Brazilian Engineering Exchange Program

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Abstract - This paper presents the external, summative evaluation findings of the “International Teams in Engineering Industrial Projects: A Cooperative Manufacturing and Production Engineering Program”, funded by the Fund for Improving Postsecondary Education (FIPSE): Special Focus Projects from 1 September 2002 to 31 August 2007. The project was a collaborative between two US universities in North Carolina and two universities in Brazil, and involved student exchanges to the respective countries, where students studied engineering coursework.

During the evaluation, relevant documents were analyzed, interviews were held with the project PIs, and those students who had participated in the exchange visits to Brazil were surveyed. Evaluation findings are presented in relationship to the project objectives and other unanticipated outcomes. Overall, the exchange program was successful in achieving its objectives.

Index Terms – Program evaluation, study abroad program, student learning outcomes.

INTRODUCTION

The summative evaluation of the “International Teams in Engineering Industrial Projects: A Cooperative Manufacturing and Production Engineering Program” was conducted in the spring and summer of 2007. This program was funded by the Fund for Improving Postsecondary Education (FIPSE): Special Focus Projects. The project partnership involved the Industrial & Systems Engineering departments at two US universities (North Carolina State University & North Carolina A&T State University) and two universities in Brazil (Universidade Federal do Rio de Janeiro and Universidade Federal de Juiz de Fora). This report focuses on the two US universities and students sent on exchange to Brazil.

Increasingly, engineers are expected to complete globally and work in teams with people from different countries, including working in virtual communities. This in turn brings about logistical, cultural and technical challenges [1]. Additionally products and services must be designed to meet the social and technical constraints in other countries [2]. To help prepare students for future workplace requirements, the intention of this project was to provide students with experiences that would make them able to function more effectively as engineers by helping them in “understanding the cross-cultural issues that can impede successful team performance” [3].

To this end, the main objectives of the project were to
i. Promote the international exchange of engineering students,
ii. Enhance foreign language skills,
iii. Help students to understand different social and technical cultures,
iv. Build student capacity to work in a multi-national engineering design team.

METHODOLOGY

Methodologies employed during the evaluation process included interviews with the project PIs/faculty, a survey of students who participated in the exchange program to Brazil and the review of relevant documentation (including the FIPSE project proposal, progress reports, and students’ reflective accounts of their exchange experiences).

The survey questions were developed after reading all documentation and noting the processes that students were exposed to before and during their exchange program, and identifying the student learning outcomes that the faculty intended the students to achieve during the exchange. In addition to a few open-ended questions, students were asked to rate their opinions on a scale of 1 to 4 on 25 statements about their exchange experiences, where 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree. Data were aggregated and means and standard deviations calculated. Open-ended questions were analyzed by looking for common themes.

Faculty interview questions were generated based on documentation, student comments, and areas needing clarification. These were also analyzed for themes.

FINDINGS OF THE SUMMATIVE EVALUATION

I. Student Numbers

As stated in the project proposal, the project PIs aimed to send 18 students to Brazil over a 4 year period and they achieved this goal. In addition, there were 30 students who participated in project activities through the senior design projects, but who decided not to go on the exchange. Students typically spent six months in Brazil, starting with six weeks of language immersion prior to starting a semester of coursework, during which they took engineering courses in Portuguese.
II. Student Perspectives

The importance of students obtaining credit for coursework done in Brazil was identified early in the project and effective mechanisms, involving the Study Abroad Offices at respective institutions, were put in place to facilitate the transfer of credit between countries. While in Brazil students took courses approved by the home institution, and although some students signed up for additional hours, all students ultimately earned 9 or 12 credit hours toward their degree program and were satisfied with the arrangement. The additional hours they took were either courses that were outside of their degree requirements or electives that they did not need to graduate. All students agreed or strongly agreed that the exchange program had not negatively impacted their anticipated time to graduation.

When asked an open-ended question about what the most significant thing was that they had learned, students cited the value of becoming part of another culture for an extended period of time in helping them to learn to value diversity and different perspectives, and in building self-reliance and flexibility. They suggested that more students should undergo some form of exchange program because it enables one to see the world from a different and broader perspective. One student reflected that, “The education I received by living in the middle of the city, walking the streets everyday, and conversing with various people in Portuguese is invaluable and I urge anyone who is thinking about studying abroad to consider this program.”

