all other countries, USA respondents rated the importance of using collaboration technologies in intercultural interactions primarily as ‘Very Important’ as compared to a rating of ‘Important’ by those in all other countries ($\chi^2(3) = 8.8$, $p = .033$, ES V=.49). This trend might be explained by the culture of the USA in which many individuals are early adopters of technology and are more comfortable than those in other countries with communicating through technological methods that provide less immediacy, or social presence, than what is afforded in face to face interactions. Similarly, USA respondents rated practicing tolerance and flexibility when involved in intercultural interactions as ‘Very Important’ whereas those in all other countries generally rated the competency as only ‘Moderately Important’ ($\chi^2(2) = 8.8$, $p = .012$, ES V=.49). Perhaps there is greater emphasis placed on these attributes in the cultures of engineering companies located in the USA than in engineering companies located in other countries.

### *Differences Based on the Position of the Respondent*

A third interesting relationship was found in controlling response by job type. Managers (or Directors) considered using collaboration technologies in intercultural interaction to primarily be ‘Very Important’ whereas all other job-types generally ranked the competency as ‘Important’ only ($\chi^2(3) = 15.1$, $p = .002$, ES V=.64). Managers and directors are heavily involved in collaborative tasks in business and engineering. Their perspective may be influenced by their own experience, or by their vision and understanding of trends related to collaborative engineering activities.

### *Differences Based on International Experience*

Interestingly, no significant differences in academic responses were found when controlling for faculty status, department affiliation, and years involved global curricular activities. However, academicians who provided a self-rating of their own global competence of poor, fair, or good provided split ratings for collaborating and working towards a common goal on a multicultural team as either 'Important' or 'Very Important' whereas those indicating a higher personal rating (very good or excellent), rated the competency as 'Very Important ($\chi^2(2) = 8.6$, $p = .014$, ES V=.45). Academicians who provided a high self rating related to global competence may have more extensive firsthand experience in multicultural interactions than other academic respondents leading them to recognize the challenges associated with these interactions and the importance of obtaining experience in this area. This same global competency was also influenced according to the number of countries in which the respondent had lived. Those who had lived in more than one country tended to indicate that collaborating as a team member on a multicultural team was 'Very Important', whereas those who had not lived in more than one country tended to rate the competency as 'Important' only ($\chi^2(2) = 12.2$, $p = .002$, ES V=.54). This finding may be explained in a similar way to the previous finding in that increased personal experience in intercultural interactions may directly influence the extent to which interacting with those from another culture is perceived as important to developing global competence.

***Additional Competencies***

An additional competency was suggested by a survey respondent that was unique among the other competencies that were rated by respondents. It was based upon the idea of maintaining long term international networks. Although one of the dispositional competencies focuses on developing a desire to interact with people from different countries to solve global problems, no effort to maintain long term social or project networks was included in the set of global competencies.

## 4.2 **Comparative Analysis of Global Educational Programs**

The comparative evaluation between five BYU engineering study abroad programs and Global ME 471 (research methodology described in Chapter 3.3) was conducted from April through December 2010. Results from surveys sent to students that participated in these programs were analyzed and are reported in this section. First, the student response groups will be described. Next, results of the comparative study of global engineering education programs will be presented. Finally, a discussion of the results of the study will be conducted.

### **4.2.1 Response Group Demographics**

As described in Chapter 3.3.1, aggregate survey data of participants in five engineering study abroad programs at BYU was compared to data gathered from students who participated in the BYU Global ME 471 course. This section describes the response groups for the two program types of interest in this study.

### *Educational Demographics*

Students participating in one of five study abroad programs received the survey included in Appendix G. A total of 123 students received this survey, with 93 students completing the entire survey for an overall response rate of 76%. Of these, 75 students that were enrolled in study abroad programs received invitations, of which 57 completed the entire survey, for a response rate of 76% for the study abroad response group. The response rates for each of the five study abroad programs surveyed is included as Table 4-3. The high response rate is attributed to encouragement from, or in some cases incentives provided by instructors and facilitators of these programs. Responses from four study abroad students who partially completed the survey were included only in the analysis of response group demographics.

**Table 4-3:** Response rate for students participating in the comparative study

| | Responses | Invitations | Response Rate |
|---|---|---|---|
| China Globalization | 12 | 14 | 86% |
| China Megastructures and Megacities | 19 | 23 | 83% |
| Engineering for International Development-Peru | 13 | 19 | 68% |
| Global Product Development: Europe | 10 | 11 | 91% |
| International Product Development and Design-Singapore | 3 | 8 | 38% |
| Study Abroad Total | 57 | 75 | 76% |
| Global ME 471 | 36 | 48 | 75% |
| Total | 93 | 123 | 76% |

Students participating in Global ME 471 received the similar survey, included in Appendix H, to that received by the study abroad students. Of the 48 students participating in the course that received invitations to participate in the study, 36 completed the entire survey, for a response rate of 75%. Similar to the study abroad programs, the high response rate is attributable for the high encouragement and extra credit course points made available by the instructor to students who completed the survey. One partial response was disregarded from the comparative analysis of the global programs, but was included for demographics analysis.

Study abroad students that participated in this research were from a variety of programs within the Ira Fulton College of Engineering and Technology at BYU. As shown in Table 4-4, students were predominantly enrolled in the Civil and Environmental Engineering and Mechanical Engineering departments, with 40% and 34% of respondents in each of these programs, respectively. This distribution was distinctly different from that of the students participating in the Global ME 471 course, with 92% of students in a Mechanical Engineering program at their respective university.

**Table 4-4:** Respondent department affiliation categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| Chemical Engineering | 7 (11%) | 0 (0%) | 7 (7%) |
| Civil and Environmental Engineering | 25 (40%) | 0 (0%) | 25 (26%) |
| Electrical and Computer Engineering | 4 (6%) | 0 (0%) | 4 (4%) |
| Mechanical Engineering | 21 (34%) | 33 (92%) | 54 (55%) |
| School of Technology | 5 (8%) | 1 (3%) | 6 (6%) |
| Other | 0 (0%) | 2 (6%) | 2 (2%) |
| Total | 62 (100%) | 36 (100%) | 98 (100%) |

### *Geographical Demographics*

Geographically, most students (88%) that were surveyed were currently living in the United States, although four other countries were represented in the study. All of the respondents who participated in one of the five engineering study abroad programs were currently residing in the USA, although they may not have been US citizens. As noted in Table 4-5, it is clear that this is not the case for Global ME 471, as about 33% of student respondents were from another country.

**Table 4-5:** Student current country of residence categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| USA | 60 (100%) | 24 (67%) | 84 (88%) |
| Mexico | 0 (0%) | 6 (17%) | 6 (6%) |
| Brazil | 0 (0%) | 3 (8%) | 3 (3%) |
| Canada | 0 (0%) | 2 (6%) | 2 (2%) |
| China | 0 (0%) | 1 (3%) | 1 (1%) |
| Total | 60 (100%) | 36 (100%) | 96 (100%) |

In general, the large majority of students (96%) had lived on average in their current country of residence for at least the past five years, as shown in Table 4-6. No significant differences were found for this metric between the two response groups.

**Table 4-6:** Years lived in current country of residence categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| 1 year or less | 1 (1.6%) | 0 (0.0%) | 1 (1.0%) |
| 1 to 5 years | 2 (3.2%) | 1 (2.8%) | 3 (3.1%) |
| 5 or more years | 59 (95%) | 35 (97%) | 94 (96%) |
| Total | 62 (100%) | 36 (100%) | 98 (100%) |

Most respondents had spent some time living abroad (61%), with 57% of respondents having lived in a country other than their current country of residence for more than one year, as shown in Table 4-7.

**Table 4-7:** Years lived outside country current country of residence categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| 0 years (None) | 26 (42%) | 12 (33%) | 38 (39%) |
| 1 year or less | 0 (0.0%) | 4 (11%) | 4 (4.1%) |
| 1 to 2 years | 21 (34%) | 16 (44%) | 37 (38%) |
| 2 years or more | 15 (24%) | 4 (11%) | 19 (19%) |
| Total | 62 (100%) | 36 (100%) | 98 (100%) |

This high level of time spent abroad for BYU students is likely attributable to many young men and women serving full-time missions in foreign countries for The Church of Jesus-Christ of Latter-day Saints, the sponsoring organization of BYU. No data was gathered to verify this, however. Although a statistically significant difference ($\chi^2(3) = 10.0$, $p = .018$, ES V=.32) was found between groups according to time spent living outside of their current country of residence, no readily identifiable differences are noted. Respondents in study abroad programs may have either spent more than one year abroad, or none at all, whereas several Global ME 471 respondents may have spent limited time abroad, in addition to respondents who have lived abroad for significant periods of time, or who have not spent time abroad at all.

Of all respondents who had lived abroad, most (78%) had lived in one country other than their current country of residence only. However, 22% of respondents having lived abroad had lived in two countries, with 5% having lived for some period of time in three or more countries, as noted in Table 4-8. No significant differences were noted between response groups regarding the number of countries in which each respondent had lived.

**Table 4-8:** Number of other countries in which resided categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| 1 | 26 (72%) | 21 (88%) | 47 (78%) |
| 2 | 8 (22%) | 2 (8%) | 10 (17%) |
| 3 | 1 (3%) | 1 (4%) | 2 (3%) |
| 5 | 1 (3%) | 0 (0%) | 1 (2%) |
| Total | 36 (100%) | 24 (100%) | 60 (100%) |

Among respondents who had spent time living abroad, Brazil was the most frequently noted country of prior residency, with 14% of all respondents having lived there. The top ten countries of prior residency for respondents having spent time abroad are noted in Table 4-9.

**Table 4-9:** Top ten countries of prior residency categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| Brazil | 6 (12%) | 5 (18%) | 11 (14%) |
| Canada | 2 (4%) | 3 (11%) | 5 (6%) |
| China | 3 (6%) | 2 (7%) | 5 (6%) |
| USA | 2 (4%) | 3 (11%) | 5 (6%) |
| Australia | 3 (6%) | 1 (4%) | 4 (5%) |
| Italy | 2 (4%) | 1 (4%) | 3 (4%) |
| Japan | 3 (6%) | 0 (0%) | 3 (4%) |
| Mexico | 1 (2%) | 2 (7%) | 3 (4%) |
| Peru | 3 (6%) | 0 (0%) | 3 (4%) |
| Argentina | 1 (2%) | 1 (4%) | 2 (3%) |
| Other | 24 (48%) | 10 (36%) | 34 (44%) |
| Total | 50 (100%) | 28 (100%) | 78 (100%) |

### *Linguistic Demographics*

A variety of native languages was noted among survey respondents. The majority of respondents were native English speakers (85%), although six languages were represented among the combined group sample, as shown in Table 4-10.

**Table 4-10:** Native languages spoken among respondents categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| English | 58 (94%) | 25 (69%) | 83 (85%) |
| Spanish | 1 (2%) | 5 (14%) | 6 (6%) |
| Portuguese | 1 (2%) | 3 (8%) | 4 (4%) |
| Chinese | 1 (2%) | 2 (6%) | 3 (3%) |
| Japanese | 1 (2%) | 0 (0%) | 1 (1%) |
| Nepali | 0 (0%) | 1 (3%) | 1 (1%) |
| Total | 62 (100%) | 36 (100%) | 98 (100%) |

Many student respondents also spoke a foreign language. Among all respondents, 68% indicated foreign language skills, with 63% and 78% among the study abroad programs and Global ME 471 groups, respectively, as noted in Table 4-11.

**Table 4-11:** Foreign language capability among respondents categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| Yes | 39 (63%) | 28 (78%) | 67 (68%) |
| No | 23 (37%) | 8 (22%) | 31 (32%) |
| Total | 62 (100%) | 36 (100%) | 98 (100%) |

Of all foreign languages spoken, the most common was Spanish (30%), followed by English (17%) and Portuguese (14%). Table 4-12 lists the top ten most common foreign languages spoken among student respondents.

**Table 4-12:** Ten most common foreign languages spoken among respondents categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| Spanish | 17 (35%) | 9 (23%) | 26 (30%) |
| English | 5 (10%) | 10 (26%) | 15 (17%) |
| Portuguese | 6 (12%) | 6 (15%) | 12 (14%) |
| French | 3 (6%) | 6 (15%) | 9 (10%) |
| Chinese | 3 (6%) | 1 (3%) | 4 (5%) |
| Italian | 1 (2%) | 2 (5%) | 3 (3%) |
| Japanese | 2 (4%) | 1 (3%) | 3 (3%) |
| German | 2 (4%) | 0 (0%) | 2 (2%) |
| Hungarian | 1 (2%) | 1 (3%) | 2 (2%) |
| Amharic | 1 (2%) | 0 (0%) | 1 (1%) |
| Other | 8 (16%) | 3 (8%) | 11 (13%) |
| Total | 49 (100%) | 39 (100%) | 88 (100%) |

Finally, regarding foreign language fluency, students were asked to rate their fluency in three dimensions: reading, writing, and speaking. The overall language fluency for each student was estimated by calculating the average of these three fluency dimensions. Among all respondents, the most common self-assessment of foreign language fluency was ‘Good’, with distributions as shown in Table 4-13.

**Table 4-13:** Respondent foreign language proficiency categorized by response group

| | Study Abroad Programs | Global ME 471 | Total |
|---|---|---|---|
| Poor | 2 (4%) | 2 (5%) | 4 (4%) |
| Fair | 12 (24%) | 11 (27%) | 23 (26%) |
| Good | 21 (43%) | 20 (49%) | 41 (46%) |
| Excellent | 14 (29%) | 8 (20%) | 22 (24%) |
| Total | 49 (100%) | 41 (100%) | 90 (100%) |

### 4.2.2 Results of Comparative Study of Global Engineering Education Programs

Data from the surveys sent to the study abroad programs and to the Global ME 471 course was collected, aggregated, and analyzed. Similar to the academic and industry validation results reported in Chapter 4.1.2, results describing how well each program type taught and enabled students to develop global competencies are displayed in Table 4-14, sorted according to competencies best addressed by Global ME 471. Each competency is listed in this table, along with its associated competency grouping (i.e. COMM-Communication, DISP-Dispositions, WRLD-World Knowledge, TEAM-Teamwork, and ENGR-Engineering Specific). The study abroad and Global ME 471group means and standard deviations are provided in addition to the overall means and standard deviations for each competency. The 1 to 6 scale corresponds to the six point Likert response scale used in the survey. A rating of 1 indicated that respondents “Strongly Disagreed” that the global program in which they participated taught and enabled that particular global competency. Similarly, a rating of 2 corresponded to “Disagree”; 3 – “Somewhat Disagree”; 4 – “Somewhat Agree”; 5 – “Agree”; 6 – “Strongly Agree”. An asterisk next to the overall mean for specific competencies indicates where there was a significant difference in the responses between the two surveyed groups.

