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A Comparative Survey of Domestic and International Experiences in Capstone Design

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Abstract

This paper studies the differences between student experiences in domestic and international capstone design offerings for mechanical engineering students at Clemson University. For this, we conducted surveys and interviews of students participating in both the traditional domestic version of a capstone course at Clemson University and a group of students that participated in an international, study abroad version of a capstone course jointly administered by Clemson University and West Virginia University. The surveys were given to students before and after the program to assess whether the international component had an impact on their global awareness when compared to their peers in the traditional domestic program. The surveys, due to the low sample size available from only a dozen participating students, are augmented with interviews conducted at the end of the international program. The findings suggest that there is not a significant change in recognized attributes of global awareness for the population, but there was some movement within individuals. It is also seen that the reasons for participation in the international version of the course varied widely from a desire for international experience to the desire to graduate during the summer sessions when the only capstone option was the international version. The findings begin to provide justification for the international option based on some improvements with global awareness, but additional investigation is warranted as existing programs are continued and new programs introduced.

Keywords: Senior Design, Engineering Globalization, International Capstone, Capstone Design

1. Motivation: Global competency enhancement

It is generally recognized that engineers being educated today will need to achieve higher levels of global competency than those educated in the recent past. These future engineers will travel internationally as part of their work, interact with professionals from different countries with different cultures and languages, and perhaps even reside in these other countries. The social and cultural convergence of today's people and product have led to a more globalized economy [1]. Companies are becoming more decentralized, forcing engineering education to adapt to this new paradigm [2], [3]. International capstone design programs are one approach to support the development of the global competencies within students that are being deployed [4]. From the perspective of developing curricula to develop global competencies, the student should [5]:

- be aware of their role within the wider world as a citizen,
- respect and appreciate diversity of many kinds,
- understand global interactions from multiple points of view (economic, political, social, environmental, and technological)
- be a participant in the community from the local through the global level,
- assume responsibility for their own actions

There are other goals suggested, such as social justice and sustainability, but these are more morality based rather than pure competencies and are not explored here. Others, based on surveys of international programs, have developed a list of knowledge concepts that are central to defining a student's global competency [6]:

- Understand the student's own culture (norms and expectations)
- Understand other's culture (norms and expectations)
- Understand "globalization" from multiple points of view
- Awareness of current events
- Awareness of world history

The role of culture is integral in developing a successful globalization awareness program as the growth of globalization is dependent on culture rather than technical factors [7], [8]. Recognizing that developing these global competencies in future engineers is important, several engineering programs have introduced international options to their capstone design experiences [3], [9]–[12]. Many engineering design capstone programs use industry or externally sponsored projects to provide students with challenging self-directed team design experiences [13]–[18]. Moreover, these capstone design courses may involve professional engineers as sources for projects who, in turn, are a resource for evaluating student performance from a professional practice context [19]–[21]. Adding to these team and industry oriented experiences by integrating the program into an international program adds a new dimension for the students. However, there is a question about whether these new experience opportunities actually have a measureable impact on these students' global competencies. This paper begins to explore this question through a survey that was deployed to participating students in both domestic and international options in the capstone program at a domestic university, both before and after the course.

Multiple modes of international experiences currently exist for students, including those outside of engineering. There are efforts throughout the United States to support globalization of student education through opportunities such as student and faculty exchanges, overseas development, and international professional training [22]. Business Schools have recognized the need for education globalization to ensure the United States will succeed when many infrastructures continue to move overseas [23]. In 2008, nearly 300,000 students across multiple majors studied abroad for course credit [24].

Data collected within the last decade indicate less than 10% of engineering students participate in study abroad programs [25]. This number will continue to grow as schools have set goals to increase the number of study abroad opportunities. Well known engineering schools such as Georgia Tech, Purdue, and Virginia Tech have goals of 50%, 20%, and 15%, respectively, for student body participation in international experiences [26].

