AC 2012-3567: A COMPARATIVE EVALUATION OF GLOBAL VIRTUAL TEAMS TO TRADITIONAL STUDY ABROAD PROGRAMS IN ENGINEERING EDUCATION

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A Comparative Evaluation of Global Virtual Teams to Traditional Study Abroad Programs in Engineering Education

Abstract

A number of credible voices within the engineering community have expressed the need for engineering graduates to develop global competence. Many colleges of engineering have addressed this need by developing various technical study abroad programs. Typically these programs are resource intensive and only reach a fraction of students. For the past two years we have been conducting research on the possibility of developing some attributes of global competence without travel through global virtual (GV) teams which rely on internet-based collaboration. In this paper we present some preliminary data where we compare GV teams to traditional study abroad programs. The data show that for developing elements of global competence associated with teams, the GV team experience can be effective; however, for other elements of global competence, study abroad programs achieve superior results.

Introduction

Globalization is reshaping and redefining the world as we know it, increasingly integrating cultures, societies, and economies alike[1-5]. Recognizing that this trend is likely to not only continue, but also become more pervasive in the future[1,6], corporations throughout the world are increasingly using intercultural teams to meet the rising challenges and opportunities of operating on a global scale[3,4,6]. Similarly on the academic front, scholars have followed these trends, and have recognized the need to globalize the traditional university educational curriculum[1,7-9]. Numerous global program types have been proposed and developed, but particular difficulties among prominent global programs—such as study abroad programs—have been recognized, such as high resource requirements and low scalability[10].

International virtual team-based programs, 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. Also, more students can be accommodated through this method than through many of the other program types. However, little is documented of their comparative effectiveness in facilitating global competency education among engineering students.

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 a comparative investigation through which the relative strengths and weaknesses of programs in enabling the students to develop global competencies could be better understood. Therefore, this study was conducted to comparatively evaluate the extent to which engineering study abroad programs provide opportunities for engineering students to develop elements of global competence relative to those given to students that participated in the ME 471 course (a collaborative global team-based experience).

Background

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[7,10-11], few if any two programs are exactly alike. 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[11].

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[10]. Eight program types were suggested, and are included as Table 1. 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 here is to provide a representative overview of program types, this categorization will suffice.

Table 1: 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[10]

Because the objective of this research was 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, further discussion of these two program types is provided.

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 the following section where Brigham Young University (BYU) study abroad programs that were evaluated in this study are discussed.

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 1). 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[12] and programs and the ME 471 course taught at BYU, which will be further discussed in the following section.

Educational Programs Evaluated in this Study

A brief review of the different study abroad programs and the BYU class (global team project) offered in 2010 from which preliminary data for this research was collected is discussed here.

China Globalization

Through the China Globalization study abroad program, students spent six weeks 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. Several cultural excursions were taken throughout the trip to supplement this additional course emphasis. The students did not participate in design teams during the program[13].

China Megastructures and Megacities

This study abroad program is directed primarily to upper- or graduate-level civil engineering students. The emphasis of the program was to study some of the world's largest structures, such as the Three Gorges Dam. During the course, students participated in a two week excursion to China touring numerous sites and interacting with Chinese engineering students, engineers, and professors. The students worked on individual projects rather than in engineering teams in this program[14].

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" [15]. The program lasted about four weeks 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. Students participated in group projects, but were not involved in engineering design teams[15].

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. Students enrolled in an engineering course with content focused on the design of "energy, water, and sanitation for implementation in two Peruvian villages"[16]. Students also enrolled in a seminar course that prepared the "students for the trip to Peru through cultural, socio-economic, and logistics presentations"[16]. Following these courses, students were organized into engineering design teams to work on the humanitarian-based projects, and travelled to Peru for several weeks[16].

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. 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. In addition to working on the global team projects, students also visited companies located in Singapore that design and/or manufacture various products[17].

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. In this section, the traditional ME 471 class is briefly described followed by an overview of the changes that were 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. Most recently, 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.

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.

Globalized ME 471 Class

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 detail on the globalized ME 471 course and the transformation are found elsewhere[18-19].

Previous research had identified and validated twenty-three elements of global competency that are important for engineering students to develop to be prepared to work in a global environment[20]. From the list of global competencies, several competencies were identified for inclusion in the Fall 2010 ME 471 course offering, shown in Table 2. 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.