**Table 4-14:** Comparative strengths and weaknesses of study abroad programs compared to Global ME 471 in enabling students to develop global competencies ordered by Global ME 471 strengths

| Cptcy. Group | Global Competency | Response Group | Group Means | Group Std Dev | Overall Mean | Overall Std Dev |
|---|---|---|---|---|---|---|
| COMM | Use collaboration technologies in intercultural interactions | SA Programs | 4.5 | 1.2 | 4.7 | 1.2 |
| | | Glbl ME 471 | 4.9 | 1.3 | | |
| TEAM | Collaborate and work towards a common goal as a team member on a multicultural team. | SA Programs | 4.7 | 1.3 | 4.8 | 1.3 |
| | | Glbl ME 471 | 4.8 | 1.2 | | |
| ENGR | Interact with engineering students (or engineers) from a culture different than your own | SA Programs | 4.9 | 1.5 | 4.8* | 1.3 |
| | | Glbl ME 471 | 4.7 | 1.0 | | |
| DISP | Practice tolerance and flexibility when involved in intercultural interactions | SA Programs | 5.4 | 0.7 | 5.1* | 0.9 |
| | | Glbl ME 471 | 4.7 | 1.0 | | |
| TEAM | Develop multicultural team leadership skills. | SA Programs | 4.5 | 1.4 | 4.5 | 1.4 |
| | | Glbl ME 471 | 4.6 | 1.4 | | |
| TEAM | Describe how culture influences team processes | SA Programs | 4.8 | 1.2 | 4.7* | 1.2 |
| | | Glbl ME 471 | 4.5 | 1.0 | | |
| DISP | Appreciate and respect cultural differences | SA Programs | 5.7 | 0.5 | 5.2* | 1.1 |
| | | Glbl ME 471 | 4.4 | 1.2 | | |
| DISP | Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices | SA Programs | 5.2 | 0.9 | 4.9* | 1.1 |
| | | Glbl ME 471 | 4.4 | 1.2 | | |
| DISP | Develop a desire to interact with people from different countries to solve global problems | SA Programs | 5.4 | 0.7 | 5.0* | 1.3 |
| | | Glbl ME 471 | 4.3 | 1.6 | | |
| ENGR | Understand and respect engineering practices and contributions that were foreign to you | SA Programs | 5.0 | 1.0 | 4.8 | 1.1 |
| | | Glbl ME 471 | 4.3 | 1.2 | | |
| ENGR | Describe how culture influences engineering product design | SA Programs | 5.3 | 0.8 | 4.9* | 1.2 |
| | | Glbl ME 471 | 4.3 | 1.3 | | |
| COMM | Represent your own culture, social group, company, nation, etc., in a foreign culture | SA Programs | 5.3 | 0.8 | 4.9* | 1.1 |
| | | Glbl ME 471 | 4.3 | 1.1 | | |
| WRLD | Understand concepts and principles of sustainability and globalization. | SA Programs | 5.4 | 1.0 | 4.9* | 1.1 |
| | | Glbl ME 471 | 4.2 | 0.9 | | |
| ENGR | Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes | SA Programs | 5.2 | 1.1 | 4.8* | 1.3 |
| | | Glbl ME 471 | 4.1 | 1.2 | | |
| ENGR | Describe how culture affects the perception of engineering work and the engineering profession throughout the world | SA Programs | 5.3 | 0.8 | 4.8* | 1.2 |
| | | Glbl ME 471 | 4.0 | 1.3 | | |
| DISP | Develop a desire to learn about different world cultures, events, and social issues | SA Programs | 5.6 | 0.7 | 5.0* | 1.2 |
| | | Glbl ME 471 | 4.0 | 1.2 | | |

**Table 4-14:** (Continued)

| Cptcy. Group | Global Competency | Response Group | Group Means | Group Std Dev | Overall Mean | Overall Std Dev |
|---|---|---|---|---|---|---|
| WRLD | Understand and compare world cultures | SA Programs | 5.3 | 0.8 | 4.8* | 1.2 |
| | | Glbl ME 471 | 4.0 | 1.2 | | |
| DISP | Objectively evaluate and adopt advantageous cultural practices and values | SA Programs | 5.0 | 1.0 | 4.6* | 1.3 |
| | | Glbl ME 471 | 4.0 | 1.4 | | |
| COMM | Apply principles of intercultural communication | SA Programs | 4.8 | 1.1 | 4.5* | 1.2 |
| | | Glbl ME 471 | 3.9 | 1.2 | | |
| TEAM | Identify, resolve, and minimize conflicts resulting from cultural differences. | SA Programs | 4.8 | 1.1 | 4.5* | 1.3 |
| | | Glbl ME 471 | 3.9 | 1.3 | | |
| WRLD | Increase your general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc. | SA Programs | 5.2 | 1.0 | 4.7* | 1.3 |
| | | Glbl ME 471 | 3.8 | 1.4 | | |
| ENGR | Explain basic principles of global businesses | SA Programs | 4.2 | 1.5 | 4.0 | 1.5 |
| | | Glbl ME 471 | 3.7 | 1.4 | | |
| COMM | Communicate in a second language | SA Programs | 3.5 | 1.7 | 3.4 | 1.8 |
| | | Glbl ME 471 | 3.3 | 2.0 | | |

* Differences in means between the two groups were statistically significant at the 95% confidence level.

### 4.2.3 Discussion of Survey Results

Overall, the study abroad programs received higher agreement ratings that they provided opportunities that taught and enabled students to develop global competencies than did the Global ME 471 course. Also, in many cases a statistical difference was found between the agreement ratings for each competency provided by student respondents from each response group. For seventeen of the twenty-three global competencies, statistical differences were found in the level of agreement to which students felt their global program provided opportunities for students to learn and develop global competencies. In each of these seventeen cases, study abroad programs performed better than did the Global ME 471 course (see Table I-1 through Table I-17 in Appendix I for response distribution and statistical analysis details for each of these seventeen global competencies).

For six of the twenty-three global competencies, however, no statistical differences were found among agreement responses between the two response groups. These global competencies indicated without asterisks in Table 4-14 (above) include: using collaboration technologies in intercultural interactions, collaborating and working towards a common goal as a team member on a multicultural team, developing multicultural team leadership skills, understanding and respecting engineering practices and contributions that were foreign to you, explain basic principles of global businesses, and communicate in a second language. Details regarding the response distributions and statistical analysis for each of these global competencies are included as Table I-18 through Table I-23 in Appendix I.

A surprise insight was that there was no statistical difference between the two response groups for the competency relating to collaborating and work towards a common goal as a team member on a multicultural team. This is likely a result of two confounding factors. First, two teams in the Global ME 471 course consisted of students working in a virtual team with another university within the US. Although this enabled the team to utilize communication technologies in a virtual setting, it may have limited any intercultural teamwork opportunities and thus underrepresented the extent to which the ME 471 course enabled students to develop and learn this competency. Also, in a couple of the study abroad groups, the US students communicated and worked with students from the country, or countries, that they visited. The students' more liberal interpretation of working and collaborating as part of a multicultural team in these instances may have exaggerated the extent to which study abroad programs enable students to develop this competency.

Greater insight regarding these survey results is obtained when considering that each global program emphasized a unique set of global competencies. For the Global ME 471 course, the global competencies which were integrated into the course were outlined in Chapter 3.2.2. Of the five competencies which were integrated into the Global ME 471 course, four competencies were also ranked in the top five competencies best emphasized by the course according to agreement responses provided by respondents who participated in the Global ME 471 course, as shown in Table 4-15. Also, of the six global competencies for which there was found to be *no* statistical differences between response groups, three competencies (collaborate and work towards a common goal as a team member on a multicultural team, develop multicultural team leadership skills, and use collaboration technologies in intercultural interactions) were among the five that were added to the Global ME 471 course (indicated by asterisks in Table 4-15). These results indicate for most of the competencies which were intentionally integrated into the Global ME 471 course there was good execution in creating learning materials and opportunities which supported the development of these competencies.

**Table 4-15:** Review of global competencies that were emphasized by the Global ME 471 course

| Global Competencies Added to Global ME 471 | Cptcy. Group | Top 5 Ranking |
|---|---|---|
| Collaborate and work towards a common goal as a team member on a multicultural team. | TEAM | Yes* |
| Develop multicultural team leadership skills. | TEAM | Yes* |
| Interact with engineering students (or engineers) from a culture different than their own. | ENGR | Yes |
| Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies). | COMM | Yes* |
| Understand how to design a product for different cultures. | ENGR | No |

*No statistical difference between Global ME 471 and Study Abroad Programs (95% confidence)

The global competencies rated highest in each program type were mostly different from one another. For example, of the five competencies rated highest by study abroad respondents, only one of those competencies (Practice tolerance and flexibility when involved in intercultural interactions) was in the list of five competencies rated highest by Global ME 471 respondents. This indicates that the two program types have different areas of focus. For example, of the five highest rated competencies for study abroad programs (included as Table 4-16) four are dispositional-based competencies. It appears that the study abroad programs have a high capability and intention of influencing the dispositional competence of students. In contrast, the Global ME 471 course had a high focus on and capability in helping develop practical, team-based competencies among students as evidenced by the integration of several teamwork and engineering based competencies in this program type.

**Table 4-16:** Highest rated competencies by students in study abroad programs

| Highest Rated Competencies | Cptcy. Group |
|---|---|
| Appreciate and respect cultural differences | DISP |
| Develop a desire to learn about different world cultures, events, and social issues | DISP |
| Develop a desire to interact with people from different countries to solve global problems | DISP |
| Understand concepts and principles of sustainability and globalization. | WRLD |
| Practice tolerance and flexibility when involved in intercultural interactions | DISP |

Although several of the competencies in which there was found to be no statistical difference between response group were rated highly among the Global ME 471 respondents, a couple of the these competencies (Explain principles of global businesses and Communicate in a second language) were rated most poorly. Also among study abroad program respondents, five of the six competencies lacking statistical differentiation were among the most poorly rated by study abroad respondents. This indicates that neither program type emphasized a couple of these competencies, and that many were not emphasized by the study abroad programs.

### *Differences Based on Foreign Language Capability*

Only one significant difference was found between the two response groups when controlling for foreign language capability: Communicating in a second language. Respondents who spoke a foreign language tended to 'Agree' or 'Strongly Agree' that their program taught and enabled them to develop this competency, whereas those who did not speak a second language tended to 'Disagree' or 'Strongly Disagree' ($\chi^2(5) = 16.1$, $p = .007$, ES V=.42; see also Table J-1). This is likely to indicate that both of these types of global programs provide opportunities to interact and speak with others in a foreign language, however, the extent to which it is valuable to the individual student depends on whether or not they know the foreign language of the area in which or person(s) with whom they are communicating.

When considering foreign language capability among study abroad program respondents only, a couple of differences were found. Communicating in a second language was one competency in which responses were different based upon whether or not the respondent spoke another language. Similar to the finding among all students, foreign language speakers in study abroad programs tended to 'Strongly Agree' that they were enabled in developing this competency through the study abroad program whereas non-foreign language speakers tended to 'Disagree' ($\chi^2(5) = 11.9$, $p = .036$, ES V=.45; see also Table J-2). Students spending time abroad likely felt the program provided greater utility in learning and enabling them to communicate in a second language if they already had foreign language skills, particularly if those language skills were useful in the area in which time was spent abroad. Also, foreign language study abroad respondents tended to only 'Agree' whereas non-foreign language speakers leaned toward 'Strongly Agree' when considering the extent to which their program enabled them to represent their own culture, social group, nation, etc., in a foreign culture ($\chi^2(3) = 8.96$, $p = .030$, ES V=.39; see also Tabe P-3). Although significant, this finding is relatively weak and may be explained by previous experience foreign language speakers have had in relation to representing themselves or another organization that caused them to be less likely to agree to the extent that non-foreign language speakers did with this competency.

Considering differences between foreign language speakers and non-foreign language speakers in the Global ME 471 program was difficult because of the small sample sizes when differentiating at this level. For three global competencies (Understand and compare world cultures, Understand and respect engineering practices and contributions that were foreign to you, Interact with engineering students (or engineers) from a culture different from your own), foreign language speakers tended to 'Agree' in each case that the Global ME 471 course taught and enabled them to develop these three competencies. In contrast, non-foreign language speakers tended to 'Somewhat Disagree' or only 'Somewhat Agree' ($\chi^2(5) = 11.3$, $p = .046$, ES V=.57; $\chi^2(5) = 12.5$, $p = .029$, ES V=.60; $\chi^2(4) = 10.7$, $p = .030$, ES V=.55; see also Table J-4 through Table J-6, respectively). Although each of the teams in the Global ME 471 course spoke predominantly English to communicate, there were cases where BYU students' foreign language skills were utilized in order to improve team communications. In these cases, perhaps those who felt that they could communicate in a language besides English with their teammates could better understand their culture, engineering practices and contributions, and better interact with them than students who did not know the foreign language, or in the case of non-BYU students, those whose English was a second language with moderate fluency.

For further information relative to the response distributions related to differences based on foreign language capabilities, consult the previously referenced tables in Appendix J.

### *Differences Based on Experience Living Abroad*

Considering all respondents and controlling for whether or not respondents had lived in another country for at least a brief period of time yielded a difference in responses regarding developing multicultural team leadership skills. Respondents who had not spent time abroad tended to 'Agree' that their global program had provided them with opportunities to learn this competency; however, students who had spend time living abroad had mixed responses, with most tending to 'Strongly Agree', but with several respondents that tended to 'Disagree' or even 'Strongly Disagree' ($\chi^2(5) = 13.8$, $p = .017$, ES V=.39; see Table K-1 in Appendix K).

Similar results were found with two competencies when considering responses only from students participating in the Global ME 471 course. When considering developing multicultural team leadership skills, again, respondents that had experience living abroad tended to 'Agree' whereas students without experience living abroad had mixed tendencies, either to 'Strongly Disagree' or to 'Strongly Agree' ($\chi^2(5) = 11.9$, $p = .036$, ES V=.58; see Table K-2). Another competency that portrayed differences among respondents having lived abroad was that of practicing tolerance and flexibility when involved in intercultural interactions. Students having spent time abroad again tended to 'Agree' whereas respondents without international living experience either 'Disagreed' or 'Strongly Agreed' ($\chi^2(4) = 9.75$, $p = .045$, ES V=.53; see Table K-3). One reason that could explain these differences is that depending upon the cultural differences between the two partner schools, it may have been excessively difficult, or rather easy to learn and develop these competencies. Another, perhaps more likely anecdote is that some teams in the Global ME 471 course were partnered with other students attending schools also within the US. If the teams were fairly uniform regarding culture, they may have felt that they did not participate and learn much regarding multicultural teams.