2. Background literature review on global awareness

The primary motive for incorporating an international component in Senior Capstone Design is to promote global awareness. Within the last two decades, there has been an increase demand in internationalizing education from the government, academia, and industry [27]. It has also become a focal point for the Accreditation Board for Engineering and Technology (ABET) as it sets guidelines for preparing the next generation of engineers. The current ABET program outcomes are as follows [28]:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multi-disciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Six of the eleven ABET program outcomes are nontechnical, broad education outcomes [29]. Unfortunately, many of these nontechnical outcomes are perceived as soft skills [30], however this has changed in recent times due to the growth of globalization and are often considered to be professional skills [31]. A popular strategy for addressing many of these outcomes is through international capstone project experiences [29], [32]–[34]. Outside of ABET, many engineering departments also review feedback from industry to assist in determining the outline of capstone design. For instance, the formation of group projects in nearly all capstone design projects across the United States was due to industry's acknowledgment of its importance [32], [35]. The focus of this study, however, is the impact of globalization on the education of the future engineer. Must capstone design courses change to accommodate the need for a global component in student education?

Many programs within the United States have recognized the need for an international component within capstone engineering courses. As a result, programs have incorporated an international version of capstone to their course offerings. In a report by National Academy of Engineers (NAE) [36], the significance of globalization on the next generation of engineers is recognized and stresses the necessity for engineers to grow their capabilities to fit a global need [37]. The goals for the next generation are engineers who are able to function within any global setting, speaking and adapting to the language of the country. Further, it is essential that engineers can readjust themselves to such an environment so they may professionally complete their international assignment [38]. However, in order to ensure engineers are capable of such adaptation to international settings, they must first be exposed to such. As a result, one of the newer roles that educators are responsible for is exposing students to work in an increasingly global economy where young engineers could be expected to work outside of their native country [39]. The purpose of an international capstone program is to afford students an opportunity to gain experience in working in an unfamiliar, foreign environment. Other schools, such as WPI have successfully performed international capstone projects for over 30 years [40], [41].

Though the technical aspects of engineering are of prime importance, the significance of globalization and functioning in a global environment is recognized. Engineers must now be capable of adapting to global settings where they must overcome the difference in rules and regulations. For instance, an engineer must be concerned with global sustainability, and such capabilities may eventually prevail an engineer's technical capability [42].

Many engineers are required to travel to international sites to execute assignments. The world of engineering has formed into a decentralized infrastructure where multiple design teams are working in sync on specific challenges. As a result, management skills are also an important consideration when pertaining to global engineering [38]. Management skills have become an important component for engineers, and learning such a skill in an international setting has become a growing need [43]. Studies have indicated engineers are not prepared for the cultural challenges they will face in the future [44]. This is primarily due to the inexperience engineers have in multicultural settings during their studies [38].

3. Description of the capstone program at Clemson

At Clemson University, capstone students are expected to have completed their introductory and secondary technical engineering courses. The capstone course provides students an opportunity to apply the knowledge gained from their previous courses while adapting design techniques to execute technical tasks. Capstone is a three credit hour course given during a single semester. Each student is grouped into a team of three to four students. This encourages the student to work on his or her own social skills alongside their technical knowledge. The student teams are provided with an industry sponsored design project. Teams must apply their knowledge of the design process to complete the project successfully.

3.1 Domestic version

The capstone design program in the Department of Mechanical Engineering at Clemson University has been a critical part of the curriculum for over forty years. Industry partners sponsors all projects and three to five teams of four to five students are assigned to each project. The expectation of each student is ten to fifteen hours of work per week so that for a team of five, the final deliverable is well over 600 man-hours throughout the semester.

The domestic version of capstone takes place during a normal fifteen week Fall or Spring semester. In this time frame, students are expected to work in their assigned teams to design, build and test a solution to their design problem. A summary of available projects is distributed amongst the capstone students and each student must submit a resume form to ascertain each student's experience level in design and fields of interest. The form also requires students to choose two positive and one negative choice for their preferences of projects or teammates. These forms are then used to assign students to teams.

Each design problem is assigned to three teams of four to five students each. The teams work independently to solve the same industry problem. Each student team is presented with the problem simultaneously by the sponsor on the Clemson campus and provided the same information regarding the project. Each team is expected to design, prototype and test their proposed solutions. They are also required to document their solutions and any findings from testing. Assigning multiple teams to the same problem allows for three to four distinct developed, prototyped, and tested solutions.

