Global Confidence: U.S. Student Outcomes from an International Capstone Design Experience

Dr. Daria A Kotys-Schwartz, University of Colorado Boulder

Daria Kotys-Schwartz is the Industry/University Cooperative Project Center Director and an Instructor in the Department of Mechanical Engineering at the University of Colorado Boulder. She received B.S. and M.S degrees in mechanical engineering from The Ohio State University and a Ph.D. in mechanical engineering from the University of Colorado Boulder. Dr. Kotys-Schwartz has focused her research in engineering student learning, retention, and identity development within the context of engineering design. She is currently investigating the impact of a four-year hands-on design curriculum in engineering, a holistic approach to student retention, the effects of service learning in engineering education, and informal learning in engineering.

Dr. Chiang Shih, Florida A&M University/Florida State University

Dr. Chiang Shih is a Professor in the Department of Mechanical Engineering, FAMU-FSU College of Engineering. He received his Ph.D. degree from the Aerospace Engineering Department at the University of Southern California in 1988 and joined the Department of Mechanical Engineering shortly after. He served the Chair of the Department from 2002 to 2011, during which time he led efforts in advancing both the undergraduate and graduate programs of the Department including the improvement of the senior capstone design project course sequence by providing students with real-world professional experience through the establishment of strong multidisciplinary and international collaborations. Dr. Shih's research interests are in the areas of unsteady aerodynamics, separated flow control, aero-acoustics, and optical diagnostic techniques. In recent years, Dr. Shih is responsible for the establishment of the Aeropropulsion, Mechatronics and Energy (AME) Center to build a coalition of multidisciplinary researchers in these three fields. He currently serves as the Director of the AME Center.

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Abstract
The Fund for the Improvement of Postsecondary Education (FIPSE)-Sustainable Energy and Aeronautical Engineering Program (SEAEP) brings together a consortium of four universities: Florida State University (FSU), the University of Pittsburgh (Pitt), Universidade Federal de Itajubá (UNIFEI) and Federal University of Paraná (UFPR) to train post-secondary engineering students for global engineering careers. A key aspect of this program is using design courses as a vehicle for student and faculty collaboration—both U.S. and Brazilian students are exposed to technical, professional and cultural experiences that can only take place through a international exchange program.

The purpose of this paper is to highlight how the cross-institutional international capstone design project course is impacting the program's anticipated U.S. student outcomes. We briefly review the FIPSE-SEAEP structure; detail the program goals, objectives and anticipated U.S. student outcomes; and provide an assessment approach to evaluating program criteria for a small cohort of student participants. The data presented represents the views of the FSU student participants from the 2011-2012 cohort. Assessment results indicate that FSU students are achieving 5 out of 8 of the anticipated U.S. student outcomes. Last, we highlight the strengths and weaknesses of the FIPSE-SEAEP, with respect to international capstone design project courses, and give recommendations for improving the program, which center on project-based courses.

Background
Previous studies have shown that international experiences for students can promote cross-cultural understanding, enhanced knowledge and skills, as well as global preparedness.[1-3] Additionally, research in engineering education has demonstrated that project-based courses can increase student retention, motivation, problem-solving ability, communication skills, knowledge retention, teamwork skills and the capacity for self-directed learning. [4-8] The FIPSE-Sustainable Energy and Aeronautical Engineering Program (SEAEP) places a project-based course in an international context—anticipating that student participants would realize the benefits of both study-abroad and project-based learning.

The Brazil-U.S. Fund for the Improvement of Postsecondary Education (FIPSE)-Sustainable Energy and Aeronautical Engineering Program (SEAEP) integrates the academic strengths of the two U.S. universities: Florida State University (FSU) and the University of Pittsburgh (Pitt), as well as the two Brazilian universities: Universidade Federal de Itajubá (UNIFEI) and Federal University of Paraná (UFPR). This structured exchange program provides an opportunity for U.S. and Brazilian students to expand their global, professional and technical competencies by leveraging a unique engineering design experience. [9]

A key *portion* of the FIPSE-SEAEP model is the cross-institutional international Senior Capstone Design project course.[9,10] Through this collaboration, FSU and the two

Brazilian universities develop Senior Capstone Design projects during the months of June, July and August. Select U.S. students travel to Brazil during the U.S. fall semester (the Brazilian spring term). These students participate in one of the international Senior Capstone Design projects developed during the summer before their departure. U.S. students work with Brazilian students to undertake the design and planning of the projects in Brazil.