### *Differences Considering Only Team-centered Programs*

To better see how the Global ME 471 course aligned with a study abroad-based counterpart, an analysis was conducted comparing differences in responses between the Global ME 471 course and study abroad programs that had students participate in some sort of significant team engineering experience as part of the program. Controlling in this way yielded 33 study abroad participant responses to compare with 35 Global ME 471 participant responses. As a result of this analysis, eleven global competencies were found where there were no significant differences between student responses regarding how well the global program taught and enabled the students to develop those particular competencies. All six of the competencies in which there were no significant differences noted from comparing the Global ME 471 directly to study abroad programs remained without significant difference. In addition to these competencies were added five others: practice tolerance and flexibility when involved in intercultural interactions, describe how culture influences team processes, develop a desire to interact with people from different countries to solve global problems, objectively evaluate and adopt advantageous cultural practices and values, and apply principles of intercultural communication (see Appendix L for response pattern and analysis details).

These findings follow logical reasoning which would suggest that by performing a more direct comparison between study abroad programs that operate with a significant team emphasis and the Global ME 471 course yield resulting ratings with fewer significant differences, mirroring a similar program emphasis and structure. However, in all other cases where there remained distinct differences, study abroad programs maintained higher respondent agreement ratings. This was especially true for several competencies such as appreciating and respecting cultural differences, developing a desire to learn about different world cultures, events, and social issues, and describing how culture influences engineering product design. It is likely that the increased exposure resulting from interacting with foreign people and places by physically traveling abroad yielded an abundance of rich cultural and professional experiences that better enabled study abroad students to develop these competencies than could be done by the students in the Global ME 471 course. It is also likely that despite the team experiences offered through the study abroad programs there were other significant learning outcomes that aligned with these additional competencies that went beyond the global emphasis of the Global ME 471 course.

# 5 CONCLUSIONS

This chapter details the conclusions that can be drawn from the results obtained in this research. As was described in Chapter 1.2, the primary objective of this study was to determine how effectively a global team- and project-based, computer aided engineering course provided learning opportunities that enabled students to develop elements of global competence in comparison to existing engineering study abroad programs. Through the research methodology described in Chapter 3, this comparative study was performed with results and analysis provided in Chapter 4. Based on these results, first, several conclusions will be presented. Then, recommendations on future research will be provided.

## 5.1 Research Conclusions

Several important findings resulted from this research. This section details the research conclusions that were drawn from the analysis and results performed in this study

### 5.1.1 Global Competencies were Identified and Validated

Prerequisite to performing a comparative evaluation of the BYU Global ME 471 course to current BYU study abroad programs, it was necessary to identify and validate a set of comprehensive global competencies upon which the comparative study could be based. From this research a comprehensive set of twenty-three global competencies was identified and arranged within five broad categories. The twenty-three competencies were validated by two professional groups who rated each of the competencies based on their importance. Not all of the competencies were considered to have equal importance, but each was considered to be at least somewhat important; preference was typically placed on dispositional-based global competencies. Academic and industry experts largely confirmed that it was important for engineering students to develop these global competencies.

### 5.1.2 Global Engineering Programs Have Complementary Strengths and Weaknesses

Based upon the comparative analysis that was performed between the Global ME 471 class and the study abroad programs, it was apparent that the two program types provided clearly distinct emphases. The collaborative team project based program type (Global ME 471) was evaluated by student respondents to be a vehicle best situated to provide instruction relative to practical, global-team based engineering collaboration and project work. In contrast, the study abroad program types were assessed by respondents as providing invaluable experience that helped to change and shape global dispositions, attitudes, and world knowledge. Further, although for most of the global competencies considered, study abroad programs were rated by students as providing opportunities to learn and develop global competencies superior to those provided by the Global ME 471 course, six global competencies were identified in which there was no statistical difference noted by respondents between the two program types.

### 5.1.3 Collaborative Global Team Projects are Important for Engineering Programs

As was noted during the background to this research that was presented in Chapter 2, several of the most problematic and restrictive constraints to providing a global education for engineering students are problems of economy and scale. Most programs that have traditionally been used to enable students to develop global competencies have been study abroad or similar programs requiring student and faculty travel abroad. As has been extensively recognized, these programs are resource intensive and can only have limited impact upon the entire engineering student body. Collaborative team projects can represent an important part of the global engineering educational portfolio, in addition to study abroad and other global programs, by opening access to global experiences to more students in a more affordable way for both engineering departments and students.

### 5.1.4 Selected Global Competencies Can Be Taught Via Global Collaborative Courses

Of the twenty-three global competencies, five were identified and implemented into the Global ME 471 course. Students ratings indicated that four of the five competencies integrated into the course were in fact facilitated best through the course when compared to all other competencies. Of these, no statistical differences were found for three competencies between the study abroad programs and the Global ME 471 course. From this, it appears that international collaborative team project courses like the Global ME 471 course can teach and enable students to develop selected global competencies.

Although Global ME 471 enabled students to development most of the competencies which were emphasized in the course, conclusions cannot be drawn that these are the only, or the best, competencies that global collaborative team project courses can enable students to learn and develop. It is likely however, that there are certain competencies which will best be addressed by study abroad programs, and other competencies which could be just as easily addressed, if not better addressed, by global collaborative team project courses.

## 5.2 Suggestions for Future Work

Continuing research and development work focused on improving global programs needs to continue to be conducted. This section details several specific areas in which future work related to global engineering education, and in particular this research, is necessary.

### 5.2.1 Integrate Global Competencies into Engineering Department Curriculum

Engineering programs need to utilize the set of global competencies which has been identified and validated through this research in further globalizing engineering programs. Research and development work needs to be conducted to identify ways in which global competencies can be integrated throughout courses and programs in an engineering department. The description of and model associated with the global competencies that was presented in Chapter 2.2 will be useful in identifying appropriate ways to integrate the global competencies throughout a traditional engineering curriculum.

### 5.2.2 Explore Other Programs Types that Provide Instruction on Global Competencies

In this research, it was discovered that a complementary relationship exists between study abroad programs and global collaborative project-based courses. However, it is not anticipated that these two program types are the only two program types that are complementary. As was noted in Chapter 2.3.1, numerous program types have been proposed and implemented. In addition, other courses focused on global team training or other competency development should be considered. Further research should be conducted to better understand the strengths and weaknesses of these many program types and the ways in which they can complement a global engineering curriculum.

### 5.2.3 Improve Global ME 471 Course Logistics and Technology

Although global collaborative project-based programs such as the ME 471 course provide distinct advantages, course logistics and technology requirements prove to be an area of challenge. Future research and development work needs to be conducted to improve inter-university logistics to ensure a more uniform and mutually beneficial educational experience for all students involved in the course. In addition, research should be conducted to better understand the technology requirements for successful global collaborative projects and identify ways to improve the collaborative experience of distributed engineering teams.

### 5.2.4 Develop Global Competency Assessment Tools

The global competencies that have been identified and validated set the stage for research and development work to begin related to tools for evaluating student knowledge, skills, and attitudes relative to the development of global competencies. Examples of this would include: creating an instrument to understand how global and cultural attitudes are changed as a result of experience in global engineering programs; developing protocols and tools to assess student global skills; and building appropriate tests to evaluate student knowledge related to global competencies.

### 5.2.5 Develop Additional Materials for Global Engineering Programs

As a part of this research that was described in Chapter 3.2.2, several teaching and learning materials were developed to help students develop global skills and gain cross-cultural knowledge. However, these limited materials are insufficient for use in a globalized engineering curriculum. Additional work needs to be conducted to identify what types of learning materials and learning methodologies should be developed and implemented that will best facilitate student learning of global competencies. In conjunction with this research, development of learning outcomes and course materials for use among engineering students in both a variety of as well as specific global programs needs to be developed that will help engineering students develop global competencies and be prepared to work in an increasingly competitive, global engineering industry.

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## APPENDIX A: EXTRACTED GLOBAL COMPETENCIES FROM LITERATURE

| | Global Competency Identified in Literature | Source(s) |
|---|---|---|
| 1. | Communications across cultures | Downey (2006) |
| 2. | understand cultural diffebyu rences in communication regarding such things as status, formality, saving face, directness, the meaning of “yes”, non-verbal cues, etc. | Parkinson (2009) |
| 3. | Are able to communicate across cultures | Parkinson (2009) |
| 4. | Interact comfortably with persons in a different cultural environment | Lohmann (2006) |
| 5. | identifies group conflicts, seeks and implements culturally sensitive strategies to solve. | Deardorff (2006) |
| 6. | Good interpersonal skills exercised interculturally; the sending and receiving of messages that are accurate and appropriate | Deardorff (2006) |
| 7. | Ability to communicate effectively and appropriately in intercultural situations based on one’s intercultural knowledge, skills, and attitudes. | Deardorff (2006) |
| 8. | Ability to adapt to varying intercultural communication and learning styles | Deardorff (2006) |
| 9. | Sociolinguistic competence (awareness of relation between language and meaning in societal context) | Deardorff (2006) |
| 10. | to communicate effectively—both orally and in writing—in the international business language of English | Galloway (2008) in Parkinson 2009 |
| 11. | Speak a second language at a conversational level | Parkinson (2009) |
| 12. | Speak a second language at a professional (i.e. technical) level | Parkinson (2009) |
| 13. | Communicate in a second language | Lohmann (2006) |
| 14. | Readily use second language skills and/or knowledge of other cultures to extend their access to information, experiences, and understanding | Lohmann (2006) |
| 15. | can speak/understand a foreign language. | Lambert (1998) cited in Hunter (2006) |
| 16. | to understand the importance of transparency while working with local populations | Galloway (2008) in Parkinson 2009 |
| 17. | Are proficient working in or directing a team of ethnic and cultural diversity. | Parkinson (2009) |
| 18. | Use cultural frames of reference and alternate perspectives to think critically and solve problems within the discipline in the context of at least one other culture, nation, or region | Lohmann (2006) |
| 19. | Can effectively deal with ethical issues arising from cultural or national differences. | Parkinson (2009) |
| 20. | demonstrates trust in group members. | Deardorff (2006) |
| 21. | display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution | Downey (2006) |
| 22. | Work productively with radically different cultures | Downey (2006) |
| 23. | Collaborate professionally with persons of different cultures, and function effectively in multi-cultural work environments | Lohmann (2006) |
| 24. | the ability to effectively interact with people from diverse cultures | Bielefeldt (2007) |

| | | |
|---|---|---|
| 25. | predisposition to work effectively with people who define problems differently than they do. | Downey (2006) |
| 26. | the knowledge to work effectively with people who define problems differently than they do. | Downey (2006) |
| 27. | ability to work effectively with people who define problems differently than they do. | Downey (2006) |
| 28. | can interact with cross-cultural team members to accomplish a common goal. | Hunter (2006) |
| 29. | participates in multicultural affairs or cross-cultural simulations | Hunter (2006) |
| 30. | Ability to achieve one's goals to some degree through constructive interaction in an intercultural context | Deardorff (2006) |
| 31. | Learning through interaction | Deardorff (2006) |
| 32. | to work effectively in multinational teams | Galloway (2008) in Parkinson 2009 |
| 33. | Can appreciate other cultures. | Parkinson (2009) |
| 34. | Convey an appreciation for different cultures in terms of language, art, history, etc. | Lohmann (2006) |
| 35. | an appreciation for other cultures | Downey (2006) |
| 36. | develop a predisposition to value the contributions of others to engineering work | Downey (2006) |
| 37. | to appreciate people, culture, and engineering practices of other nations and to develop students' capacities for intercultural sensitivity | Downey (2006) |
| 38. | accepts foreign people and their culture. | Deardorff (2006) |
| 39. | General openness toward intercultural learning and to people from other cultures | Deardorff (2006) |
| 40. | Respect for other cultures | Deardorff (2006) |
| 41. | Withholding judgment | Deardorff (2006) |
| 42. | can empathize with peoples of other nations. | Lambert (1998) cited in Hunter (2006) |
| 43. | can shift frame of reference from one's own culture to another. | Deardorff (2006) |
| 44. | Ability to shift frame of reference appropriately and adapt behavior to cultural context; adaptability, expandability, and flexibility of one's frame of reference/filter | Deardorff (2006) |
| 45. | Cross-cultural empathy | Deardorff (2006) |
| 46. | Cognitive flexibility—ability to switch frames from etic to emic and back again | Deardorff (2006) |
| 47. | understanding and avoiding ethnocentrism | Parkinson (2009) |
| 48. | demonstrates flexibility when encountering ideas and actions of different cultures (i.e. patience, tolerance for ambiguity, not knowing all the details of of a situation at a given time.) | Hunter (2006) |
| 49. | Ability to identify behaviors guided by culture and engage in new behaviors in other cultures even when behaviors are unfamiliar given a person's own socialization | Deardorff (2006) |
| 50. | Behaving appropriately and effectively in intercultural situations based on one's knowledge, skills, and motivation | Deardorff (2006) |
| 51. | Adaptability and adjustment to new cultural environment | Deardorff (2006) |
| 52. | Flexibility | Deardorff (2006) |
| 53. | Tolerating and engaging ambiguity | Deardorff (2006) |
| 54. | Accept cultural differences and tolerate cultural ambiguity | Lohmann (2006) |
| 55. | Tolerate cultural ambiguity | Lohmann (2006) |
| 56. | Comfortably assimilate within other cultures | Lohmann (2006) |