Table 2: 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.

Partnerships were 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. 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).

Additional course content in the form of lectures, reading materials, assignments, and labs was also introduced. Two new lectures were created focusing on global product design and the rationale for developing global competency. New readings were also provided as supplements for these course topics[21-22]. The first four labs of the course were modified to include training on communication tools (e.g. Skype, Dropbox, and Teamcenter Community) and virtual teambuilding exercises. Through the newly developed lab exercises, students became better acquainted with their remote team members and developed greater familiarity with the collaboration technologies. By working together in a global team, and by receiving instruction focused on topics pertinent to selected elements of global competence, students in the course were provided with opportunities to develop certain global competencies.

Research Method

A survey-based research methodology was employed to facilitate meeting the primary purpose of this study, which was to perform an evaluation of the ME 471 course in comparison to five study abroad programs offered at BYU. In addition to the study abroad programs mentioned previously, a pilot survey was sent to students participating in Winter 2010 Mexico Engineering Study Abroad (MESA) study abroad program. Several revisions to the survey were made to clarify question wording and improve the understandability of the survey based upon student feedback and analysis of survey results from the pilot studies. Data was collected from the Fall 2010 course offering of the ME 471 course, against which the aggregated study abroad program data was compared.

The set of twenty-three global competencies identified in the literature served as a basis for performing the comparative evaluation. A survey was developed and administered to students enrolled in each of the seven programs identified, enabling them to provide an evaluation of the extent to which the program of which they were a part enabled them to develop each of the twenty three identified and validated global competencies. A survey instrument was chosen primarily to obtain quantitative 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 programs either shortly before or after the completion of the program in which the student had participated.

The survey instrument used to perform the comparative evaluation consisted of 35 questions in three categories: educational demographics, linguistic capability, and incorporation of instruction on global competencies. The first questions in the survey (Questions 1 through 5 and Question 8) gathered general educational and geographical demographics information. The next section (Questions 6 and 7 and Questions 9 through 12) primarily dealt with student linguistic capability. In the third section, the students 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.

Results

The student response groups are first briefly described followed by a presentation of the results of the comparative study of global engineering education programs.

Response Group Demographics

The educational, geographical, and linguistic characteristics of the response groups for the two program types of interest in this study were analyzed and are reported in this section.

Of the 123 students participating in one of the six educational programs that received the survey, 93 students completed the entire survey for an overall response rate of 76%. Of the 75 students that were enrolled in study abroad programs, 57 completed the entire survey, for a response rate of 76%. Of the 48 students participating in the Global ME 471 course, 36 completed the entire survey, for a similar response rate of 75%.

Study abroad students that participated in this research 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.

Geographically, most students (88%) that were surveyed were currently living in the United States, although four other countries were represented in the study. However, in Global ME 471, about 33% of student respondents were from another country. 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.

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. 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.

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. Results describing how well each program type taught and enabled students to develop global competencies are displayed in Table 3, 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 3: 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		
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		

Table 3: (Continued)

Cptcy. Group	Global Competency	Response Group	Group Means	Group Std Dev	Overall Mean	Overall Std Dev
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.

Discussion of Survey Results

Overall, this preliminary data indicates that 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.

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 3 (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.

An unexpected 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. 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. 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). 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: 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 5) 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 5: 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	DISP

problems	
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 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.

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.

Conclusions

Although these findings are preliminary, several important conclusions were identified in this study. 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 data in this study also suggests that 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. With additional study and positive findings, collaborative team projects may prove an important part of the global engineering educational portfolio, in addition to study abroad and other global programs, by opening access to certain global experiences to more students in a more affordable way for both engineering departments and students.

Future Work

Several areas of future work are recommended to the global engineering education academic community. This study focused on performing a preliminary comparative analysis between only study abroad program types and a global collaborative project-based course. Additional research is needed to further validate the initial findings noted in this paper. Also, numerous other program types have been proposed and implemented. Further research should also 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.

Additionally, learning materials for teaching and tools for evaluating student knowledge, skills, and attitudes relative to the development of global competencies need to be further developed. Examples of this would include: development of learning outcomes and course materials for use among engineering students in both a variety of as well as specific global programs, 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.

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