As the U.S. students travel to Brazil, a group of Brazilian exchange students concurrently participate in an international Senior Capstone Design projects with U.S. students at FSU. At the conclusion of the fall semester (the Brazilian spring term), U.S. exchange students return to FSU to complete the design projects, and the Brazilian exchange students have the option to travel back to Brazil, intern with a U.S. engineering company, or stay at the host institution in the U.S. for an additional semester. For language and culture preparation, all of the U.S. exchange students were required to take a 1-semester Portuguese for Engineers (or equivalent) course. Additional details about the FIPSE-SEAEP international Senior Capstone Design projects, coordination between universities, student preparation, and barriers to success, can be found in previous papers written by the FIPSE-SEAEP team.[9,10]

For this paper, the authors focus on the *assessment results* of the U.S. exchange students that participated in the international Senior Capstone Design projects. It should be noted that not all FIPSE-SEAEP students were required to participate in the international Senior Capstone Design projects. For example, students from Pitt did not participate in this portion of the FIPSE-SEAEP program. Therefore, the assessment results discussed in this paper represent the opinions of the 2011-2012 cohort of students from FSU. The FIPSE-SEAEP team hypothesized that all eight of the expected U.S. student outcomes (listed in a subsequent sub-section) can be met by participation in a yearlong international Senior Capstone Design project. Achieving these anticipated program outcomes is essential to meeting the technical, professional and global competency expectations that budding U.S. engineers will face in industry.

Program Goals

The FIPSE-SEAEP has three key goals guiding the overall project:

Goal 1: Create diverse multi-national teams of engineering students with the opportunity to learn engineering in a global context

Objectives:

Diversity

1.1 Recruit a diverse multi-national group of U.S. and Brazilian students to participate in FIPSE-SEAEP

1.2 Recruit a diverse multi-national group of U.S. and Brazilian faculty to participate in FIPSE-SEAEP

Learning Opportunities

1.3 Establish international collaborative course projects and Senior Capstone Design projects between FSU, Pitt, UNIFEI, and UFPR
1.4 Create international internship opportunities for FIPSE-SEAEP participants

Goal 2: Prepare students for global professional experiences by increasing their cultural awareness

Objectives:

2.2 Create intensive language and cultural courses that will prepare FIPSE-SEAEP students for international exchange
2.2 Develop an online community where FIPSE-SEAEP students and faculty can interact and participate as a professional group

Goal 3: Establish long-term cross-cultural collaboration between consortium universities

Objectives:

3.1 Establish international research collaborations between FSU, Pitt, UNIFEI, and UFPR
3.2 Create self-sustaining research collaborations between U.S. and Brazilian engineering faculty at the consortium universities
3.3 Create long-term teaching collaborations between U.S. and Brazilian engineering faculty at the consortium universities

Expected U.S. Student Outcomes

After completing the FIPSE-SEAEP exchange program, it was expected that students will:

a. Be able to demonstrate proficiency in the Portuguese language (in oral and written form)
b. Be able to explain and recognize the cultural differences between Brazilian and U.S. engineers
c. Be able to explain the implications of designing and fabricating engineering products for use in a global context
d. Be able to understand the advantages and challenges of using web-based communications for cross-cultural engineering meetings
e. Be able to organize and use web-based communications to effectively run professional cross-cultural engineering meetings
f. Develop the teamwork and interpersonal skills necessary to successfully participate in a cross-cultural engineering team
g. Be able to successfully complete a cross-cultural engineering design project
h. Be prepared to apply to, and accept, engineering jobs that require international travel, or have corporate locations outside of the U.S.

Program Assessment

A mixed-methods (quantitative and qualitative) assessment approach was mapped to each of the program objectives and expected student outcomes. Table 1 depicts the assessment matrix for the project. Assessment methods target specific performance criteria to

ascertain whether expected program outcomes are met. Criteria are linked to a program outcome that is, in turn, linked to a project goal.