| | |
|---|---|
| 57. gains new insights and ideas from another culture. | Hunter (2006) |
| 58. and development of a multicultural perspective | Downey (2006) |
| 59. View themselves as “citizens of the world,” as well as citizens of a particular country; appreciate challenges facing mankind such as sustainability, environmental protection, poverty, security, and public health | Parkinson (2009) |
| 60. able to seek out further international or intercultural opportunities | Lohmann (2006) |
| 61. Skills to analyze, interpret, and relate | Deardorff (2006) |
| 62. Curiosity and discovery | Deardorff (2006) |
| 63. Mindfulness | Deardorff (2006) |
| 64. Skills to listen and observe | Deardorff (2006) |
| 65. Understanding the value of cultural diversity | Deardorff (2006) |
| 66. exposure to foreign cultures | Downey (2006) |
| 67. practice interacting with and engaging engineers from other countries in simulated encounters | Downey (2006) |
| 68. Have had a chance to practice engineering in a global context, whether through an international internship, a service- learning opportunity, a virtual global engineering project or some other form of experience. | Parkinson (2009) |
| 69. Understand implications of cultural differences on how engineering tasks might be approached. | Parkinson (2009) |
| 70. demonstrate substantial knowledge of the similarities and differences among engineers | Downey (2006) |
| 71. understsand and articulate the perspectives toward engineering work they hold themselves as engineering students | Downey (2006) |
| 72. Transformational process toward enlightened global citizenship that involves intercultural adroitness (behavioral aspect focusing on communication skills), intercultural awareness (cognitive aspect of understanding cultural differences), and intercultural sensitivity (focus on positive emotion toward cultural difference) | Deardorff (2006) |
| 73. Understand cultural differences relating to manufacture and use. | Parkinson (2009) |
| 74. demonstrate and ability to analyze how people's lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work | Downey (2006) |
| 75. Understand cultural differences relating to product design, manufacture | Parkinson (2009) |
| 76. has an understanding of own culture's norms and expectations. | Hunter (2006) |
| 77. Cultural self-awareness and capacity for self-assessment | Deardorff (2006) |
| 78. Deep knowledge and understanding of culture (one’s own and others’) | Deardorff (2006) |
| 79. the ability to recognize the importance of cultural differences | Bielefeldt (2007) |
| 80. identifies cultural differences | Hunter (2006) |
| 81. is able to compare and contrast different cultures. | Deardorff (2006) |
| 82. Ethnorelative view | Deardorff (2006) |
| 83. demonstrates comparative thinking skills. | Deardorff (2006) |
| 84. demonstrate knowledge about cultures within a global and comparative context | Lohmann (2006) |
| 85. has knowledge other countries' history, traditions, beliefs and values. | Hunter (2006) |
| 86. respects other countries' history, traditions, beliefs and values. | Hunter (2006) |
| 87. Understanding of role and impact of culture and the impact of situational, social, and historical contexts involved | Deardorff (2006) |
| 88. Culture-specific knowledge and understanding host culture’s traditions | Deardorff (2006) |
| 89. Understanding others’ worldviews | Deardorff (2006) |
| 90. Demonstrate knowledge of at least one other culture, nation, or region, | Lohmann (2006) |

| | | |
|---|---|---|
| | such as beliefs, values, perspectives, practices, and products | |
| 91. | Have some exposure to international aspects of topics such as supply chain management, intellectual property, liability and risk, and business practices | Parkinson (2009) |
| 92. | to understand other cultures, especially the societal elements of these cultures | Galloway (2008) in Parkinson 2009 |
| 93. | to understand public policy issues around the world and in the country in which one is working | Galloway (2008) in Parkinson 2009 |
| 94. | Are familiar with the history, government and economic systems of several target countries | Parkinson (2009) |
| 95. | exposure to global issues and/or foreign cultures | Downey (2006) |
| 96. | demonstrate knowledge of global issues, processes, trends, and systems | Lohmann (2006) |
| 97. | the ability to understand that the world economy has become tightly linked with much of the change triggered by technology | Galloway (2008) in Parkinson 2009 |
| 98. | to recognize and understand issues of sustainability | Galloway (2008) in Parkinson 2009 |
| 99. | Have an understanding of the connectedness of the world and the workings of the global economy | Parkinson (2009) |
| 100. | learn about the historical emergence and contemporary states of the engineering profession in different countries | Downey (2006) |
| 101. | demonstrate substantial knowledge of the similarities and differences among non-engineers from different countries | Downey (2006) |
| 102. | have a knowledge of events (i.e. news) and organizations (i.e. governments) in other countries. | Lambert (1998) cited in Hunter (2006) |
| 103. | has knowledge of world events and how they are interconnected. | Hunter (2006) |
| 104. | has a knowledge of the world (i.e. geography, climate, nations, governments, etc.) | Deardorff (2006) |

## APPENDIX B: SURVEY SENT TO ACADEMIC PROFESSIONALS

**Informed Consent to Participate in Research and Survey**

**Title of Research Project**
An Academic Evaluation of the Importance of Proposed Global Knowledge, Skills, and Attitudes for Undergraduate Mechanical Engineering Students

**Purpose of this Study**
The purpose of this survey is **to identify if the proposed global knowledge, skills, and attitudes are important and can provide an indication of global competence among undergraduate engineering students.** This research will provide information valuable to colleges and universities in establishing learning outcomes for programs designed to enable students to become more globally competent. Please be candid in your responses.

As a member of the academic community interested in global education you are invited to participate in this study.

This survey is being conducted by Aaron Ball (Graduate Student) and M.S. Mechanical Engineering Candidate at Brigham Young University (BYU).

**Procedures**
Completion of this survey will take approximately 10 minutes to complete. Questions in four (4) sections relate to general information about your academic employment, global competence, experience, behavior, and values, and an evaluation of the proposed global competencies.

**Benefits**
The analyzed survey results will be provided to those that elect to participate, and may be of value to you and your institution. However, no known direct personal benefits will result from your participation in this study.

**Compensation**
No compensation will be provided for participating in this study.

**Confidentiality**
Any 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:

Aaron Ball, Graduate Student, Department of Mechanical Engineering, Brigham Young University.
Tel: 1 (801) 422-2019; Email: aaronball85@gmail.com

Dr. Greg Jensen, Professor, Department of Mechanical Engineering, Brigham Young University.
Tel: 1 (801) 422-6540; Email: cjensen@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 | No |
|---|---|
| ○ | ○ |

## 1 of 4: About Your Academic Institution Employment

Please select the category that best describes your current position.

- Part-time Staff
- Full-time Staff
- Part-time Faculty
- Full-time Faculty
- Administration

With which academic department are you affiliated?

- Civil or Environmental Engineering
- Electrical and Computer Engineering
- Industrial Design or Engineering
- Manufacturing Engineering
- Mechanical Engineering
- Other

How many years have you been employed in academia? (Round up to the nearest year, if necessary)

- 5 years or less
- 6 to 10 years
- 11 to 15 years
- More than 15 years

How many years have you been involved in the following activities?

| | 0 years (Never) | 1 to 3 years | 4 to 6 years | 7 to 9 years | 10 years or more |
|---|---|---|---|---|---|
| Teaching or supervising global, international, or cross-cultural curricular activities (i.e. study abroad programs, international class projects, distance learning programs, etc.) | | | | | |
| Researching topics related to global, cross-cultural issues (i.e. cross-cultural virtual teams, design for culture, intercultural competence, etc.) | | | | | |
| Directing or facilitating extracurricular global, international, or cross-cultural activities (i.e. P.A.C.E. projects, etc.) | | | | | |

## 2 of 4: Your Evaluation of Student-Needed Global Knowledge, Skills, and Attitudes

Each of the following statements represents a global competency (knowledge, skill, or attitude). To be considered globally competent, how important is it that a student be able to:

| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
|---|---|---|---|---|---|
| Interact with engineering students (or engineers) from a culture different than their own. | ○ | ○ | ○ | ○ | ○ |
| Collaborate and work towards a common goal as a team member on a multicultural team. | ○ | ○ | ○ | ○ | ○ |
| Develop multicultural team leadership skills. | ○ | ○ | ○ | ○ | ○ |
| Understand and respect engineering practices and contributions that are foreign to them. | ○ | ○ | ○ | ○ | ○ |
| Represent their own culture, social group, company, nation, etc., in a foreign culture. | ○ | ○ | ○ | ○ | ○ |
| Objectively evaluate and adopt advantageous cultural practices and values. | ○ | ○ | ○ | ○ | ○ |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Explain how culture influences engineering standards, problem solving, and manufacturing processes. | ○ | ○ | ○ | ○ | ○ |
| Appreciate and respect cultural differences. | ○ | ○ | ○ | ○ | ○ |
| Understand how to design a product for different cultures. | ○ | ○ | ○ | ○ | ○ |
| Understand and differentiate among other cultures (i.e. beliefs, values, perspectives, practices, products, etc.). | ○ | ○ | ○ | ○ | ○ |
| Develop a desire to interact with people from different countries to solve global problems. | ○ | ○ | ○ | ○ | ○ |
| Communicate in a second language (speak, read, write, and listen). | ○ | ○ | ○ | ○ | ○ |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Develop a desire to learn about different world cultures, events, and social issues. | ○ | ○ | ○ | ○ | ○ |
| Practice tolerance and flexibility when involved in intercultural interactions | ○ | ○ | ○ | ○ | ○ |
| Understand concepts and principles of sustainability and globalization. | ○ | ○ | ○ | ○ | ○ |
| Identify, resolve, and minimize conflicts resulting from cultural differences. | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| Describe how culture affects the perception of engineering work and the engineering profession throughout the world. | ○ | ○ | ○ | ○ | ○ |
| Describe how culture influences team processes (i.e. team structure and processes, developing objectives, establishing rules, building trust, work ethic, etc.). | ○ | ○ | ○ | ○ | ○ |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Apply principles of intercultural communication (i.e. Adjustments to formality, directness, body language, facial expressions, idioms, humor, etc. when communicating with persons of another culture). | ○ | ○ | ○ | ○ | ○ |
| Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices. | ○ | ○ | ○ | ○ | ○ |
| Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies). | ○ | ○ | ○ | ○ | ○ |
| Develop a general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc. | ○ | ○ | ○ | ○ | ○ |
| Explain basic principles of global businesses (i.e. supply chain management, intellectual property, liability and risk, etc.). | ○ | ○ | ○ | ○ | ○ |

Are there other important global competencies that were not presented above that you would like to suggest?

○ Yes

○ No

Please list the additional essential global competencies below.

Additional Competency 1 [ ]

Additional Competency 2 [ ]

Additional Competency 3 [ ]

Additional Competency 4 [ ]

Additional Competency 5

## 3 of 4: About Your Global Knowledge, Experience, Abilities, and Values

How would you rate your personal global knowledge, skills, and abilities?

| Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Please indicate to what extent you would agree that the following statements describe you.

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| I have an understanding of the concepts of sustainability and globalization. | ○ | ○ | ○ | ○ | ○ | ○ |
| I have experience collaborating and working towards a common goal as a team member on a multicultural team. | ○ | ○ | ○ | ○ | ○ | ○ |
| I have an understanding of cultural value framework principles (i.e. power distance, individualism vs. collectivism, uncertainty avoidance, femininity vs. masculinity, etc.) | ○ | ○ | ○ | ○ | ○ | ○ |
| I understand how culture influences team processes (i.e. team structure and processes, developing objectives, establishing rules, building trust, work ethic, etc.). | ○ | ○ | ○ | ○ | ○ | ○ |
| I am experienced in communicating in a second language at a professional level (reading, writing, and speaking). | ○ | ○ | ○ | ○ | ○ | ○ |
| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree |
| I have significant experience designing or engineering products for multiple cultures. | ○ | ○ | ○ | ○ | ○ | ○ |
| I have experienced how different cultures influence engineering design processes, standards, problem solving, and manufacturing processes. | ○ | ○ | ○ | ○ | ○ | ○ |
| I have an broad understanding of world cultures (i.e. cultural beliefs, values, perspectives, practices, products, etc.). | ○ | ○ | ○ | ○ | ○ | ○ |
| I have a broad knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc. | ○ | ○ | ○ | ○ | ○ | ○ |
| I have experience using collaboration technologies in a global context (i.e. web-conferencing, video conferencing, instant messaging, application sharing technologies). | ○ | ○ | ○ | ○ | ○ | ○ |

## 4 of 4: About Your Global Demographics

Please select the country in which you currently live.

[ ▾ ]

Have you lived in a country other than the country where you currently live?

- Yes
- No

How many years have you lived inside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- 1 year or less
- 2 to 5 years
- More than 5 years

How many years have you lived outside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- 1 year or less
- 2 to 5 years
- More than 5 years

Please select the countries (other than ${q://QID31/ChoiceGroup/SelectedChoices}) where you have lived.
(CTRL+click to select multiple countries)

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria

How many different countries have you visited throughout your career? Note: Do not include countries visited only for vacation purposes.

- None
- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 or more

# APPENDIX C: SURVEY SENT TO INDUSTRY PROFESSIONALS

**Informed Consent to Participate in Research and Survey**

**Title of Research Project**
An Industry Evaluation of the Importance of Proposed Elements of Global Knowledge, Skills, and Attitudes for Undergraduate Mechanical Engineering Students

**Purpose of this Study**
The purpose of this survey is **to identify if the proposed global knowledge, skills, and attitudes are important and can provide an indication of global competence among undergraduate engineering students.** This research will provide information valuable to colleges and universities in establishing learning outcomes for programs designed to enable students to become more globally competent. Please be candid in your responses.

As a member of the engineering community, you are invited to participate in this study.

This survey is being conducted by Aaron Ball (Graduate Student) and M.S. Mechanical Engineering Candidate at Brigham Young University (BYU).

**Procedures**
Completion of this survey will take approximately 5 to 10 minutes to complete. Questions in three (3) sections relate to general information about your employment, company, and an evaluation of the proposed global competencies.

**Benefits**
The analyzed survey results will be provided to those that elect to participate, and may be of value to you and your company. However, no known direct personal benefits will result from your participation in this study.

**Compensation**
No compensation will be provided for participating in this study.

**Confidentiality**
Any 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:

Aaron Ball, Graduate Student, Department of Mechanical Engineering, Brigham Young University.
Tel: 1 (801) 422-2019; Email: aaronball85@gmail.com

Dr. Greg Jensen, Professor, Department of Mechanical Engineering, Brigham Young University.
Tel: 1 (801) 422-6540; Email: cjensen@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 | No |
| --- | --- |
| ○ | ○ |

## 1 of 3: About Your Employment

Please select the country that best describes where you currently (or most recently) work.

[ ▾ ]

Please select the category that best describes your employment status.

- ○ Employed (30 hours or more per week)
- ○ Employed part time (less than 30 hours per week)
- ○ Self-employed
- ○ Stay-at-home parent
- ○ Not currently employed
- ○ Retired
- ○ Student

Have you previously worked full-time in industry?

- ○ Yes
- ○ No

**Note: Please consider your most recent (instead of current) work experience when considering the questions in the survey.**

Please select the category that best describes your current job title.

- ○ Senior Executive (CEO, President, Owner, CFO, CTO, VP, etc)
- ○ Director or Manager (Engineering, Product, Program, Plant, etc.)
- ○ Engineer (Analyst, Denign, Senior, Junior, etc.)
- ○ Other

[ ]

How many years have you been employed in industry? (Round up to the nearest year, if necessary)

- ○ 5 years or less
- ○ 6 to 10 years
- ○ 11 to 15 years
- ○ More than 15 years

How many different countries have you visited throughout your career? Note: Do not include countries visited only for vacation purposes.