Industry sponsors provide the teams with a presentation of the problem to be solved. This presentation is succeeded by a plant tour and student verification and clarification of the proposed problem. Student teams give the sponsor an official progress report in their midterm presentation. The students are required to present their understanding of the problem during the midterm presentation. The sponsor is expected to be available to answer questions periodically throughout the semester. At the conclusion of the semester, teams present their final design and recommendations to the sponsor.

On campus, students have access to multiple forms of technical aide. The student machine shop is available to students during normal business hours where students can use machining tools such as mills, lathes, and other power and hand tools to prototype their designs. They also have access to a computational lab for creation of computer models and analysis as well as a meeting and discussion room reserved solely for the capstone design teams. Student teams are encouraged to have a short weekly internal meeting to collaborate on their design within the team in this room.

Two faculty members and a graduate coach are assigned to each project as an advisory committee. Weekly design reviews are conducted to provide feedback to the student design teams. Teams prepare a fifteen minute presentation to summarize the work completed over the past week and to propose a schedule of tasks for the upcoming week. Approximately eight weeks into the semester, teams are required to give a midterm presentation to the sponsor, including the understanding of the problem and their proposed solution ideas. During the second half of the semester, the teams must choose a solution, build a prototype, and test it. The results of the testing must be included in their final presentation and design report. Final deliverables include a prototype, fully detailed solution, and final design report complete with any necessary drawings and information for implementing the chosen solution.

3.2 International version

The international capstone program replaced the existing semester long capstone design course with a six week design course taking place in Querétaro, Mexico. In collaboration with one other domestic university and six Mexican universities, the program accommodates approximately 50 students. These students are working on their degrees in Mechanical or Mechatronic Engineering (Clemson University does not offer a Mechatronic Engineering degree). Each team will have a minimum of two students from each country and each student will be from a different university. Domestic students are also asked to submit a résumé so teams are created to best accommodate the industry sponsor, project needs, and student interests. The program is supported with assistance from the Mexican Council for Science and Technology, a governing body equivalent to the National Science Foundation (NSF) in the United States. The council collaborates with the two domestic schools to help students to learn how to work in a diverse team where they must overcome cultural and language barriers while successfully completing a project.

Before students arrive in Mexico, faculty advisors identify projects with local Mexican industry partners and prepare the project. This includes identifying the number of teams needed, skill set required, and scope of the project. Industry projects are assigned within the first week of the semester and a team is assigned by faculty to each project. In most instances, each project is only assigned one team. Each team visits their assigned industry sponsor to learn about the problem and the deliverable expected. Teams are encouraged to conceptually design, build, and test their solutions. Students then return to their sponsor the following day to begin working on the design problem. Students work on the project with their teammates at the industry sponsor site for eight hours a day, five days a week. The advantage of this, unlike its domestic counterpart, is students are in constant contact with the sponsor.

Students have access to their school programs and technology remotely through the internet but are not given a centrally located machine shop. The students have access to computer programs from their home university through use of their personal laptops. Student teams often work in the same room for the duration of the program but are still encouraged to have short team meetings each week.

Guidance for the project is provided in the form of two faculty members visiting each team twice weekly. On Fridays, students take a half-day from work so all the teams could meet in a central location to present their project and its current status. Each team presents their progress to all involved faculty, other students, and industry liaison to receive design feedback and constructive criticism. In these cases, teams are expected to fully design and perform as much analysis on the recommended design as possible without testing. All teams are required to supply the faculty with a written final design report discussing the problem, recommended solution, and validation for choosing the suggested solution. The final report must be produced in both English and Spanish.

4. Survey items

Based on a successfully deployed survey found in the literature [45], pre and post course surveys were developed to target information about student motivation and expectations of the course as well as their reflections on the program and how the experience influenced them. The sample size for the survey is determined by the enrollment of the capstone course versions. Each survey consisted of the following sections: participant demographics information, survey questions and instructions for survey completion. The survey questions were answered using a 1 to 5 Likert scale. For instance, a question regarding significance may have the following scale: (1) Strongly Insignificant, (2) Insignificant, (3) neutral, (4) Significant, and (5) Strongly Significant.