Table 1. FIPSE-SEAEP Assessment Matrix

Performance Criteria	Assessment Method
Goal 1: Create diverse teams of engineering students with the opportunity to learn engineering in a global context	
▪ Recruit U.S. and Brazilian student FIPSE-SEAEP participants ▪ Recruit U.S. and Brazilian faculty to participate in FIPSE-SEAEP ▪ Create and implement year-long capstone design projects ▪ Facilitate mentored international internship opportunities for U.S. and Brazilian students	▪ U.S. and Brazilian international exchange participant count ▪ U.S. and Brazilian international internship count ▪ Pre-departure survey ▪ Post-arrival survey ▪ Student interviews
Goal 2: Prepare students for global professional experiences by increasing their cultural awareness	
▪ Develop Portuguese for Engineers language class ▪ Create FIPSE-SEAEP website with program information ▪ Create FIPSE-SEAEP Facebook page to document student experiences in Brazil	▪ Pre-departure survey ▪ Post-arrival survey ▪ Student interviews ▪ Online community review
Goal 3: Establish long-term cross-cultural collaboration between consortium universities	
▪ Arrange faculty visits between consortium universities to explore research and teaching collaborations ▪ Form research collaborations between faculty at consortium universities ▪ Form teaching collaborations between faculty at consortium universities	▪ Faculty international exchange participant count ▪ Visiting faculty count ▪ Research proposal count ▪ Faculty interviews

Pre-departure surveys were chosen to establish a general baseline for U.S. student skills and attitudes regarding the FIPSE-SEAEP before the international exchange intervention. Topics in this survey included: general knowledge and attitudes about FIPSE-SEAEP; confidence in language preparation; confidence and attitudes toward FIPSE-SEAEP educational objectives; confidence about cultural preparation and interactions; confidence about professional preparation. A post-arrival survey — given once U.S. students returned to their home-institution and at the end of the academic year — was used to appraise the effectiveness of the FIPSE-SEAEP in changing students' attitudes assessed in the pre-departure survey. Semi-structured interviews were chosen so that the external evaluator would have the flexibility to probe participants for details and explore both FIPSE-SEAEP strengths and areas where students believed that improvements are needed. The end of the academic year was chosen for the post-arrival survey and student interviews since Senior Capstone Design projects, a foundational course for the FSU students, is a two-semesters class and culminates with an open house for project sponsors.

It should be noted that semi-structured interviews were also conducted with the Brazilian participants. However, these results were used as formative assessment for the program and will not be presented as part of paper.

A matrix to document individual student departures to the exchange university and return to their home-institution is being utilized to track students. This matrix also serves as a mode of communication between external evaluator and the FIPSE-SEAEP program directors regarding the status of each participant. This matrix is also employed to track administration of assessment to each student.

Data Collection

The data collected for the second year of the project took place between August 2011 and June 2012. Pre-departure surveys were administered to the FSU students in July 2011. All four participating FSU students filled out the survey before their departure to Brazil. The post-arrival survey was conducted in May 2012, with a response count of four. Both surveys were administered to students using an online survey system. Interviews were conducted with two FSU students in late April 2012 and the remaining interviews were conducted with the FSU students in late May 2012. A review of the content on the FIPSE-SEAEP website and FSU-Brazil Exchange page on Facebook was conducted in December 2011 and May 2012.

Results

Student Participation and Project Count

The FIPSE-SEAEP team set the goal of 16 undergraduate students participating in the international exchange between the U.S. and Brazil during the second year of the program. It was anticipated that each participating university would have an equal number of students (n=4) participating within the exchange.

For the 2011-2012 academic year, 14 undergraduate students participated in the FIPSE-SEAEP. Table 2 presents the data for the number of undergraduate students who participated in an international exchange between the U.S. and Brazil during the 2011-2012 academic year. The highest student exchange participation came from UNIFEI. Six students spent at least one semester at FSU and three students spent at least one semester at Pitt—for a total of nine UNIFEI students.