- None
- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 or more

Have you lived in another country besides ${q://QID31/ChoiceGroup/SelectedChoices}?

- Yes
- No

How many years have you lived inside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- 1 year or less
- 2 to 5 years
- More than 5 years

How many years have you lived outside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- 1 year or less
- 2 to 5 years
- More than 5 years

## 2 of 3: About Your Company

How many employees (worldwide) does your company employ?

- Less than 100
- 100 to 999
- 1000 to 9,999
- More than 10,000
- Don't Know

What is the approximate annual revenue (US$) of your company?

- Less than $10 million
- $10 million to $99 million
- $100 million to $999 million
- $1 billion to $10 billion
- Over $10 billion
- Don't Know

What percentage of your company's business is conducted for markets outside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- None (0%)
- 1 to 24%
- 25 to 50%
- 50 to 74%
- 75 to 100%
- Don't Know

What percentage of your company's in-house operations are outside of ${q://QID31/ChoiceGroup/SelectedChoices}? (e.g. Offshore facilities but NOT outsourced operations)

- None (0%)
- 1 to 24%
- 25 to 50%
- 50 to 74%
- 75 to 100%
- Don't Know

What percentage (by US$ volume) of your company's product or service suppliers are outside of ${q://QID31/ChoiceGroup/SelectedChoices}?

- None (0%)
- 1 to 24%
- 25 to 50%
- 50 to 74%
- 75 to 100%
- Don't Know

## 3 of 3: Your Evaluation of Elements of Global Competence

Each of the following statements describes an element of global competence. To be considered globally competent, how important is it for a mechanical engineer at your company to be able to:

| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
|---|---|---|---|---|---|
| Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies). | ○ | ○ | ○ | ○ | ○ |
| Demonstrate a desire to learn about different world cultures, events, and social issues. | ○ | ○ | ○ | ○ | ○ |
| Collaborate and work towards a common goal as a team member on a multicultural team. | ○ | ○ | ○ | ○ | ○ |
| Demonstrate a general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc. | ○ | ○ | ○ | ○ | ○ |
| Understand basic principles of global businesses (i.e. supply chain management, intellectual property, liability and risk, etc.). | ○ | ○ | ○ | ○ | ○ |
| Interact with engineers from a culture different than their own. | ○ | ○ | ○ | ○ | ○ |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Demonstrate multicultural team leadership skills. | ○ | ○ | ○ | ○ | ○ |
| Understand concepts and principles of sustainability and globalization. | ○ | ○ | ○ | ○ | ○ |
| Understand and respect engineering practices and contributions that are foreign to them. | ○ | ○ | ○ | ○ | ○ |
| Practice tolerance and flexibility when involved in intercultural interactions | ○ | ○ | ○ | ○ | ○ |
| Demonstrate a desire to interact with people from different countries to solve global problems. | ○ | ○ | ○ | ○ | ○ |
| Understand how culture influences engineering standards, problem solving, and manufacturing processes. | ○ | ○ | ○ | ○ | ○ |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Objectively evaluate and adopt advantageous cultural practices and values. | ○ | ○ | ○ | ○ | ○ |
| Represent their own culture, social group, company, nation, etc., in a foreign culture. | ○ | ○ | ○ | ○ | ○ |
| Understand how to design a product for different cultures. | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| Communicate in a second language (speak, read, write, and listen). | | | | | |
| Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices. | | | | | |
| Understand and differentiate among other cultures (i.e. beliefs, values, perspectives, practices, products, etc.). | | | | | |
| | Unimportant | Of Little Importance | Moderately Important | Important | Very Important |
| Appreciate and respect cultural differences. | | | | | |
| Apply principles of intercultural communication (i.e. Adjustments to formality, directness, body language, facial expressions, idioms, humor, etc. when communicating with persons of another culture). | | | | | |
| Understand how culture influences team processes (i.e. team structure and processes, developing objectives, establishing rules, building trust, work ethic, etc.). | | | | | |
| Identify, resolve, and minimize conflicts resulting from cultural differences. | | | | | |
| Understand how culture affects the perception of engineering work and the engineering profession throughout the world. | | | | | |

Are there other important global competencies that were not presented above that you would like to suggest?

- Yes
- No

Please list the additional essential global competencies below.

Additional Competency 1

Additional Competency 2

Additional Competency 3

Additional Competency 4

Additional Competency 5

# APPENDIX D: OCTOBER COURSE CALENDAR FOR ME 471

## October 2010

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11<br>Columbus Day (US)<br>Thanksgiving Day<br>Holiday (Canada) | 12<br>Columbus Day<br>(Mexico)<br>Holy Mary Day<br>Holiday (Brazil) | 13 | 14 | 15 | 16 |
| 17<br>Daylight Savings<br>Time Begins (Brazil) | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31<br>Halloween<br>(US/Canada)<br>Daylight Savings<br>Time Ends (Mexico) | | | | | | |

*October 17, 2010—October 30, 2010*

| -1hr | BYU | +1hr | +2hr | +4hr | +14hr | +15hr |
|---|---|---|---|---|---|---|
| UBC | BYU | Toluca | MAC | USP | Tongji | Hongik |
| | | PVAMU | UCON | | | |
| | | UIA | Wayne | | | |

*October 31, 2010—November 6, 2010*

| -1hr | BYU (0) | +1hr | +2hr | +4hr | +14hr | +15hr |
|---|---|---|---|---|---|---|
| UBC | BYU | PVAMU | MAC | USP | Tongji | Hongik |
| | Toluca | | UCON | | | |
| | UIA | | Wayne | | | |

# APPENDIX E: INSTITUTIONAL PARTICIPATION AGREEMENT

## Institutional Participation Agreement for International ME 471

The Advanced Applications in Computer Aided Engineering Course (ME 471) is designed to provide students with an opportunity to learn and practice the theory and application of CAx, communication, and engineering product lifecycle management (PLM) tools in a distributed (international) team environment. Teams with international team members will have an opportunity to develop cross-cultural skills and experience working in a global virtual team. To ensure the success of each team and participant the following participation requirements and expectations must be adhered to:

***1. Institutional Software Resources***

Students must have on-campus access to the software programs that will be used throughout the course. Software licenses must be up-to-date and in sufficient quantity to accommodate all students who will be participating from the local institution. The required programs include:

- Siemens NX 6.0
- Siemens NX-Nastran Solver
- Siemens NX-ADAMS Solver
- Altair HyperMesh 10.0
- ANSYS-Fluent 6.3.26
- Skype
- High Speed Internet for Access to:
    - Google Docs Suite
    - Siemens Teamcenter Community (TcC)
    - Siemens Teamcenter Engineering (TcE)

The hours of access to computers and the above mentioned software programs must be reasonable and sufficient to enable the student teams to collaboratively work on and complete their team projects.

In addition, a connectivity test must be conducted for Skype, TcC, and TcE prior to the beginning of the course between the local institution and Brigham Young University (BYU) to ensure that adequate bandwidth and communication quality can be attained for team collaboration activities.

***2. Institutional Hardware Resources***

Students must have on-campus access to videoconferencing equipment and rooms for the duration of the course. Although institutions may elect to participate asynchronously for lecture and lab activities, videoconferencing hardware is required to support student team and faculty collaboration needs. If necessary, conferencing facilities and hardware must be scheduled in advance to ensure student or faculty collaboration is not impeded. *See the lecture and lab schedules to insure correct reservations of your conferencing facility. Additional hours will need to be reserved for weekly faculty and student team meetings.*

The videoconferencing hardware must be able to connect via an IP address with the BYU Tandberg endpoint and Conferencing Bridge. A connectivity test must be conducted prior to the beginning of the course between the local institution and BYU to ensure that adequate bandwidth is present to suggest that good and reliable communication quality can be attained for team and faculty collaboration needs.

***3. Prerequisites for Student Participation***

Students must have satisfactorily completed a beginning CAD course prior to enrolling in the ME 471 course (preferably focused on Siemens NX CAD software). CAD topics in ME 471 are of an advanced nature and necessitate this requirement. At BYU, the ME 471 course is offered as a technical elective for junior (3$^{rd}$ year) or senior (4$^{th}$ year) engineering students. Students that participate should be of a similar standing in their engineering program.

Prior to the beginning of the course, students must be made aware of and agree to the commitments and expectations of involvement in the ME 471 course, which are outlined in the "Student Participation Agreement for International ME 471".

***4. Student Mentoring Resources***

We have found that the extent to which students have access to mentoring resources at the local institutions has a direct effect on student performance and understanding of the course material. To ensure that students have reasonable resources available to help them in learning course material, it is required that a faculty member, or a teaching assistant (TA) at the participating university be available to mentor students as necessary throughout the course. This may be accomplished through offering standard faculty or TA 'office hours' or other methods as agreed upon between the participating university and BYU.

In addition to local mentoring resources, BYU TAs will be available via Skype during scheduled hours each week to mentor non-local students. Also, non-local students are welcome to contact the BYU professors as needed.

***5. Faculty Commitment***

A significant level of faculty support and commitment is required to ensure that students are given the best international course and project experience as possible. As noted in (4) above, a faculty member at the participating university must make themselves available on a regular basis to assist students as necessary with course and teaming needs. This need may also be fulfilled through a TA or other method as agreed upon between the participating university and BYU.

Weekly faculty correlation meeting will be held via videoconference. This will enable faculty members from each participating university to discuss, coordinate, and receive feedback regarding student performance and comprehension of material, etc. Participating faculty members must agree to attend these sessions. Lecture materials will be made available to each professor in advance of the topic being presented in class. Participating faculty members may be asked to teach one (1) lecture topic during the semester. Plenty of advanced warning will be given to allow the faculty member adequate time to prepare.

It is estimated that the required faculty time commitment per week for participating in the international ME 471 course is 4 hours (per week).

***6. Department Commitment***

Department leadership must agree to support the students and faculty who will participate in the ME 471 course. This support is defined as: 1) Providing appropriate engineering course credit for students that participate in ME 471, 2) ensuring the necessary software, hardware, and other facilities are made available to faculty and students for the duration of the course, and 3) recognizing the faculty member time commitment for participating in ME 471.

Course credit can be provided as an engineering technical elective, a 'special topics in engineering' course, etc. such that all students (both at BYU, your participating institution, as well as at other institutions) receive similar motivation via the course grades/marks to contribute to and collaborate on their team project. Agreeing to 'recognize faculty member commitment to the course' indicates that the department will ensure that the faculty member has sufficient time and resources for participation as outlined in (5).

***After reviewing the above requirements and expectations related to participation in the ME 471 course, please sign and return this participation form to Dr. Greg Jensen (BYU).***

*We acknowledge that we have read the Institutional Participation Agreement for International ME 471 document and understand the above requirements and expectations governing our participation in ME 471. We agree that these expectations are reasonable and will abide by them.*

| | | | |
|---|---|---|---|
| **Faculty Member:** | ______________________ Print Name | ______________________ Signature | __________ Date |
| **Department Head:** | ______________________ Print Name | ______________________ Signature | __________ Date |

# APPENDIX F: STUDENT PARTICIPATION AGREEMENT

## Student Participation Agreement for International ME 471

The Advanced Applications in Computer Aided Engineering Course (ME 471) is designed to provide you with an opportunity to learn and practice the theory and application of CAx, communication, and engineering product lifecycle management (PLM) tools in a distributed (international) team environment. Teams with international team members will have an opportunity to develop cross-cultural skills and experience working in a global virtual team. To ensure the success of each team and participant the following participation requirements and expectations must be adhered to:

***1. Prerequisites for Participation***

As noted in the ME 471 Syllabus, you must have successfully completed an Engineering Graphics—Principles and Applications course (ME 172) or equivalent beginning-level CAD class. You are also required to have completed Engineering Mechanics and Dynamics courses (CE 203 and 204) or equivalent. Exceptions must be authorized in advance by Dr. Greg Jensen.

Lecture and lab instruction will be provided in International, or Global, English (i.e. the concept of English as a global means of communication). Also, team meetings and collaboration will primarily be conducted in International English. Although effort will be made to associate foreign-language BYU speakers with international students who have the correlative native language, it is expected that all students that participate will be able to communicate in English.

***2. Collaboration and Time Expectations***

As a team member on an international team, you are expected to make every reasonable effort to collaborate effectively on a personal and professional level with your team members. The extent and quality of team collaborations have a direct impact on team success and performance. It is expected that you will be fully committed to the success of your team project, and that you will work together using the collective team member strengths to be successful.

As noted in the ME 471 Syllabus, the class will *on average* require three (3) hours outside of class for every one (1) hour in class or lab. It is expected that you will plan for and allow the necessary time to work on the team project throughout the semester. You must also be flexible regarding times during which you can meet with your team, as this will depend to some extent on the location and availability of your international team members.

***3. Communication Expectations***

You are expected to be on time for course videoconference lectures and labs, and other team meetings. *Lectures and labs begin sharply on the hour.* Because of time zone and semester scheduling differences among participating universities, class lectures and labs will be recorded and made available online as soon as possible following lecture and labs. However, it is expected that students will make it a priority to participate synchronously in the videoconferences to the extent that it is possible. In addition, you are expected to be flexible to changes in lecture and lab times because of holidays and daylight savings time changes.

In connection with the collaboration expectations noted in (2), you will be required to establish and adhere to a team communication contract for working in your project team. A communication contract will improve team success by ensuring that each team member has a common understanding of team communication and process procedures. This is especially important when working in a distributed environment with people who may not have the same cultural background as you do. An example communication contract is provided on the reverse side of this document.

***After reviewing the above requirements and expectations related to participation in the ME 471 course, please sign and return this participation form to Dr. Greg Jensen (BYU).***

I acknowledge that I have read the Student Participation Agreement for International ME 471 document and understand the above requirements and expectations governing my participation in ME 471. I agree that these expectations are reasonable and will abide by them.

**Student:** ______________________ ______________________ ____________

Print Name | Signature | Date

## Sample Team Communication Contract[1]

The team communication contract should be drafted by the team leader and reviewed by the team. Once created, everyone should be explicitly asked and agree to uphold the decisions of the team. If someone later does not comply with the contract, then there is a specified agreement which can be referenced.

***Keep in touch with other team members:***

- ☐ Check your voice mail every day and return calls within 24 hours.
- ☐ Check your e-mail every day and respond to messages within 24 hours.
- ☐ 'Presence' will be used whenever you have schedule class, lab, or project time.
- ☐ Exchange documents using TcC, TcE, and other agreed upon technologies
- ☐ Attend all mandatory meetings.
- ☐ If you are going to be unavailable, let other people know in advance.
- ☐ E-mail messages are to be used for updating and exchanging information only. There are to be no surprises over e-mail about problems. Interpersonal issues are not to be resolved using e-mail: use the telephone or a face-to-face meeting.