The sample sizes for each category of students surveyed are shown in Table 1~~Table 1~~. The Fall 2011 sample size of students from Clemson was twenty-four (24). The Summer 2011 students who participated in the programs consisted of seventeen (17) domestic and eleven (11) Mexican students. Of the seventeen domestic students, six were from West Virginia University students and the remaining eleven from Clemson University. Three students were females and the remainder males. Of the seventeen students, twelve had professional internship or cooperative education experience at an engineering site.

Table 1: Sample Size per Category

	Domestic	Mexican
Fall 2011 (Domestic Program)	24	NA
Summer 2011 (International Program)	17	11

The pre-course survey asked students about their future plans, past experience, the importance of various factors in choosing the program they selected, their level of preparation for the upcoming semester, their expectations about the course, and what they expected to gain from it. Two versions of the pre-course survey were distributed. The domestic version survey excluded some of the seemingly irrelevant questions from the international version such as, “What did you do to prepare for the challenge of living in a country that does not universally speak (English)?”

After completion of the course, students completed another survey which focused on how prepared they felt they were, if the experience caused them to change their future plans, and the importance of factors in their progress throughout the program. To capture more information about their experience and how it influenced/affected them, post-course interviews were conducted.

The survey was segmented into a quantitative portion, where students responded based on a Likert scale and other questions where students could comment or select one (or several) answers. The non-quantitative portion inquired about introductory student information such as how many technical elective courses they have completed, how often they had traveled, and their background in Spanish. Further, additional questions on how students prepared for the challenge of working in a foreign environment were included. Students were also asked about their goals for participating in the program. Students were given twelve answers to choose from and they were to select all that applied. They were also given the option to state a response outside of the given choices. This was the most critical question in the non-quantitative portion as it identified the motivation of students for participating in the program.

The quantitative portion of the survey makes use of a Likert scale to measure student response. It focused on the aspects of the program students felt were important in their decision to participate, the relevance of each survey item to their participation in the program, their expectations of the program, and how prepared they were for the challenges they experienced. The forty-four (44) quantitative questions given to the students are shown in Table 2~~Table 2~~.

Table 2: Quantitative Survey Questions

Item #	Survey Question
1	Are you interested in taking formal instruction in Spanish upon returning to the US? *
2	How influential do you believe this experience will be to your future? *
	How important were the considerations listed below in your decision to participate in this program?
3	Information/encouragement from previous program students
4	Information/encouragement from program faculty/TAs
5	Applicability to future career/education goals
6	To learn/improve a language or language skills
7	The opportunities for programs such as this
8	The availability of an adequate program financial package
9	School/program requirements
10	Desire to travel
11	I want to experience going to another country
	Rate each statement below on its relevance to your participation in this program.
12	I want to learn Spanish in a technical context
13	I want to apply my engineering knowledge to real life problems
14	I wanted to be with my friends in a foreign country
15	The program related to my area of study within engineering
16	I want to get experience working on a multicultural team
17	I want to use my knowledge to serve others
	Do you expect this program to help you develop your:
18	Leadership skills?
19	Do you expect this program to help you develop your Cultural Awareness skills?
20	Do you expect this program to help you develop your Team Working skills?
21	Do you expect this program to help you develop your Technical Competence skills?
22	Do you expect this program to help you develop your Language skills?
	Indicate how important the ability below is to you
23	Communicate in your host country's language in a social setting (conversational fluency)
24	Communicate in your host country's language in a social setting (professional/technical fluency)
25	Exercise leadership skills
26	Function on multidisciplinary or cross functional teams
27	Resolve interpersonal conflict within a group or team
28	Indicate how important the ability above is to you
29	Carry out projects independently
30	Practice engineering in different cultural settings
31	Work in a cross-cultural environment
32	Professionally collaborate with persons in your host country's workplace environment
33	Approach problems from different perspectives
	Rate how prepared you feel you are in the ability
34	Communicate in your host country's language in a social setting (conversational fluency)
35	Communicate in your host country's language in a social setting (professional/technical fluency)
36	Exercise leadership skills
37	Function on multidisciplinary or cross functional teams
38	Resolve interpersonal conflict within a group or team
39	Indicate how important the ability above is to you
40	Carry out projects independently
41	Practice engineering in different cultural settings
42	Work in a cross-cultural environment
43	Professionally collaborate with persons in your host country's workplace environment
44	Approach problems from different perspectives