Table 2. FIPSE-SEAEP 2011-2012 Undergraduate Student Exchange Participation

	FSU and UFPR	FSU and UNIFEI	Pitt and UFPR	Pitt and UNIFEI	Total Students
U.S. Student Count	2	2	0	0	**4**
Brazilian Student Count	1	6	0	3	**10**

The cross-university collaborative Senior Capstone Design projects that were established in 2011-2012 included: Microalgae Biophotoreactor, SAE Aero Design Competition, Museum Drag Racing Exhibit, and the Rotor Assembly System.

Pre-Departure Survey

When evaluating the survey data, an 80% criterion was used to measure program success. For a Likert-type scale the ratings were assigned a numerical value, where strongly

disagree = 1 and strongly agree = 5. However, one should exercise caution when reviewing these numbers. With such a small sample size (n=4), a single respondent can dramatically alter the mean value. To reach the 80% criterion, a mean score of 4.0 or above is preferred. Mean values for a selection of survey questions are presented in Table 3.

Overall, students left for Brazil with an understanding of the FIPSE-SEAEP objectives and their personal responsibilities. There were initial concerns regarding the stipend provided to participate in the program (mean = 3.50). Students reported just above marginal confidence when it came to their ability to communicate using the Portuguese language. Though they felt the Portuguese for Engineers course was effective (mean = 4.0), their confidence in their ability to communicate in social situations or in the classroom was below the program targeted rating for success (mean scores = 3.25 and 3.75). Students demonstrated a high degree of confidence when asked about their ability to function in a foreign learning environment and on cross-cultural teams (see Table 4 – Educational and Professional Questions, mean = 5.0). Additionally, students felt the FSU FIPSE-SEAEP directors and Portuguese for Engineers course (required for all FSU FIPSE-SEAEP participants) prepared them for the cultural aspects of living and studying in Brazil.

Table 3. FIPSE-SEAEP 2011-2012 Pre-Departure Survey Results

Survey Questions	Mean Value
General Questions	
I understand the program objectives of the exchange program.	4.75
I understand my personal and professional responsibilities as a FIPSE Fellow and an FSU exchange student.	4.50
The stipend fund provided through the exchange program is adequate to supplement additional expenses for me to stay in Brazil (i.e. airfare, Visa, and some living expenses).	3.50
Language Questions	
The Portuguese language class is effective for me to acquire an adequate understanding of the language.	4.0
I am confident in my knowledge of the Portuguese language.	3.25
My understanding of the language will allow me to communicate effectively during my stay in Brazil.	3.75
I am confident that I can learn effectively in engineering courses being taught in the Portuguese language.	3.75
Educational Questions	
I am prepared for exposure to a foreign learning environment that may be different from what I have been used to.	5.0
I am confident in my ability to work as part of a design team with members whose cultural background may differ from that of my own.	5.0
Cultural Questions	
The exchange program coordinators implemented activities to better prepare me for a new social/cultural atmosphere.	4.0
I acquired high level of exposure to Brazilian culture/values by means of introductory Portuguese course and/or exchange program activities.	4.25
I am confident in my ability to work as a part of a design team with	5.0

members whose cultural background may differ from that of my own.	
Professional Questions	
I am confident in working effectively with a multi-national engineering student design team.	5.0
I am confident in my ability to travel abroad and function professionally in a foreign country.	5.0

Post-Arrival Survey

As discussed in the Pre-Departure Survey section — an 80% criterion was used to measure program success. Mean values and a selection of post-arrival survey questions are presented in Table 4. Again, one should look at these numbers as adding evidence to the program evaluation; but not proof of success or failure. With a sample size (n=4), a single respondent can shift the meaning of the results.