***Meeting Management:***

- ☐ Be on time for videoconferences and other meetings and attend the entire meeting.
- ☐ Rotate time zones for meetings in order to be equitable and fair.
- ☐ Link times and dates to _____ (For example, Mountain Standard Time in North America).
- ☐ In video conferences keep the mute button on when not speaking.
- ☐ Do not interrupt others in meetings. Respect the agenda.
- ☐ An agenda is sent out by team leader via e-mail 48 hours in advance of every meeting, and minutes are sent out via e-mail 48 hours after every meeting. Rotate taking minutes.
- ☐ If there are people attending the meeting or in the audio conference or video conference whose native language is different from the language in which the meeting is being conducted, give them time to think and time to speak. Provide "think breaks" so that people can gather their thoughts.
- ☐ At the end of each meeting, evaluate how we performed in terms of abiding by our team norms.

***Decision Making and Problem Solving:***

- ☐ Strive for consensus but realize that consensus takes time and is not always necessary. If we cannot reach consensus, go with our expert team member's opinion.
- ☐ Keep the interests and goals of the team in the forefront of all decisions.
- ☐ Balance the local interests of team members with those of the entire team.

***Conflict Management:***

- ☐ Do not attempt to settle differences by using e-mail. Use the telephone and speak directly to the person. Go to the person first, not to the team leader or another team member. Engage the team leader only if the conflict cannot be resolved this way.
- ☐ Realize that conflict is a normal part of the team's life cycle and that conflict that is focused on the task and not on another person is healthy and productive.
- ☐ Recognize that unproductive conflict is more difficult to detect in a virtual setting and take the pulse of the team frequently to ensure that conflict produces positive tension. Don't let tensions build.

***Working Together to Produce or Review Documents/Designs:***

- ☐ Do not review details of long documents during group audio conferences; send them to the team leader or to another designated person.
- ☐ When working in a sequential (assembly line) fashion, move the document through the system in a timely manner. Give one another feedback when promised.
- ☐ Review the team's progress for one hour via audio conference every Monday morning. All team members are to attend, with no exceptions! All will send their agenda items and updates to the facilitator by Thursday at 5:00 P.M. (for example, Mountain Standard Time in North America).

[1] Adapted from: Bray, S. "Meeting the Challenges of Cross Cultural Work Teams." *12th Annual Colloquium on International Engineering Education*. 2009. 34-35.

# APPENDIX G: SURVEY SENT TO STUDY ABROAD PROGRAM STUDENTS

*Q1.1.* The purpose of this survey is to assess the impact of various study programs that are offered in the Fulton College of Engineering and Technology. Please be candid in answering the questions. Because the college offers several different kinds of study programs, some proposed learning outcomes will likely not apply to your situation, and you should not hesitate to indicate that you did NOT learn a particular skill. This will help us understand the strengths and weaknesses of the various programs. Your responses will be kept confidential and will not affect your grade in any way.

*Q1.2.* Please select your school:

- Brigham Young University (BYU)
- ITESM - Toluca
- McMaster University (Mac)
- National University of Singapore (NUS)
- Universidad Iberoamericana (UIA)
- University of British Columbia (UBC)
- University of Toronto (UT)

*Q1.3.* Please select the study program that you participated in this past semester:

- China Globalization
- China Megastructures and Megacities
- Engineering for International Development-Peru
- Engineering Internship: India
- Engineering Internship: China
- Global Product Development: Europe
- International Product Development and Design-Singapore
- Mexico Engineering (MESA)
- ME 475 Capstone (US Teams)
- ME 495R International Capstone
- ME 471 Advanced CAx

*Q1.4.* With which academic department are you affiliated?

- Chemical Engineering
- Civil and Environmental Engineering
- Electrical and Computer Engineering
- Mechanical Engineering
- School of Technology
- Other

*Q1.7.* What is your native language?

*Q1.8.* Do you speak a language other than your native language?

- Yes
- No

*Q1.9.* Please select the countries (other than current) where you have lived.
(CTRL+click to select multiple countries)

- Afghanistan
- Albania
- Algeria
- Andorra
- Angola
- Antigua and Barbuda
- Argentina
- Armenia
- Australia
- Austria

*Q1.10.* Please list the other language(s) (besides ${q://QID19/ChoiceTextEntryValue}) that you speak.

Second Language

Third Language

Fourth Language

*Q1.11.* Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/1}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | | | | |
| Writing | | | | |
| Speaking | | | | |

*Q1.12.* Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/2}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | | | | |
| Writing | | | | |
| Speaking | | | | |

*Q1.13*. Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/3}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | ○ | ○ | ○ | ○ |
| Writing | ○ | ○ | ○ | ○ |
| Speaking | ○ | ○ | ○ | ○ |

*Q2.1*. Consider the following statements as they relate to ${q://QID1/ChoiceGroup/SelectedChoices}. Please note that not all of the statements below will necessarily have been incorporated in ${q://QID1/ChoiceGroup/SelectedChoices}. **With this in mind, to what extent do you agree that ${q://QID1/ChoiceGroup/SelectedChoices} taught and enabled you to:**

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strong Agre |
|---|---|---|---|---|---|---|
| Understand concepts and principles of sustainability and globalization. | ○ | ○ | ○ | ○ | ○ | ○ |
| Understand and respect engineering practices and contributions that were foreign to you. | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe how culture influences team processes (i.e. team structure and processes, developing objectives, establishing rules, building trust, work ethic, etc.). | ○ | ○ | ○ | ○ | ○ | ○ |
| Apply principles of intercultural communication (i.e. Adjustments to formality, directness, body language, facial expressions, idioms, humor, etc. when communicating with persons of another culture). | ○ | ○ | ○ | ○ | ○ | ○ |
| Collaborate and work towards a common goal as a team member on a multicultural team. | ○ | ○ | ○ | ○ | ○ | ○ |
| Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices. | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain basic principles of global businesses (i.e. supply chain management, intellectual property, liability and risk, etc.). | ○ | ○ | ○ | ○ | ○ | ○ |
| Represent your own culture, social group, company, nation, etc., in a foreign culture. | ○ | ○ | ○ | ○ | ○ | ○ |
| Increase your general knowledge of global: history, events, public policy, politics, world organizations, geography, religions, etc. | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe how culture affects the perception of engineering work and the engineering profession throughout the world. | ○ | ○ | ○ | ○ | ○ | ○ |
| Develop a desire to interact with people from different countries to solve global problems. | ○ | ○ | ○ | ○ | ○ | ○ |
| Understand and compare world cultures (i.e. cultural beliefs, values, perspectives, practices, products, etc.). | ○ | ○ | ○ | ○ | ○ | ○ |
| Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies). | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Develop a desire to learn about different world cultures, events, and social issues. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Interact with engineering students (or engineers) from a culture different than your own. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Practice tolerance and flexibility when involved in intercultural interactions | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Describe how culture influences engineering product design. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Objectively evaluate and adopt advantageous cultural practices and values. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Appreciate and respect cultural differences. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Develop multicultural team leadership skills. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Identify, resolve, and minimize conflicts resulting from cultural differences. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Communicate in a second language (speak, read, write, and listen). | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

*Q3.1.* Were you a member of an engineering, design, or similiar team during ${q://QID1/ChoiceGroup/SelectedChoices}?

◯ Yes

◯ No

*Q3.2.* Did your team activities extend for the majority of the duration of the study program?

◯ Yes

◯ No

*Q3.3.* Who was your team leader?
(If you did not have a team leader, enter "None")

*Q3.4.* Please briefly describe your team's project objectives.

*Q3.5.* How often did you use the following technologies to interact with your team?

| | Never | Monthly | Weekly | Daily | More than once a day |
|---|---|---|---|---|---|
| E-mail | | | | | |
| Face-to-Face | | | | | |
| Network Folders/File Sharing (e.g. Google docs, CAEDM, TcC) | | | | | |
| Phone Calls | | | | | |
| Text Messaging | | | | | |
| Instant Messaging (e.g. Google Chat) | | | | | |
| Personal Computer Conferencing (e.g. Skype, iChat) | | | | | |
| Video Conferencing Room | | | | | |

*Q4.1.* Considering your team experience during ${q://QID1/ChoiceGroup/SelectedChoices}. Please indicate the extent to which you would agree that each statement describes your behavior and values.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| My experience on this team was positive. | | | | | |
| I learned how to work effectively on a team. | | | | | |
| Rules and procedures were set in our team's first meeting. | | | | | |
| I know how to use virtual technologies better. | | | | | |
| I communicate effectively on a team. | | | | | |
| Our team was very successful at accomplishing our project. | | | | | |
| I trust my teammates. | | | | | |
| My teammates share knowledge without being asked. | | | | | |
| Personality conflicts between team members occurred often. | | | | | |
| I took greater care in what I said and wrote so I did not offend other teammates. | | | | | |
| Our team openly discussed all team suggestions and options. | | | | | |
| Team members responded to e-mails within 24 hours. | | | | | |
| Some team member's suggestions were more important than others. | | | | | |
| My teammates regularly missed assignment deadlines. | | | | | |
| I can tell you 5 non-work related things about each teammate. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Teammates increased my understanding of the team task. | | | | | |
| Some teammates were difficult to work with. | | | | | |
| Rules and procedures set in our team's first meeting were not followed. | | | | | |
| Teammates were willing to adjust to each other's schedule. | | | | | |

*Q5.1.* Please indicate the extent to which each statement describes your behavior and values.

| | 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 my society has on other cultures. | | | | | |
| I love spending time with people from other cultures. | | | | | |
| Community and government are stronger with ethnic diversity. | | | | | |
| 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. | | | | | |
| Our country should welcome refugees and immigrants. | | | | | |
| I feel more comfortable living in a neighborhood with similar ethnic backgrounds to my own. | | | | | |
| I do better when my manager and supervisor are from my own country and cultural background. | | | | | |
| Minority groups within a country should conform to the customs and values of the majority. | | | | | |
| I read or watch world news. | | | | | |
| Learning about world events is important to me. | | | | | |
| I respect ideas and beliefs of people from foreign cultures. | | | | | |

# APPENDIX H: SURVEY SENT TO GLOBAL ME 471 STUDENTS

**Purpose of this Survey**
The purpose of this survey is to assess the impact of various global study programs that are offered in the Fulton College of Engineering and Technology. Please be candid in answering the questions.

Because the college offers several different kinds of global study programs, some proposed learning outcomes will likely not apply to your situation, and you should not hesitate to indicate that you did NOT learn a particular skill. This will help us understand the strengths and weaknesses of the various programs. Your responses will be kept confidential.

**Procedures**
The survey is comprised of questions in five (5) sections and will take approximately 30 to 45 minutes to complete. If you are unable to complete the survey in one session, your responses will be saved and you can exit and return to complete the survey at another time by following the survey link provided to you via email.

## Section 1

Please select your university:

- Brigham Young University (BYU)
- Hongik University (Korea)
- Toluca - ITESM
- Tongji University (China)
- Universidad Iberoamericana (UIA)
- University of British Columbia (UBC)
- University of Connecticut (UCONN)
- University of Sao Paulo (USP)
- Wayne State University (WSU)

With which other university did your team collaborate?

- Brigham Young University (BYU)
- Hongik University (Korea)
- Toluca - ITESM
- Tongji University (China)
- Universidad Iberoamericana (UIA)
- University of British Columbia (UBC)
- University of Connecticut (UCONN)
- University of Sao Paulo (USP)
- Wayne State University (WSU)

With which academic department are you affiliated?

- Chemical Engineering
- Civil and Environmental Engineering
- Electrical and Computer Engineering
- Mechanical Engineering
- School of Technology
- Other

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

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

What is your native language?

Do you speak a language other than your native language?

- Yes
- No

Please select the countries (other than current) where you have lived.
(CTRL+click to select multiple countries)

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria

Please list the other language(s) (besides ${q://QID19/ChoiceTextEntryValue}) that you speak.

| | |
|---|---|
| Second Language | |
| Third Language | |
| Fourth Language | |

Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/1}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | ○ | ○ | ○ | ○ |
| Writing | ○ | ○ | ○ | ○ |
| Speaking | ○ | ○ | ○ | ○ |

Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/2}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | ○ | ○ | ○ | ○ |
| Writing | ○ | ○ | ○ | ○ |
| Speaking | ○ | ○ | ○ | ○ |

Please indicate your level of fluency for ${q://QID10/ChoiceTextEntryValue/3}.

| | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Reading | ○ | ○ | ○ | ○ |
| Writing | ○ | ○ | ○ | ○ |
| Speaking | ○ | ○ | ○ | ○ |

## Section 2

Consider the following statements as they relate to ME 471. Please note that not all of the statements below will necessarily have been incorporated in ME 471. **With this in mind, to what extent do you agree that ME471 taught and enabled you to:**

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strong Agre |
|---|---|---|---|---|---|---|
| Represent your own culture, social group, company, nation, etc., in a foreign culture. | ○ | ○ | ○ | ○ | ○ | ○ |
| Use collaboration technologies in intercultural interactions. (i.e. web-conferencing, video conferencing, instant messaging, e-mail, application sharing technologies). | ○ | ○ | ○ | ○ | ○ | ○ |
| Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices. | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes. | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Understand and respect engineering practices and contributions that were foreign to you. | | | | | | |
| Objectively evaluate and adopt advantageous cultural practices and values. | | | | | | |
| Develop a desire to interact with people from different countries to solve global problems. | | | | | | |
| Apply principles of intercultural communication (i.e. Adjustments to formality, directness, body language, facial expressions, idioms, humor, etc. when communicating with persons of another culture). | | | | | | |
| Describe how culture influences engineering product design. | | | | | | |
| Understand concepts and principles of sustainability and globalization. | | | | | | |
| Collaborate and work towards a common goal as a team member on a multicultural team. | | | | | | |
| Understand and compare world cultures (i.e. cultural beliefs, values, perspectives, practices, products, etc.). | | | | | | |
| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strong Agre |
| Interact with engineering students (or engineers) from a culture different than your own. | | | | | | |
| Increase your general knowledge of global: history, events, public policy, politics, world organizations, geography, religions, etc. | | | | | | |
| Develop multicultural team leadership skills. | | | | | | |
| Practice tolerance and flexibility when involved in intercultural interactions | | | | | | |
| Communicate in a second language (speak, read, write, and listen). | | | | | | |
| Explain basic principles of global businesses (i.e. supply chain management, intellectual property, liability and risk, etc.). | | | | | | |
| Describe how culture influences team processes (i.e. team structure and processes, developing objectives, establishing rules, building trust, work ethic, etc.). | | | | | | |
| Develop a desire to learn about different world cultures, events, and social issues. | | | | | | |
| Appreciate and respect cultural differences. | | | | | | |
| Describe how culture affects the perception of engineering work and the engineering profession throughout the world. | | | | | | |
| Identify, resolve, and minimize conflicts resulting from cultural differences. | | | | | | |

## Section 3

Please indicate the extent to which each statement describes your behavior and values.
Note: You may have responded to these statements at the beginning of the semester. The purpose of this post-survey is to identify any changes in the way you respond to the same survey statements.

| | 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 my society has on other cultures. | ○ | ○ | ○ | ○ | ○ |
| I love spending time with people from other cultures. | ○ | ○ | ○ | ○ | ○ |
| Community and government are stronger with ethnic diversity. | ○ | ○ | ○ | ○ | ○ |
| 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. | ○ | ○ | ○ | ○ | ○ |
| Our country should welcome refugees and immigrants. | ○ | ○ | ○ | ○ | ○ |
| I feel more comfortable living in a neighborhood with similar ethnic backgrounds to my own. | ○ | ○ | ○ | ○ | ○ |
| I do better when my manager and supervisor are from my own country and cultural background. | ○ | ○ | ○ | ○ | ○ |
| Minority groups within a country should conform to the customs and values of the majority. | ○ | ○ | ○ | ○ | ○ |
| I read or watch world news. | ○ | ○ | ○ | ○ | ○ |
| Learning about world events is important to me. | ○ | ○ | ○ | ○ | ○ |
| I respect ideas and beliefs of people from foreign cultures. | ○ | ○ | ○ | ○ | ○ |
| | Almost Never True | Sometimes True | Usually True | Frequently True | Almost Always True |

## Section 4

Please rate your proficiency at the beginning and end of this semester for the following four (4) items.