The first two questions refer to the students' interest in taking formal instruction in the foreign language. The second question grouped influence of the experience on the student. The remaining quantitative survey items are segmented under five question groups. The first question group measures how important specific factors (survey item 3-11) were in their decision to participate in the program. The second question group measures the relevance of specific factors (survey items 12-17) to student participation in the program. The third question group investigates how specific aspects of the program (survey items 18-22) have helped develop the student. The fourth and fifth question groups inquire about the perceived importance and student preparedness, respectively, of key abilities (survey items 23-33) needed within the program.

5. Analysis of survey results

The analysis of the survey revealed two important findings regarding student's reasons for participating in capstone and the influence of the program on the students. Most of the remaining questions did not result in significantly different responses between summer, fall, or domestic or Mexican students' samples.

5.1 Domestic vs. international participation

Figure 1~~Figure 1~~ contains responses between the pre course survey questions for domestic (Fall 2011) and international (Summer 2011) capstone students. Students who participated in capstone design were asked to complete a survey before the start of the course. This was performed to measure the difference in initial perception between both course versions. The responses shown in Figure 1~~Figure 1~~ pertain to the question of student motivation for participating in the program. Since students were allowed to select more than one response, the percentage of students who selected the each of the response choices from the domestic and international schools is shown. The three most popular responses from students are (1) resume enhancement, (2) growth of interpersonal skills, and (3) growth of maturity and self-confidence. These three responses were equally popular amongst students regardless of the course version they chose to participate in. The greatest difference identified was in the survey question relating to "Greater understanding of the U.S. and world affairs and history". Students electing to take the international version are slightly more interested in the U.S. and world affairs and history than students participating in the domestic version.