Table 4. FIPSE-SEAEP 2011-2012 Post-Arrival Survey Results

Survey Questions	Mean Value
General Questions	
The stipend fund provided through the FIPSE exchange program was adequate to supplement additional expenses for me to stay in Brazil.	2.5
I would participate in the exchange program again, if given the choice.	5.0
The goals of the FIPSE program were met: establish international collaborative Senior Capstone Design projects.	4.75
The goals of the FIPSE program were met: create internship opportunities for FIPSE participants.	3.75
The goals of the FIPSE program were met: learning engineering in a global context.	4.25
Language Questions	
The language class adequately prepared me to communicate effectively when I arrived in Brazil.	3.75
I was capable of taking engineering classes in Portuguese and understanding the material through lectures, labs, and textbooks.	3.75
Language has not created a barrier when trying to communicate thoughts or ideas clearly amongst the design team.	4.25
Educational Questions	
I effectively incorporated web-based communication (e.g., video conferences, dedicated websites, and/or social media networking) in the exchange of data, information, and project progression between local and abroad design team members.	4.0
I gained valuable experience from my collaboration with my assigned international design team.	5.0
I learned alternative approaches to the design process by observing foreign student team members undertake the design process.	4.5
My design experience provided by the exchange program has enhanced my ability to collaborate on projects in complex environments with people from diverse backgrounds.	4.75
Cultural Questions	
In retrospect, I think the FIPSE exchange program coordinators implemented activities which prepared me for new social/cultural atmosphere.	4.0
I feel confident in my ability to work as a part of a design team with	5.0

members whose cultural backgrounds differ from my own.	
I gained a greater appreciation of culture differences and I am more aware of different cultural perspectives as a result of my stay in Brazil.	4.75
I have a better appreciation of global issues as a result of my stay in Brazil.	4.75
Professional Questions	
The term "global economy" means more now than it did prior to the FIPSE exchange.	4.0
The exchange has given me the confidence to travel abroad and function effectively in a foreign country.	4.5
My awareness of the differences in technical constraints between a highly industrialized country and an emerging industrialized country has improved.	3.75
I would feel confident in my ability to engage in international collaborative projects involving emerging industrialized countries given my experience from the FIPSE exchange program.	4.5
The exchange program better prepared me for future involvement in multicultural engineering teams when I enter the professional field.	4.25

As was highlighted in the pre-departure survey, FIPSE-SEAEP students did not feel that the stipend provided was enough to cover the expense of living in Brazil (mean = 2.5). However, this did not change their attitude about participating in the program. All four students strongly agreed that they would participate in the program again (mean = 5). Students indicated that the FIPSE-SEAEP successfully met the goals of establishing international Senior Capstone Design projects (mean = 4.75) and having the opportunity to learn engineering in a global context (mean = 4.25). However, the program did not meet the expectations of all of the students when it came to the opportunity for international internships (mean = 3.75). Upon return, participants felt that their knowledge of Portuguese did not inhibit their ability to communicate on an international design team. But, ratings for student ability to understand a class in Portuguese (mean = 3.75) and the ability to use Portuguese in a social situation (mean = 3.75) when they arrived in Brazil were consistent with the pre-departure survey. By the end of the program, the participating U.S. engineers believed that they could integrate online tools to communicate with international team members (mean = 4.0). Additionally, they have learned alternative methods to approaching the engineering design process by working on a cross-cultural team (mean = 4.5). The students have also expanded their appreciation for the cultural differences (mean = 4.75) and global issues (mean = 4.75) after their stay in Brazil, and feel confident about working in international design teams (mean = 5.0). The first cohort of FIPSE-SEAEP students is leaving with a greater understanding of what it means to be an engineer working within a global economy (mean = 4.0) and the confidence to work and travel abroad (mean = 4.5).

Student Interviews

The following section highlights portions of the semi-structured interviews that took place between external reviewer and the FSU students. Rating questions as well as general open-ended questions were asked during the interview, allowing the evaluator to have the flexibility to create questions during the interview and probe for details. With the limited number of students interviewed, names/pseudonyms are not used when discussing the interviews. Instead, only the direct quotes are published to better protect

the anonymity of the students. Additionally, Senior Capstone Design project names were not used, in an effort to protect the students interviewed.

For the rated questions, a Likert-type scale was used. To determine mean ratings, a numerical value was assigned, where the low end of the scale = 1 and the high end of the scale = 5. The evaluator would read the questions to the interviewee during the phone interview and record the response. Table 5 reflects a portion of the rated questions. Students indicated that the FIPSE-SEAEP did meet their expectations (mean = 4.0). The low rating (rating = 2.0, mean = 3.3) for language preparation came from one student, who recommended that "usable" Portuguese (common phrases) be taught in the Portuguese for Engineers class. A single student also rated the academic preparation and team assignment preparation low (rating = 2.0, mean = 3.3). He expressed that he did not have the analysis background to complete a portion of the Senior Capstone Design project when in Brazil.