At the (Beginning/End) of this semester, I was proficient:

...having a personal audio conversation with individuals in foreign countries

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...having a team meeting using audio conferencing technology

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...having a personal video meeting with individuals in foreign countries

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...conducting a team meeting using video conferencing technology

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

Please rate your proficiency at the beginning and end of this semester for the following four (4) items.

At the (Beginning/End) of this semester, I was proficient:

...sharing documents and files with team members over the Internet.

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...using an online calendaring tool to schedule team meetings or other team events.

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | | | | | |
| End of the Semester | | | | | |

...using an online project management tool to keep track of the progress of a project.

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | | | | | |
| End of the Semester | | | | | |

...using a CAD system to design a product with other team members and share parts over the Internet.

| | Never did it. | Did it, but not proficient | Somewhat proficient | Proficient | Very Proficient |
|---|---|---|---|---|---|
| Beginning of the Semester | | | | | |
| End of the Semester | | | | | |

How often did you use the following communication technologies during this semester while working with your team members?

| | Never | A few times a semester | A few times a month | A few times a week | Daily |
|---|---|---|---|---|---|
| E-mail | | | | | |
| Audio Calls | | | | | |
| Texting | | | | | |
| Instant Messages | | | | | |
| Video Calls | | | | | |
| Computer Screen Share | | | | | |
| Online Document/File Share and Collaboration | | | | | |
| Online Team Calendaring | | | | | |
| Online Project Management | | | | | |

From the virtual communication technologies listed below, select three (3) technologies and briefly explain appropriate and inappropriate situations for using those technologies.

1. Email
2. Telephone/Audio Calls
3. Texting
4. Instant Messaging
5. Video Calls
6. Computer Screen Share
7. Online Document/File Share and Collaboration
8. Online Team Calendaring
9. Online Project Management

| | |
|---|---|
| Technology 1 | |
| Technology 2 | |
| Technology 3 | |

What are specific lessons you have learned about using virtual communication technologies while interacting with your team members from a different university during the Fall 2010 semester? Briefly explain what you have learned and specific instances that helped you to learn the lessons.

## Section 5

Please indicate your level of competency at the beginning and end of this semester for the following five (5) items. Note: Even if you didn't have a cross-cultural collaboration experience, please indicate your level of competency (although your competency level might not change from the beginning to end).

At the (Beginning/End) of this semester, I was competent:

...communicating with people from different cultures.

| | Did not have relevant experience | Had some experience, but, little competence | Moderately Competent | Competent | Very Competent |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...completing tasks while working with people from different cultures.

| | Did not have relevant experience | Had some experience, but, little competence | Moderately Competent | Competent | Very Competent |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...resolving cross-cultural conflicts in a culturally sensitive manner.

| | Did not have relevant experience | Had some experience, but, little competence | Moderately Competent | Competent | Very Competent |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...building a good working relationship of trust with people from different cultures.

| | Did not have relevant experience | Had some experience, but, little competence | Moderately Competent | Competent | Very Competent |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

...applying different engineering standards from foreign countries.

| | Did not have relevant experience | Had some experience, but, little competence | Moderately Competent | Competent | Very Competent |
|---|---|---|---|---|---|
| Beginning of the Semester | ○ | ○ | ○ | ○ | ○ |
| End of the Semester | ○ | ○ | ○ | ○ | ○ |

To what extent do you agree that the ME 471 course materials and learning activities helped you to increase your desire to work in an international project team?

| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

During the past semester, how often did you communicate with team members from a different culture?

| Daily | A few times a week | A few times a month | A few times a semester | Never |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

On average, how many hours did you work on your ME 471 project per week?

[ ▼]

What percentage of the time you spent on your ME 471 project was spent working with team members from a different university?

[ ▼]

Please respond to the following short essay questions. Note: Do not hesitate to indicate that you did NOT learn a particular skill.

What specific lessons did you learn about how to effectively communicate with people from a different culture during the Fall 2010 semester? Briefly explain what you have learned and share the experience(s) that helped you to learn the lessons.

What specific lessons did you learn about how to effectively work on tasks with team members from a different culture during the Fall 2010 semester? Briefly explain what you have learned and share the experience(s) that helped you to learn the lessons.

Please respond to the following short essay questions. Note: Do not hesitate to indicate that you did NOT learn a particular skill.

What kinds of conflicts or challenges did your team experience?

What specific lessons did you learn about how to effectively resolve cross-cultural conflicts during the Fall 2010 semester? Briefly explain what you have learned and share the experience(s) that helped you to learn the lessons.

What did you learn about how engineering practices differ in different cultures as a result of the ME 471 experience?

# APPENDIX I: STATISTICAL ANALYSIS DETAILS OF GLOBAL COMPETENCIES

**Table I-0-1:** Apply principles of intercultural communication.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 3 | 4 | 13 | 19 | 19 | 58 |
| Global ME 471 | 1 | 4 | 6 | 12 | 9 | 3 | 35 |
| Total | 1 | 7 | 10 | 25 | 28 | 22 | 93 |

*Statistically different response pattern ($\chi^2(5) = 11.8$, $p = .037$, ES V=.36)

**Table I-0-2:** Represent your own culture, social group, company, nation, etc., in a foreign culture.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 3 | 5 | 22 | 28 | 58 |
| Global ME 471 | 1 | 1 | 4 | 16 | 8 | 5 | 35 |
| Total | 1 | 1 | 7 | 21 | 30 | 33 | 93 |

*Statistically different response pattern ($\chi^2(5) = 26.4$, $p < .001$, ES V=.53)

**Table I-0-3:** Appreciate and respect cultural differences.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 0 | 2 | 16 | 40 | 58 |
| Global ME 471 | 1 | 1 | 4 | 14 | 7 | 8 | 35 |
| Total | 1 | 1 | 4 | 16 | 23 | 48 | 93 |

*Statistically different response pattern ($\chi^2(5) = 36.4$, $p < .001$, ES V=.63)

**Table I-0-4:** Objectively evaluate and adopt advantageous cultural practices and values.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 4 | 13 | 18 | 22 | 58 |
| Global ME 471 | 1 | 5 | 5 | 13 | 5 | 6 | 35 |
| Total | 1 | 6 | 9 | 26 | 23 | 28 | 93 |

*Statistically different response pattern ($\chi^2(5) = 15.5$, $p = .008$, ES V=.41)

**Table I-0-5:** Practice tolerance and flexibility when involved in intercultural interactions.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 1 | 5 | 24 | 28 | 58 |
| Global ME 471 | 0 | 2 | 1 | 10 | 14 | 8 | 35 |
| Total | 0 | 2 | 2 | 15 | 38 | 36 | 93 |

*Statistically different response pattern ($\chi^2(4) = 12.5$, $p = .014$, ES V=.37)

**Table I-0-6:** Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 3 | 7 | 22 | 26 | 58 |
| Global ME 471 | 0 | 2 | 7 | 10 | 7 | 9 | 35 |
| Total | 0 | 2 | 10 | 17 | 29 | 35 | 93 |

*Statistically different response pattern ($\chi^2(4) = 15.4$, p = .004, ES V=.41)

**Table I-0-7:** Develop a desire to learn about different world cultures, events, and social issues.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 2 | 1 | 16 | 39 | 58 |
| Global ME 471 | 0 | 4 | 8 | 12 | 5 | 6 | 35 |
| Total | 0 | 4 | 10 | 13 | 21 | 45 | 93 |

*Statistically different response pattern ($\chi^2(4) = 43.9$, p < .001, ES V=.69)

**Table I-0-8:** Develop a desire to interact with people from different countries to solve global problems.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 1 | 5 | 19 | 33 | 58 |
| Global ME 471 | 2 | 5 | 3 | 5 | 10 | 10 | 35 |
| Total | 2 | 5 | 4 | 10 | 29 | 43 | 93 |

*Statistically different response pattern ($\chi^2(5) = 18.5$, p = .002, ES V=.48)

**Table I-0-9:** Increase your general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 2 | 10 | 15 | 30 | 58 |
| Global ME 471 | 2 | 5 | 5 | 14 | 5 | 4 | 35 |
| Total | 2 | 6 | 7 | 24 | 20 | 34 | 93 |

*Statistically different response pattern ($\chi^2(5) = 27.5$, p < .001, ES V=.54)

**Table I-0-10:** Understand and compare world cultures.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 1 | 4 | 23 | 29 | 58 |
| Global ME 471 | 1 | 2 | 9 | 9 | 11 | 3 | 35 |
| Total | 1 | 3 | 10 | 13 | 34 | 32 | 93 |

*Statistically different response pattern ($\chi^2(5) = 31.2$, p < .001, ES V=.58)

**Table I-0-11:** Understand concepts and principles of sustainability and globalization.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 3 | 5 | 13 | 36 | 58 |
| Global ME 471 | 0 | 2 | 3 | 18 | 9 | 3 | 35 |
| Total | 0 | 3 | 6 | 23 | 22 | 39 | 93 |

*Statistically different response pattern ($\chi^2(4) = 32.6$, $p < .001$, ES V=.59)

**Table I-0-12:** Identify, resolve, and minimize conflicts resulting from cultural differences.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 2 | 1 | 1 | 15 | 22 | 17 | 58 |
| Global ME 471 | 2 | 3 | 7 | 11 | 8 | 4 | 35 |
| Total | 4 | 4 | 8 | 26 | 30 | 21 | 93 |

*Statistically different response pattern ($\chi^2(5) = 16.0$, $p = .007$, ES V=.42)

**Table I-0-13:** Describe how culture influences team processes.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 2 | 2 | 3 | 10 | 22 | 19 | 58 |
| Global ME 471 | 0 | 0 | 6 | 12 | 12 | 5 | 35 |
| Total | 2 | 2 | 9 | 22 | 34 | 24 | 93 |

*Statistically different response pattern ($\chi^2(5) = 11.3$, $p = .046$, ES V=.39)

**Table I-0-14:** Interact with engineering students (or engineers) from a culture different than your own.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 3 | 3 | 4 | 7 | 11 | 30 | 58 |
| Global ME 471 | 0 | 1 | 2 | 12 | 11 | 9 | 35 |
| Total | 3 | 4 | 6 | 19 | 22 | 39 | 93 |

*Statistically different response pattern ($\chi^2(5) = 12.4$, $p = .030$, ES V=.37)

**Table I-0-15:** Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 2 | 0 | 1 | 8 | 18 | 29 | 58 |
| Global ME 471 | 1 | 4 | 2 | 15 | 9 | 4 | 35 |
| Total | 3 | 4 | 3 | 23 | 27 | 33 | 93 |

*Statistically different response pattern ($\chi^2(5) = 24.6$, $p < .001$, ES V=.51)

**Table I-0-16:** Describe how culture affects the perception of engineering work and the engineering profession throughout the world.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 1 | 6 | 24 | 26 | 58 |
| Global ME 471 | 1 | 4 | 5 | 13 | 7 | 5 | 35 |
| Total | 1 | 5 | 6 | 19 | 31 | 31 | 93 |

*Statistically different response pattern ($\chi^2(5) = 27.6$, $p < .001$, ES V=.55)

**Table I-0-17:** Describe how culture influences engineering product design.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 0 | 3 | 5 | 22 | 28 | 58 |
| Global ME 471 | 1 | 4 | 2 | 13 | 8 | 7 | 35 |
| Total | 1 | 4 | 5 | 18 | 30 | 35 | 93 |

*Statistically different response pattern ($\chi^2(5) = 23.6$, $p < .001$, ES V=.51)

**Table I-0-18:** Communicate in a second language.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 7 | 15 | 8 | 11 | 5 | 12 | 58 |
| Global ME 471 | 11 | 5 | 1 | 5 | 6 | 7 | 35 |
| Total | 18 | 20 | 9 | 16 | 11 | 19 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 9.9$, $p = .078$, ES V=.33)

**Table I-0-19:** Use collaboration technologies in intercultural interactions.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 5 | 5 | 16 | 18 | 14 | 58 |
| Global ME 471 | 1 | 1 | 1 | 10 | 7 | 15 | 35 |
| Total | 1 | 6 | 6 | 26 | 25 | 29 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 7.4$, $p = .196$, ES V=.28)

**Table I-0-20:** Develop multicultural team leadership skills.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 2 | 5 | 3 | 15 | 17 | 16 | 58 |
| Global ME 471 | 2 | 1 | 3 | 8 | 11 | 10 | 35 |
| Total | 4 | 6 | 6 | 23 | 28 | 26 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 1.9$, $p = .863$, ES V=.15)

**Table I-0-21:** Collaborate and work towards a common goal as a team member on a multicultural team.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 2 | 3 | 4 | 12 | 16 | 21 | 58 |
| Global ME 471 | 0 | 3 | 1 | 7 | 12 | 12 | 35 |
| Total | 2 | 6 | 5 | 19 | 28 | 33 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 2.6$, p = .759, ES V=.17)