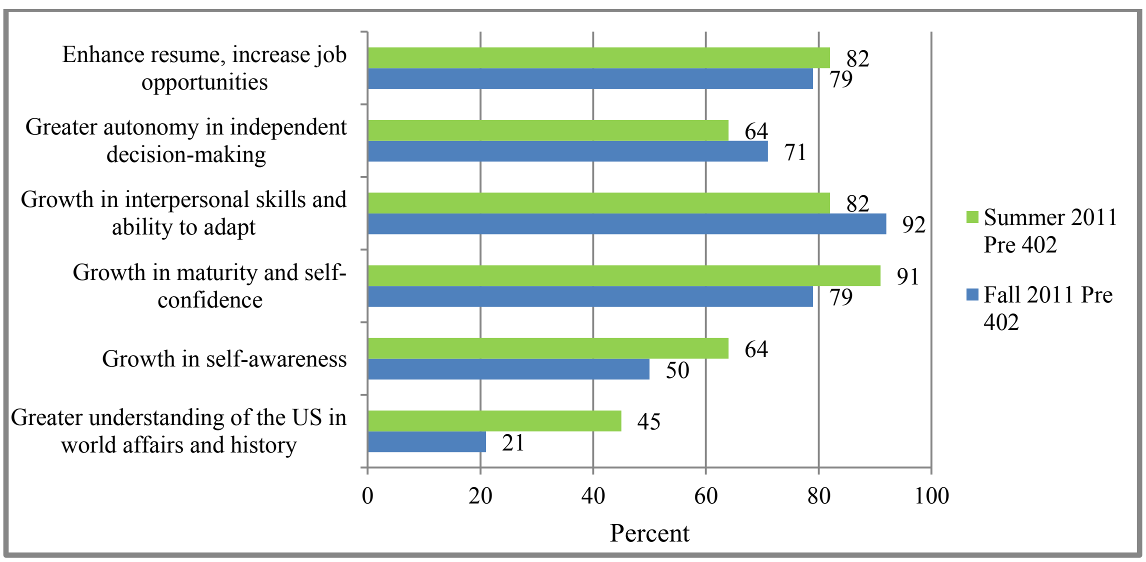

Figure 1: Student Expectations

The influence of the program on the students yielded a large disparity between sample groups. Students were asked about the influence they felt the program would have on their future. Comparisons of responses were made between domestic students before and after course responses as well as between domestic and Mexican student responses. The greatest disparity was identified between students who participated in the international and domestic version of the program. Figure 2~~Figure 2~~ shows the percentage of students who give this response a 1, 2, 3, 4 or a 5 (from strongly insignificant to strongly influential) on the Likert scale. For instance, 67% of the international students and 39% of the domestic students felt this program would have an influence (Likert score of 4) on their career.

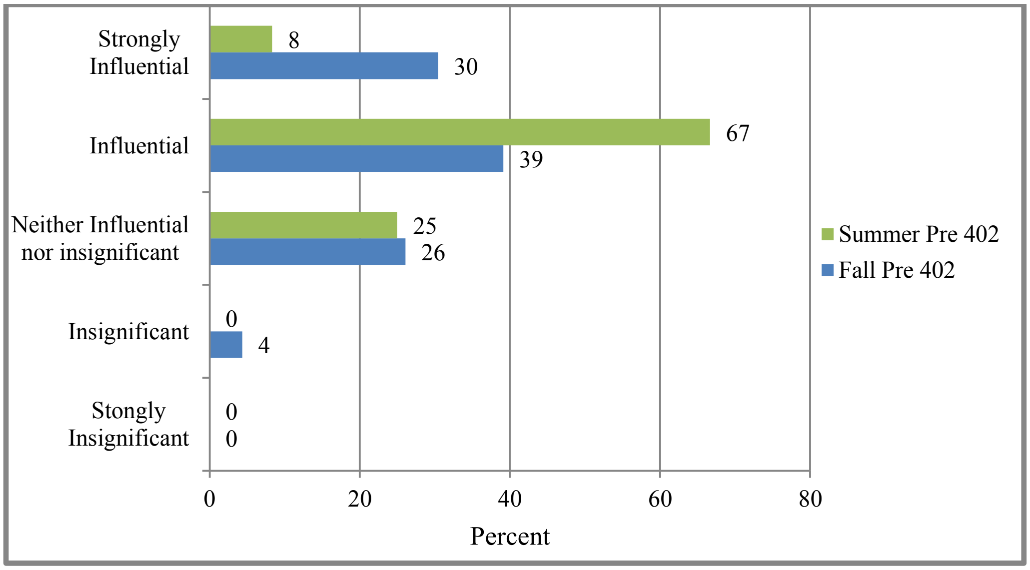

Figure 2: Anticipated Career Influence

Survey questions asked students how important certain factors were in their choice to participate in their version of capstone. They were also asked how relevant some factors were in their decision making process. The responses to the questions were analyzed using the corresponding Likert scale value. A t-test was performed to test for significant difference of the means of their responses. Although students have various motivations and goals for the program, relevance of factors to their course selection and importance of influences on their decision are not significantly different between the domestic and international students. Students were also asked before and after the course what they expected from the course in terms of personal development and what they gained. Again the responses showed no significant difference between before and after.

Students participating in the international version of the program indicated their desired to take advantage of the experience. This included: traveling to a foreign country, being abroad with friends, learning to speak a new language, or improving their current foreign language skills. These motivations for participation in this program are not seen amongst students electing to take the domestic version. It is also noted that students with more than average amounts of foreign language instruction or experience are more likely to choose the international version than the domestic.

5.2 International student responses

Over 50% of Mexican students were influenced enough by this experience that they had changed their future plans. Less than 20% of domestic students indicated a change of future plans after the experience. This may be indicative of the opportunities realized through the program as Mexican students seemed to be influenced by the program more than their American counterparts.