Similarly, responding to an open-ended question about the most beneficial part of the exchange visit, students said learning to speak Portuguese and learning to live in a different country were the most valuable. Being exposed to living in another culture was noted as a central learning by most of the students, with comments like “being able to see and experience things not available in the US”, “learning to live in a different culture”, “improving survival skills” and “living with locals that are content to have half as much as I do” showed that the experience significantly impacted them. Gaining a global perspective on engineering was also considered important.

Three students stated that the most difficult part of the exchange visit was the absence of family and friends as a support structure. Six cited that the language difference was a barrier in taking courses and communicating with others, particularly in the initial few months of the visit while they were still building confidence to speak Portuguese. One student wrote in his reflection that, “The task of learning a language in 5 months and then studying course work in that language is by far no easy task. It is very difficult. It is also by all means worth the struggle.” Another wrote, “Because of total immersion, I was able to learn Brazilian Portuguese and become accepted by the locals.” Some students complained about the housing in Brazil, while others were satisfied with their accommodation. Despite any of the difficulties experienced, all students agreed or strongly agreed that they would ‘do it all again’.

Suggestions for improving the program included providing more cultural preparation and better orientation upon arrival, or even providing a mentor for the first few months. Student reflections showed that when new students were ‘shown the ropes’ by US exchange students who were already in Brazil and at the end of their exchange, that it helped with the process of adjusting the newcomers. Not all students were able to benefit from this due to the different timeframes when students participated in the program.

Some students found certain courses they took in Portuguese to be very difficult. Again, the role of language was cited as an area that needs reinforcement and students suggested that faculty stress the importance of learning the language sufficiently before embarking on the exchange.

Table 1 provides a summary of student responses to the 25 closed survey questions. Responses with a mean of 3 or higher indicate student satisfaction with that particular item. There are 18 items falling in this category, indicating that overall students were satisfied with their experiences and the level of support from their US institution. It also indicates that they felt that most of the exchange program learning outcomes had been achieved satisfactorily.

The highest ratings were given by students to their perceptions of their:

a. confidence to travel abroad and operate effectively in a foreign country (mean = 3.88 on 4 point scale),
b. recognition that there are different ways to achieve goals (mean = 3.75 on 4 point scale),
c. understanding and value of different cultural perspectives (mean = 3.75 on 4 point scale),
d. ability to work with different cultures and ethnicities (mean = 3.75 on 4 point scale),
e. ability to work in a multinational engineering team (mean = 3.75 on 4 point scale), and,
f. confidence in being assigned to work in an emerging industrialized country (mean = 3.75 on 4 point scale).

These six specific learning outcomes relate to two of the fundamental project objectives, namely (i) helping students to understand different social and technical cultures, and (ii) teaching students to work in a multi-national engineering design team, thus indicating that these objectives were achieved by the program.

The lowest scoring item, with a score of 2, showed that most students disagreed or strongly disagreed that they had learned new technological tools for use in engineering (1 A, 6 DA, 1 SDA). (Note: SA = strongly agree, A = agree, DA = disagree, SDA = strongly disagree, N/A = not applicable). The project PIs noted that while state of the art technology was available to them, they had experienced many problems
TABLE I
Summary of student responses to survey questions