**Table I-0-22:** Understand and respect engineering practices and contributions that were foreign to you.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 0 | 1 | 3 | 13 | 17 | 24 | 58 |
| Global ME 471 | 1 | 1 | 6 | 10 | 12 | 5 | 35 |
| Total | 1 | 2 | 9 | 23 | 29 | 29 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 10.7$, p = .058, ES V=.34)

**Table I-0-23:** Explain basic principles of global businesses.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Study Abroad Programs | 4 | 4 | 7 | 16 | 13 | 14 | 58 |
| Global ME 471 | 3 | 5 | 6 | 10 | 9 | 2 | 35 |
| Total | 7 | 9 | 13 | 26 | 22 | 16 | 93 |

*Not a statistically different response pattern ($\chi^2(5) = 6.1$, p = .294, ES V=.26)

## APPENDIX J: FOREIGN LANGUAGE CAPABILITY ANALYSIS DETAILS

**Table J-0-1:** Foreign language capability (all students): Communicate in a second language.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 9 | 12 | 6 | 9 | 11 | 18 | 65 |
| No | 9 | 8 | 3 | 7 | 0 | 1 | 28 |
| Total | 18 | 20 | 9 | 16 | 11 | 19 | 93 |

*Statistically different response pattern ($\chi^2(5) = 16.1$, $p = .007$, ES V=.42)

**Table J-0-2:** Foreign language capability (SA programs): Communicate in a second language.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 3 | 9 | 5 | 4 | 5 | 11 | 37 |
| No | 4 | 6 | 3 | 7 | 0 | 1 | 21 |
| Total | 7 | 15 | 8 | 11 | 5 | 12 | 58 |

*Statistically different response pattern ($\chi^2(5) = 11.9$, $p = .036$, ES V=.45)

**Table J-0-3:** Foreign language capability (SA programs): Represent your own culture, social group, company, nation, etc., in a foreign culture.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 0 | 0 | 3 | 5 | 16 | 13 | 37 |
| No | 0 | 0 | 0 | 0 | 6 | 15 | 21 |
| Total | 0 | 0 | 3 | 5 | 22 | 28 | 58 |

*Statistically different response pattern ($\chi^2(3) = 8.96$, $p = .030$, ES V=.39)

**Table J-0-4:** Foreign language capability (Global ME 471): Understand and compare world cultures.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 0 | 2 | 5 | 9 | 10 | 2 | 28 |
| No | 1 | 0 | 4 | 0 | 1 | 1 | 7 |
| Total | 1 | 2 | 9 | 9 | 11 | 3 | 35 |

*Statistically different response pattern ($\chi^2(5) = 11.3$, $p = .046$, ES V=.57)

**Table J-0-5:** Foreign language capability (Global ME 471): Understand and respect engineering practices and contributions that were foreign to you.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 1 | 0 | 3 | 7 | 12 | 5 | 28 |
| No | 0 | 1 | 3 | 3 | 0 | 0 | 7 |
| Total | 1 | 1 | 6 | 10 | 12 | 5 | 35 |

*Statistically different response pattern ($\chi^2(5) = 12.5$, $p = .029$, ES V=.60)

**Table J-0-6:** Foreign language capability (Global ME 471): Interact with engineering students (or engineers) from a culture different than your own.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| Yes | 0 | 1 | 0 | 9 | 9 | 9 | 28 |
| No | 0 | 0 | 2 | 3 | 2 | 0 | 7 |
| Total | 0 | 1 | 2 | 12 | 11 | 9 | 35 |

*Statistically different response pattern ($\chi^2(4) = 10.7$, $p = .030$, ES V=.55)

# APPENDIX K: EXPERIENCE LIVED ABROAD ANALYSIS DETAILS

**Table K-0-1:** Lived abroad (all students): Develop multicultural team leadership skills.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| No | 0 | 3 | 4 | 7 | 16 | 5 | 35 |
| Yes | 4 | 3 | 2 | 16 | 12 | 21 | 58 |
| Total | 4 | 6 | 6 | 23 | 28 | 26 | 93 |

*Statistically different response pattern ($\chi^2(5) = 10.7$, p = .017, ES V=.39)

**Table K-0-2:** Lived abroad (Global ME 471): Develop multicultural team leadership skills.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| No | 0 | 0 | 3 | 1 | 6 | 2 | 12 |
| Yes | 2 | 1 | 0 | 7 | 5 | 8 | 23 |
| Total | 2 | 1 | 3 | 8 | 11 | 10 | 35 |

*Statistically different response pattern ($\chi^2(5) = 11.9$, p = .036, ES V=.58)

**Table K-0-3:** Lived abroad (Global ME 471): Practice tolerance and flexibility when involved in intercultural interactions.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| No | 0 | 0 | 0 | 2 | 9 | 1 | 12 |
| Yes | 0 | 2 | 1 | 8 | 5 | 7 | 23 |
| Total | 0 | 2 | 1 | 10 | 14 | 8 | 35 |

*Statistically different response pattern ($\chi^2(4) = 9.75$, p = .045, ES V=.53)

# APPENDIX L: TEAM-BASED ANALYSIS DETAILS OF GLOBAL COMPETENCIES

**Table L-0-1:** Team-based experience (All students): Communicate in a second language.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 5 | 9 | 4 | 8 | 2 | 5 | 33 |
| ME 471 | 11 | 5 | 1 | 5 | 6 | 7 | 35 |
| Total | 16 | 14 | 5 | 13 | 8 | 12 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 8.17$, p = .147, ES V=.35)

**Table L-0-2:** Team-based experience (All students): Apply principles of intercultural communication.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 3 | 1 | 8 | 13 | 8 | 33 |
| ME 471 | 1 | 4 | 6 | 12 | 9 | 3 | 35 |
| Total | 1 | 7 | 7 | 20 | 22 | 11 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 8.46$, p = .133, ES V=.35)

**Table L-0-3:** Team-based experience (All students): Represent your own culture, social group, company, nation, etc., in a foreign culture.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 1 | 3 | 13 | 16 | 33 |
| ME 471 | 1 | 1 | 4 | 16 | 8 | 5 | 35 |
| Total | 1 | 1 | 5 | 19 | 21 | 21 | 68 |

*Statistically different response pattern ($\chi^2(5) = 19.6$, p = .001, ES V=.54)

**Table L-0-4:** Team-based experience (All students): Use collaboration technologies in intercultural interactions.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 3 | 1 | 10 | 13 | 6 | 33 |
| ME 471 | 1 | 1 | 1 | 10 | 7 | 15 | 35 |
| Total | 1 | 4 | 2 | 20 | 20 | 21 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 7.61$, p = .179, ES V=.33)

**Table L-0-5:** Team-based experience (All students): Appreciate and respect cultural differences.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 0 | 1 | 12 | 20 | 33 |
| ME 471 | 1 | 1 | 4 | 14 | 7 | 8 | 35 |
| Total | 1 | 1 | 4 | 15 | 19 | 28 | 68 |

*Statistically different response pattern ($\chi^2(5) = 23.7$, p < .001, ES V=.59)

**Table L-0-6:** Team-based experience (All students): Objectively evaluate and adopt advantageous cultural practices and values.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 3 | 7 | 14 | 8 | 33 |
| ME 471 | 1 | 5 | 5 | 13 | 5 | 6 | 35 |
| Total | 1 | 6 | 8 | 20 | 19 | 14 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 10.5$, p = .063, ES V=.39)

**Table L-0-7:** Team-based experience (All students): Practice tolerance and flexibility when involved in intercultural interactions.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 1 | 3 | 17 | 12 | 33 |
| ME 471 | 0 | 2 | 1 | 10 | 14 | 8 | 35 |
| Total | 0 | 2 | 2 | 13 | 31 | 20 | 68 |

*Not a statistically different response pattern ($\chi^2(4) = 6.81$, p = .146, ES V=.32)

**Table L-0-8:** Team-based experience (All students): Practice cultural equality by eliminating personal cultural prejudices, stereotypes, and discriminatory practices.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 3 | 3 | 14 | 13 | 33 |
| ME 471 | 0 | 2 | 7 | 10 | 7 | 9 | 35 |
| Total | 0 | 2 | 10 | 13 | 21 | 22 | 68 |

*Statistically different response pattern ($\chi^2(4) = 10.4$, p = .034, ES V=.39)

**Table L-0-9:** Team-based experience (All students): Develop a desire to learn about different world cultures, events, and social issues.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 2 | 1 | 10 | 20 | 33 |
| ME 471 | 0 | 4 | 8 | 12 | 5 | 6 | 35 |
| Total | 0 | 4 | 10 | 13 | 15 | 26 | 68 |

*Statistically different response pattern ($\chi^2(4) = 26.1$, p < .001, ES V=.62)

**Table L-0-10:** Team-based experience (All students): Develop a desire to interact with people from different countries to solve global problems.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 1 | 3 | 11 | 18 | 33 |
| ME 471 | 2 | 5 | 3 | 5 | 10 | 10 | 35 |
| Total | 2 | 5 | 4 | 8 | 21 | 28 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 10.8$, p = .056, ES V=.40)

**Table L-0-11:** Team-based experience (All students): Increase your general knowledge of global history, events, public policy, politics, world organizations, geography, religions, etc.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 2 | 7 | 8 | 15 | 33 |
| ME 471 | 2 | 5 | 5 | 14 | 5 | 4 | 35 |
| Total | 2 | 6 | 7 | 21 | 13 | 19 | 68 |

*Statistically different response pattern ($\chi^2(5) = 15.3$, p = .009, ES V=.47)

**Table L-0-12:** Team-based experience (All students): Understand and compare world cultures.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 1 | 4 | 16 | 11 | 33 |
| ME 471 | 1 | 2 | 9 | 9 | 11 | 3 | 35 |
| Total | 1 | 3 | 10 | 13 | 27 | 14 | 68 |

*Statistically different response pattern ($\chi^2(5) = 15.1$, p = .010, ES V=.47)

**Table L-0-13:** Team-based experience (All students): Understand concepts and principles of sustainability and globalization.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 3 | 5 | 7 | 17 | 33 |
| ME 471 | 0 | 2 | 3 | 18 | 9 | 3 | 35 |
| Total | 0 | 3 | 6 | 23 | 16 | 20 | 68 |

*Statistically different response pattern ($\chi^2(4) = 17.7$, p = .001, ES V=.51)

**Table L-0-14:** Team-based experience (All students): Develop multicultural team leadership skills.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 3 | 2 | 9 | 12 | 7 | 33 |
| ME 471 | 2 | 1 | 3 | 8 | 11 | 10 | 35 |
| Total | 2 | 4 | 5 | 17 | 23 | 17 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 3.78$, p = .582, ES V=.24)

**Table L-0-15:** Team-based experience (All students): Identify, resolve, and minimize conflicts resulting from cultural differences.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 2 | 0 | 0 | 9 | 14 | 8 | 33 |
| ME 471 | 2 | 3 | 7 | 11 | 8 | 4 | 35 |
| Total | 4 | 3 | 7 | 20 | 22 | 12 | 68 |

*Statistically different response pattern ($\chi^2(5) = 13.1$, p = .022, ES V=.44)

**Table L-0-16:** Team-based experience (All students): Describe how culture influences team processes.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 2 | 2 | 1 | 6 | 16 | 6 | 33 |
| ME 471 | 0 | 0 | 6 | 12 | 12 | 5 | 35 |
| Total | 2 | 2 | 7 | 18 | 28 | 11 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 10.2$, p = .070, ES V=.39)

**Table L-0-17:** Team-based experience (All students): Collaborate and work towards a common goal as a team member on a multicultural team.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 3 | 1 | 8 | 10 | 11 | 33 |
| ME 471 | 0 | 3 | 1 | 7 | 12 | 12 | 35 |
| Total | 0 | 6 | 2 | 15 | 22 | 23 | 68 |

*Not a statistically different response pattern ($\chi^2(4) = 0.23$, p = .994, ES V=.06)

**Table L-0-18:** Team-based experience (All students): Understand and respect engineering practices and contributions that were foreign to you.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 1 | 9 | 10 | 12 | 33 |
| ME 471 | 1 | 1 | 6 | 10 | 12 | 5 | 35 |
| Total | 1 | 2 | 7 | 19 | 22 | 17 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 7.64$, p = .177, ES V=.34)

**Table L-0-19:** Team-based experience (All students): Interact with engineering students (or engineers) from a culture different than your own.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 2 | 2 | 3 | 3 | 5 | 18 | 33 |
| ME 471 | 0 | 1 | 2 | 12 | 11 | 9 | 35 |
| Total | 2 | 3 | 5 | 15 | 16 | 27 | 68 |

*Statistically different response pattern ($\chi^2(5) = 13.1$, p = .022, ES V=.44)

**Table L-0-20:** Team-based experience (All students): Explain how culture influences engineering design processes, standards, problem solving, and manufacturing processes.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 2 | 0 | 0 | 4 | 12 | 15 | 33 |
| ME 471 | 1 | 4 | 2 | 15 | 9 | 4 | 35 |
| Total | 3 | 4 | 2 | 19 | 21 | 19 | 68 |

*Statistically different response pattern ($\chi^2(5) = 19.5$, p = .002, ES V=.54)

**Table L-0-21:** Team-based experience (All students): Describe how culture affects the perception of engineering work and the engineering profession throughout the world.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 1 | 1 | 3 | 16 | 12 | 33 |
| ME 471 | 1 | 4 | 5 | 13 | 7 | 5 | 35 |
| Total | 1 | 5 | 6 | 16 | 23 | 17 | 68 |

*Statistically different response pattern ($\chi^2(5) = 18.1$, $p = .003$, ES V=.52)

**Table L-0-22:** Team-based experience (All students): Explain basic principles of global businesses.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 3 | 4 | 4 | 9 | 7 | 6 | 33 |
| ME 471 | 3 | 5 | 6 | 10 | 9 | 2 | 35 |
| Total | 6 | 9 | 10 | 19 | 16 | 8 | 68 |

*Not a statistically different response pattern ($\chi^2(5) = 2.76$, $p = .737$, ES V=.20)

**Table L-0-23:** Team-based experience (All students): Describe how culture influences engineering product design.*

| | Strongly Disagree | Disagree | Somewhat Disagree | Somewhat Agree | Agree | Strongly Agree | Total |
|---|---|---|---|---|---|---|---|
| SA | 0 | 0 | 1 | 1 | 15 | 16 | 33 |
| ME 471 | 1 | 4 | 2 | 13 | 8 | 7 | 35 |
| Total | 1 | 4 | 3 | 14 | 23 | 23 | 68 |

*Statistically different response pattern ($\chi^2(5) = 21.2$, $p = .001$, ES V=.56)