5.3 Change in domestic students' global awareness

While there is no statistical significance between the pre and post questionnaire responses, it is interesting to examine the individual level of responses. For instance, how many students increased in their desire to learn Spanish? This question could lead to insight regarding the student's appreciation for global awareness. If the program is successful in improving global awareness, it would be expected that students participating would show an increase in their responses, even if at a nominal level. If, however, it is seen that there is a decrease in their responses to this question, then it is possible that the program actually dissuades them from further studies of the language. Table 3~~Table 3~~ illustrates the changes between the pre-program and post-program questionnaires, tying the responses to individual students. The items numbers shown in the table correlate to the same item number shown in Table 2~~Table 2~~. Additionally, some non-global awareness questions are examined here as they relate to the general course objectives, such as team work and leadership impact. If it is found that there is a negative impact on the student's learning from this perspective, then a tradeoff examination is needed to determine whether the students increase in global awareness warrants the sacrifice on other course dimensions.

Table 3: Student Response Change

Item #	Questions	Average Change	Positive Change	Negative Change	Individual Shift
12	I wanted to learn Spanish in a technical context.	**0.1250**	3	2	**Positive**
13	I wanted to apply my engineering knowledge to real life problems.	-0.0625	2	3	Negative
14	I wanted to be with my friends in a foreign country.	**0.3125**	8	5	**Positive**
15	The program related to my area of study within engineering.	**0.1250**	4	5	Negative
16	I wanted to get experience working on a multicultural team.	-0.1250	4	6	Negative
17	I wanted to use my knowledge to serve others.	-0.1250	2	4	Negative
18	Did this program help you develop your Leadership skills?	-0.1250	3	5	Negative
19	Did this program help you develop your Cultural Awareness skills?	-0.1875	5	4	**Positive**
20	Did this program help you develop your Team Working skills?	**0.1875**	2	5	Negative
21	Did this program help you develop your Technical Competence skills?	-0.1875	3	5	Negative
22	Did this program help you develop your Language skills?	-0.4375	3	7	Negative

The global awareness related questions are shaded in Table 3~~Table 3~~ (No. 13, 16, 19, and 22). While each of these questions addresses global awareness, the question most closely related to global awareness is Question 19. This question, which deals with the impact of cultural awareness, resulted in more positive than negative changes for individual students. Five students responded positively and four students responded negatively to Question 19, however those who responded negatively experienced a greater overall change than those who responded positively causing the overall change average to become negative (-0.1875). For questions related to global awareness that saw a negative impact, it is unknown at this time what may cause this negative impact

For the other questions, it appears that there was positive impact on team working skills, but not on leadership and technical competence development. This could possibly suggest that students were not growing or did not recognize this growth within themselves, with respect to the general course objectives. Team work skills and recognition that the projects within the program were related to their area of study saw positive improvement.

Ultimately, the changes in the students are generally found to be negative for those questions related to global awareness and were neutral for those questions related to traditional course objectives. This possibly suggests that there is a gap between the intent of international study abroad programs such as this and the actual outcomes of the programs. Again, the statistical findings are not sufficient to warrant the abandonment of the programs, but it does suggest that a deeper study and investigation is needed, rather than a proliferation of these programs based on the faith and belief that they have a positive impact on students' global awareness. If this gap is present, one possible corrective action might be for the involved faculty to more explicitly discuss these objectives and to encourage more systematic student reflection through the program [46].

6. Interview Discussion

Alongside the survey, students were also interviewed for their feedback on the program. The interviews were performed after the students completed their final presentation to their advisors and peers. Students were given the opportunity to provide open ended feedback on the program, its benefits, and how it impacted them. Most students had positive feedback toward the program as it provided them with exposure to working in an international setting within a diverse team. Students also stated they felt better equipped to work within the engineering workforce due to their experience in the program. Students felt this program had an influence on them more than any other course in their engineering curriculum as they had to deal with challenges they never experienced. Further, students stated they felt this program would assist them in finding jobs as the experience made them more attractive candidates.

The negative comments received were primarily due to the initial learning curve students had to experience and overcome. Students expressed frustration in learning how to work with foreign team mates and communicating with their partners like they traditionally did with their domestic peers back home. Due to the language barrier, it was difficult communicating technical terms (words not often learned in basic Spanish courses) with their Mexican team mates. The initial struggle was eventually overcome, but it resulted in much time wasted and challenges in the beginning of the program. Further, engineering education in Mexico varied greatly compared to that of the United States and this was felt by the students. Students had to quickly adapt to their teammates' strengths and weaknesses. One of the greatest challenges experienced by students was the lack of availability of resources such as data, tools, or materials. Whereas in the United States most students have quick access to a machine shop or a local home improvement store to purchase material, this is not the case in Mexico.