Table 5. FIPSE-SEAEP 2011-2012 Semi-Structured Rated Interview Questions

Rated Questions	Mean Value
General Questions	
Rate your overall experience – did it meet your expectations?	4.0
Was your language preparation adequate for studying in Brazil at the time you began taking courses?	3.3
Was your academic preparation adequate for studying in Brazil?	3.3
How prepared were you for this team assignment?	3.3

When asked about the most positive aspect of their academic experience in Brazil, three FSU students highlighted that they enjoyed seeing how engineering was taught in a different country. They enjoyed the hands-on aspect of the curriculum, as well as the interaction that they had with professors when in Brazil:

"*It is like seeing [engineering] in a whole new light – a different schooling experience. It was a bit of adjusting in the beginning…in Brazil your peers rely on the Professor - not many students have a self-directed style. However, there is more of a closer relationship between Professor and students. Professors will say - hey does anyone want to go and have lunch*."

"It was interesting to see how another university handles engineering. I liked their system – a lot of hands-on experiences. We [the U.S.] could learn from this. There were many hands-on classes (dynamics, mechanical systems, tools class)….you have a project that is a bigger than yourself. Students are directly involved with building a full size bioreactor. These projects are life size and industrial size – more real world."

" I really like the hands-on aspect of the classes. I also really like the Aero Design class – we got to go to the competition."

When asked about the most negative aspect of their academic experience in Brazil, students mainly focused on the issues that they had scheduling classes, finding housing, and communication issues between the Brazil and FSU Senior Capstone Design coordinators:

"It took a long time to get into the system - they have a blackboard system. It was disorganized in the beginning. We did not get class emails. International office sat down with each student to get schedules straight - after a month of being there."

"We needed technical electives. Their technical electives are much more laid back – we didn't know what to do, neither did UFPR. These classes were not taken very seriously. Really hard to get into the classes and they were more self-led classes."

"May have been miscommunication about how Capstone Design actually works. We weren't sure what we should be doing separately or together. The team members on the US side were disappointed that we could not help with the FSU class deliverables during the fall."

"The structure of Sr. Design was the most negative part. There were different design goals...it was the same project, but we were doing a completely different aspect in Brazil."

When discussing how has the FIPSE-SEAEP changed their educational/career plans, two students remarked that they would not be part of their mechanical engineering bachelors/masters (BS/MS) program without having participated in the program:

"I would not have become a member of BS/MS program without the FIPSE program."

"Before I went to Brazil, I did not know what I wanted to do – this provided some open doors. There was an opportunity for an internship if I did BS/MS program."

Students were eager to offer recommendation to improve FIPSE-SEAEP. The following statements were constructive criticism that students felt would improve the program for coming cohorts. The academic improvements coalesced around three areas: mechanics for the scheduling of courses in Brazil, continued modification of the Portuguese for Engineers class, and review of Senior Capstone Design project created between FSU and UFPR. The issue of housing and stipends frequently came up as a recommended area of improvement:

"My recommendation for pre-departure is: 2-semesters of Portuguese in a 20-week session. To make this available, and make it a more enriching experience, integrate it more into the schedule. My recommendation for Brazil: have more structure when we get there. Update the program schedule. Form some type of map of the classes – pick classes that are actually being offered. The International office could let Professors

know that International students will be in the class – especially important if you enter a class a late."

"I would not recommend non-traditional students going due to housing. We got into a 6-month lease, which was very difficult. I felt that we were too much of a burden on the ME program. The public transportation is very challenging…two buses and about an hour to get to class. The close housing, not in the best neighborhoods and the faculty were reluctant to have the FSU students live there"

"I would recommend the Senior Design project be better coordinated for the next group. Something more similar to the Aero Design project. Also, the stipend was not enough – a great deal more expensive at UFPR. At the other university the money went a longer way. Do not have students in apartments. Oh…and the Portuguese class should be more spread out."