<table>
<thead>
<tr>
<th>Student ratings on item: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The goals of the exchange program were clear.</td>
<td>3.13</td>
<td>0.33</td>
</tr>
<tr>
<td>2. I believe the program goals were met as a result of my participation in the exchange program.</td>
<td>3.38</td>
<td>0.48</td>
</tr>
<tr>
<td>3. The funds available to me through the exchange program and my regular funding sources were sufficient to cover my expenses.</td>
<td>2.75</td>
<td>0.43</td>
</tr>
<tr>
<td>4. I learned sufficient Portuguese prior to and in the initial phase of my exchange visit, to enable me to communicate effectively.</td>
<td>2.63</td>
<td>0.86</td>
</tr>
<tr>
<td>5. The program activities prior to my exchange prepared me adequately for what to expect.</td>
<td>2.33</td>
<td>0.47</td>
</tr>
<tr>
<td>6. I graduated (or am on track to graduate) within the time frame I originally anticipated.</td>
<td>3.25</td>
<td>0.43</td>
</tr>
<tr>
<td>7. I had sufficient contact with the international office at my US institution during my time in Brazil.</td>
<td>3.00</td>
<td>0.76</td>
</tr>
<tr>
<td>8. I had sufficient contact from the faculty at my US institution during my time in Brazil.</td>
<td>3.63</td>
<td>0.48</td>
</tr>
<tr>
<td>9. My stay in Brazil helped me to recognize that there are different ways to accomplish a goal.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>10. Because of the exchange, I respect that one approach to solving a problem is not necessarily better than another.</td>
<td>3.29</td>
<td>0.70</td>
</tr>
<tr>
<td>11. I better understand different cultural perspectives and values because of my stay in Brazil.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>12. Because of the exchange experiences, I would be able to work in a multi-national engineering design team.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>13. The experience increased my confidence to travel abroad and operate effectively in a foreign country.</td>
<td>3.88</td>
<td>0.33</td>
</tr>
<tr>
<td>14. The experience increased my confidence to work among different cultures and ethnicities.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>15. I learned new technological tools for use in engineering.</td>
<td>2.00</td>
<td>0.50</td>
</tr>
<tr>
<td>16. I have a better appreciation for global issues.</td>
<td>3.50</td>
<td>0.50</td>
</tr>
<tr>
<td>17. I have a better understanding of the meaning of ‘global economy’.</td>
<td>3.63</td>
<td>0.48</td>
</tr>
<tr>
<td>18. I have a good insight into other technical cultures and perspectives as a result of the exchange.</td>
<td>3.38</td>
<td>0.48</td>
</tr>
<tr>
<td>19. I became aware of technical constraint differences that exist between a highly industrialized country and an emerging industrialized country.</td>
<td>3.38</td>
<td>0.48</td>
</tr>
<tr>
<td>20. I would feel confident being assigned by my employer to work on a project in an emerging industrialized country because of my exchange experiences.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>21. My design experiences during the exchange helped me learn to work in a complex environment with people from diverse backgrounds.</td>
<td>3.00</td>
<td>0.76</td>
</tr>
<tr>
<td>22. I was exposed to companies that operate differently to those in the US.</td>
<td>2.71</td>
<td>0.70</td>
</tr>
<tr>
<td>23. I would do it all again.</td>
<td>3.75</td>
<td>0.43</td>
</tr>
<tr>
<td>24. Did your Brazilian experiences help you to find employment?</td>
<td>2.57</td>
<td>0.73</td>
</tr>
<tr>
<td>25. Is your employer taking advantage of your knowledge of Brazilian language and culture?</td>
<td>2.14</td>
<td>0.64</td>
</tr>
</tbody>
</table>

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in getting technology exchange between the countries to work. They had intended to use the Internet and FTP sites for students to collaborate on a design project, but their experiences resulted in them deciding not to use this approach. Reasons included differences in time zones, different semester schedules between the two countries, and Brazilian students only having access to technology during the day while on campus.

Similar problems may be encountered in industry in making global design projects work, but many of these can be overcome because it is simply a job requirement for team members to be available at whatever time of the day or night communication is possible between members at different international sites. In this case, because the design project was not associated with a particular course or grade, there was little incentive for students to make the process work. And, it was not possible to make the design project a course requirement because there were other non-exchange students taking courses and also because not all exchange students took the same courses. This resulted in the specific strategy of using technology for program activities being abandoned. A focus on technology was never a primary objective of the project, so this did not distract from achieving the overarching objectives as laid out in the original grant proposal.

Other items where student responses ranged between disagree and agree (i.e. mean between 2 and 3) related to the degree of preparation prior to departure (6 A, 2 DA), to their preparation and ability to communicate in Portuguese (1 SA, 4 A, 2 DA, 1 SDA) and to the adequacy of funding for the exchange visit (2 A, 4 DA, 2 N/A). These variations were due to several factors, including when the students went on the exchange visit (i.e. differences in experiences between the early and later exchange students), the amount of preparation that students invested in learning the language and culture, and differences in the way the two institutions arranged the visits and financial disbursements.

Progress reports show that both institutions worked to overcome any difficulties on these items as they emerged.

Two other questions that were in the midrange related to the extent to which students felt that the Brazilian experience helped them find employment (1 SA, 2A, 4 DA, 1 N/A) and if their current employer was using their knowledge of Brazil (1 A, 4 DA, 1 SDA, 1 N/A). While this was not a specific goal of the project, it was an unintended and positive outcome for three of the students, one stating that her ability to speak Portuguese was why she had been employed in her current capacity.

The final question in the midrange related to exposure to companies outside of the US (1 SA, 3 A, 3 DA and 1 N/A). Students did not undergo an internship while in Brazil and any exposure to industry would have varied by which institution they attended and what coursework they took.