Overall the feedback from the interview was positive toward the program. All students, with the exception of one, stated they would recommend the program to their peers. The students stated they felt this program was their premier experience in their undergraduate education and it has helped them understand the importance of global engineering.

7. Concluding Observations and Recommendations

While analyzing the survey results, one would ideally determine alignment of the responses with findings of other researchers. ~~it is important to identify if our findings align with the findings of other researchers. However~~Unfortunately, while strides have been made in developing assessment tools and performing outcome studies, the literature is thin in proposing an effective method for measuring such outcomes [30]. ~~Overall~~Generally, students expressed an overall positive feedback on their open ended interview questions. However, the survey questions indicated some~~a~~ negative change occurred in some areas of global awareness, which is needed to justify program offering. These conflicts in responses warrant further investigation.

Through the positive survey responses and interview feedback, we conclude that the program likely adds~~ed~~ value to students by providing them with an international offering of the capstone course. The cultural component of the course enhanced their understanding and appreciation of global engineering with both positive average changes and an increase in number of positive responses for two questions relating to personal relationships and to language. Students also gained exposure to students from other mechanical engineering departments both domestically and internationally. The program challenged students to overcome cultural and language barriers by strengthening their communication and interpersonal skills. These challenges were evidenced from some of the frustrations found in the survey responses and the declines on questions such as gaining multicultural team experience and improving general teamwork skills. It is possible that the students do not immediately recognize the lessons that they learned from these challenges and associate a challenging experience with not learning. For many students, this was their first exposure to students outside of their home institution. This was a valuable experience as students will interface with engineers from various universities with various backgrounds in the workplace. Through this, students are able to effectively collaborate in a foreign setting where traditional, easy to attain resources were not easily accessible.

A key observation noted was the allocation of tasks by domestic and Mexican students. In all cases, domestic students assumed leadership positions and delegated tasks to their team members. Mexican students, on the other hand, openly volunteered to complete specific tasks before they were assigned. This was of a surprise as the greatest challenge was identified to be the language barrier and, as a result, one would expect the leader on the team to be a Mexican native so they could efficiently communicate with the sponsor. However, this was not the case. Alongside this, domestic students experienced greater difficulty in communicating in Spanish than Mexican students did in English. Mexican students, many of whom were educated in English, possessed sufficient communication skills in both languages. Therefore, the leadership skills that were needed were more than simply communication skills and were readily recognized by all participants as residing primarily within the domestically trained students. This raises questions of training or cultural prejudices that needs to be explored further.

Though the study did not result in any statistically significant results, the findings of this study may suggest that the hopes and leaps of faith associated with developing new international study abroad programs to have positive impacts on students' global competencies are only partially supported by reality. These results align with the findings of others who have attempted to evaluate the merit of study abroad programs [47]–[56]. Ultimately, similar to the findings of other researchers, there is limited empirical support to either support or oppose such a study abroad program. More detailed evaluations are needed.

Evaluation of these programs should be established to help ensure that the programs have value in creating positive impacts on global competencies while not unnecessarily degrading or devaluing the traditional core objectives of these courses that they are replacing. This critical element of evaluation and continuous improvement is one that is not common in university programs which are faculty developed and implemented. The effort associated with these evaluations might be considered onerous on the faculty and outside of their areas of expertise. However, with training and a refinement of the survey instruments, it is possible to begin to develop a clearer understanding of the international programs landscape as it relates to the impact on global awareness.

Further, it is recognized that the post-program questionnaires were administered on the last day of the formal program. The true lasting impacts of these programs are more clearly seen from alumni surveys and comparisons after a number of years. Perhaps the state of mind of the students responding to the surveys was not positive as they had just completed six weeks of intensive engineering effort. These considerations and others might temper the conclusions on the impacts that the program had on the students. Therefore, it is recommended that subsequent, longitudinal studies of students' global awareness be explored.

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