Online Community

The FIPSE-SEAEP website was reviewed for program content. The website provides students with a clear overview of the program and requirements for participation. The FSU-Brazil Exchange page on Facebook was examined to understand how often students interacted with the page and if cultural awareness is promoted through the online community. FSU exchange students in Brazil used the Facebook page to log their experiences; a consistent posting rate occurred between July 2011 and early September 2011. Starting in late September 2011, the rate of posting became erratic. Student postings represent both technical aspects of the exchange program (photos of Senior Capstone Design projects and machine shop facilities) as well as an immergence in the Brazilian lifestyle (photos of campus, typical breakfast and sightseeing trips).

As of May 2012, there appears to be no participation from the Brazilian exchange students on the Facebook page. Also, there does not appear to be faculty interaction at the social media site.

Discussion

Evaluating the assessment results, there is evidence that the FIPSE-SEAEP is meeting two of the project goals and objectives through the yearlong international capstone design project:

Goal 1: Create diverse multi-national teams of engineering students with the opportunity to learn engineering in a global context

Goal 2: Prepare students for global professional experiences by increasing their cultural awareness

Diverse teams (having male and female team members) have been created combining FSU, UFPR and UNIFEI students. Four cross-university collaborative Senior Capstone Design projects were established, including: Microalgae Biophotoreactor, SAE Aero Design Competition, Museum Drag Racing Exhibit, and the Rotor Assembly System. The U.S. student count for the FIPSE-SEAEP did not met the target quantity, however, great strides are being made by to recruit students for the next exchange. Student cultural

awareness commenced in the Portuguese for Engineers class and developed during FSU student tenure in Brazil. The Portuguese for Engineers class was created specifically for FIPSE-SEAEP participants during the first year of the grant. Student awareness and appreciation of cultural difference was made salient during the semi-structured interviews. Student reference to the different approach to engineering education in Brazil and comments describing Brazilians as a "warm people" illustrates a cognizance of the cultural differences.

Objective 2.2 is the one objective that has been only partially achieved. When reviewing the Facebook page, there is little evidence that faculty interacted with this social-networking site. This minimizes the opportunity to use the page as a space for community building. Addressing this objective has been noted as a recommendation for future years.

U.S. Student Outcomes

The following U.S. student outcomes have been successfully addressed and program criteria for success (mean scores > 80%) has been met.

Outcome b (able to explain and recognize the cultural differences between Brazilian and U.S. engineers) was addressed in the Post-Arrival Survey sub-section, with questions aimed at cultural experiences having mean values of 4.75 and higher (out of 5.0 total). U.S. students indicated on their post-arrival survey that they could effectively integrate web-based communication into their team meeting (*outcome d* - able to understand the advantages and challenges using web-based communications for cross-cultural engineering meetings and *outcome e* - able to organize and use web-based communications to effectively run professional cross-cultural engineering meetings). Additionally, each cross-cultural Senior Capstone Design team successfully completed their assigned projects (*outcome g* - able to successfully complete a cross-cultural engineering design project) — with one team taking 3rd place in the FSU end-of the year project open house. The professional questions in the post-arrival survey investigate *outcome h* (prepared to apply to, and accept, engineering jobs that require international travel, or have corporate locations outside of the U.S.). Students report that they are very comfortable working in international design teams and have the confidence to travel abroad.

The subsequent outcomes have been identified for review or additional data collection. For *outcome a* (able to demonstrate proficiency in the Portuguese language, in oral and written form), student survey results as well as the student interview identified this as an area for improvement. The program target mean was not met for the Portuguese for Engineers course in the pre-departure survey, post-arrival survey or interviews. *Outcome c* (able to explain the implications of designing and fabricating engineering products for use in a global context) was moderately examined in the post-arrival survey, with positive results. However, *outcome f* (develop the teamwork and interpersonal skills necessary to successfully participate in a cross-cultural engineering team) was not directly assessed and should be more thoroughly investigated in the coming year.

Recommendations for Program Improvement

The following items have been identified as program shortcomings and the following areas were recommended for change for the next cohort of students:

- *Portuguese for Engineering Course*: This course is required for language and cultural preparation for all FIPSE-SEAEP students from FSU. Students have suggested that the course be extended in length, and a more rigorous emphasis be placed on the development of Portuguese language skills. These options should be considered, and the implementation of a continuous improvement cycle is necessary to ensure that student outcomes in language acquisition are met.
- *Senior Capstone Design Project Model*: The FSU/UFPR Senior Capstone Design project scope and coordination should be reviewed. Students suggest modeling the project after the FIPSE-SEAEP SAE Aero Design project—where they are able to work on the design phase in Brazil (collaboratively with the FSU counterparts in Florida) and come back to the U.S. to complete the fabrication and testing phase with the design team in Florida. Contemporary research in engineering education is lending evidence that the *design* of the design experience is just as important as the context if you hope to maintain student motivation throughout the project.[12, 13] Student outcomes cannot be accomplished with just any international design project, it needs to be a well-coordinated international design project.
- *Facebook website*: The utility of the Facebook website should be discussed. If this site is meant to serve as a forum for all FIPSE-SEAEP participants (students and faculty), it will be important to identify strategies to improve participation. The website was primarily used by FSU exchange students, but has the potential to serve as a central location for informal communication.
- *Assessment Survey*: Revisions to the pre-departure survey and post-arrival survey; questions should be added to better probe U.S. student *outcome c* and *f* through the pre and post survey:
    c. Be able to explain the implications of designing and fabricating engineering products for use in a global context
    f. Develop the teamwork and interpersonal skills necessary to successfully participate in a cross-cultural engineering team
- *Housing and Course Scheduling*: Student housing and course scheduling are ubiquitous issues in foreign exchange programs. However, it is possible that these challenges can distract students from the academic program and directly impact the U.S. student educational outcomes. Mechanisms should be developed that can help streamline course scheduling issues for students once they arrive in Brazil.

Limitations and Future Work

The authors acknowledge that this study is limited by the small sample size with respect to U.S. FIPSE-SEAEP participants from FSU. The data provides a glimpse into the effectiveness of the international Senior Capstone Design projects—however, it is with caution that the authors draw conclusions about this curricular model for international exchange.

For future work, the program assessment will include FIPSE-SEAEP student and faculty perceptions of student-faculty interactions, with respect to the international Senior

Capstone Design projects. This was unclear in the assessment data and needs further exploration due to the critical role these interactions can play in project success.

Conclusions

The assessment data provided preliminary evidence that five U.S. student outcomes, out of the eight anticipated outcomes, are being met through the FIPSE-SEAEP international Senior Capstone Design projects. It is anticipated that the remaining three outcomes can be accomplished through program modifications and changes to the assessment instruments.

It should be noted that 7 out of 8 of the FIPSE-SEAEP anticipated U.S. student outcomes directly align with the ABET Criterion 3 Student Outcomes (a-k).[11] Outcomes d, f, h, i and j are notoriously difficult for engineering programs to implement, and assess, in already overcrowded curriculums:

d. an ability to function on multidisciplinary teams
f. an understanding of professional and ethical responsibility
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

Though it is left to individual engineering programs to define these outcomes and how they will be measured—the FIPSE-SEAEP yearlong international Senior Capstone Design projects displays a potential to meaningfully addresses the challenging ABET Criterion 3 outcomes, while providing a unique educational experience for the student participants. It should be explicitly noted that the FIPSE-SEAEP Senior Capstone Design projects differ from a standard year abroad because students are immersed in practices that emulate cross-continent global industry operations. The FSU exchange students were required to meet the requirements of their U.S. stakeholders by interacting remotely on a regular basis. For example, the FSU student on location in Brazil communicated with their U.S. based project partners, the Senior Capstone Design Instructor (at FSU), and the FSU FIPSE-SEAEP Program Coordinator, through Skype, teleconference, and videoconference. Additionally, final semester presentations were conducted through joint video presentations.

While conducting the student interviews, it became apparent that participation in the FIPES-SEAEP was a life-changing event for many of the students. Several interviewees expressed that Brazil what the best experience that they had in their life—their perspective on engineering practices, their ability to work in a foreign country, as well as their knowledge of designing engineering solutions under cultural constraints was positively impacted in ways that would not change over time.

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