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The original intent of the project PIs was to team students from the US and Brazil on a ‘global senior engineering design project’, once they returned from the exchange visit. This was attempted one semester using the Collaborative Engineering Software developed in Brazil, but because of the scheduling difficulties already noted, the management of collaborative design courses was too difficult to administer and so were discontinued.

In conclusion, the evidence presented by the students showed the project was successful in achieving its major objectives, even though some strategies for achieving the objectives were modified, such as by deciding not to incorporate long-distance design projects and by adjusting the foreign language requirement (see section on opposite page). For the students, the exchange experiences were valuable both professionally and personally, and they stated that they would not trade them for any other experience.

Faculty perspectives

- Grant achievements. When faculty from the two institutions were asked about the most important things that the grant had enabled them to achieve, they all stated that it had advanced student’s understanding of engineering as a global profession. In the words of one professor, “The grant enabled us to introduce the concept of ‘Global Engineering’ to the students in which engineering activities are performed through international teams of engineers working together to solve problems, and the need to know the culture and language of the international engineers to better understand how to work with them.”

- Student learning outcomes. In terms of student learning outcomes, faculty stated that they intended that students would learn the following skill sets and added that students had achieved all these outcomes:
  1. Appreciation of engineering education and working in a different culture.
  2. Working collaboratively with students in a different country.
  3. Building abilities of adapting to different cultures and systems.
  4. Understanding and appreciating the culture and belief system of others.
  5. Learning sufficient Portuguese to successfully take engineering courses in Portuguese.

Faculty added that in addition to the curricular outcomes, students also developed personal life skills and confidence, such as the ability to live and succeed in a new, different and foreign environment. Comments from the faculty included, “It forever changed their lives for the better” and “Most felt it was the most significant thing they had done in their lives”. They added that students had also developed leadership skills.

They also noted that most students were shocked by the poverty. “Although they had seen poverty in the US and assumed that in a developing country it would at the same level as here. They were stunned by what they saw in Brazil. Not just the favelas (Brazilian ghettos) but by the people who are too poor to live in favelas and must sleep on the street”. Thus, the experience gave them a broader perspective.

- Foreign language requirement. In regard to the language barrier, Portuguese courses are not offered in local high schools, and so students come to the classes without any ‘head start’. New part-time faculty had to be appointed and new courses created at one institution, while the other already had a two course sequence in place. The Foreign Language Departments (FLDs) require that students going abroad have at least two years of the relevant language prior to embarking on their study abroad. It was not possible to meet this requirement because engineering students only matriculate into programs in the sophomore year and have very full course loads. Therefore, this requirement was waived by the FLDs with the proviso that students take at least one semester of Portuguese at their home institution, then undergo an intensive six week immersion program at the beginning of their stay in Brazil, and then continue with one hour per day as part of the regular semester load. The Brazilian immersion program was developed in conjunction with the Department of Portuguese-as-a second- language at the Federal University of Rio de Janeiro. These intensive language courses were very helpful in adjusting students to the Brazilian lifestyle, learning about their culture, and gaining confidence. However, learning the new language took longer than anticipated.

Clearly, every effort was made by the project PIs to address the language issues, but it still remained an initial challenge to students, more so to some students than to others. By the end of the exchange visit, all students had learned Portuguese sufficiently to pass engineering courses in that language at the Brazilian university they attended. Student’s grades in these courses ranged from “C” to “A” grade.

- Student preparation. At NCSU, the preparation of students for international travel was done using the NCSU Study Abroad Office. That office hosts a formal series of lectures to prepare students to go abroad and the exchange students participated in those activities. NC A&T hired a native Brazilian to provide supplemental instruction by conducting workshops on culture and language. The workshops included trips to local Brazilian restaurants and native Brazilian families.
even though the grant did not cover these additional expenses. Faculty also motivated students by advocating the advantages of living in a foreign country and removing their fear of travel.

- **Parental support.** One of the challenges faced by faculty at both institutions was gaining parental buy-in and support. Parents had to be convinced that an international exchange experience had value. Many parents were fearful of sending their children abroad because of a lack of knowledge of and their perceptions about foreign countries. In addition to general information sessions for students, it was necessary to hold orientation sessions for parents and sometimes one-on-one interactions.

- **Formative program assessment.** The project PIs formatively evaluated the program on an ongoing basis by reflecting on what worked and attending to issues as they emerged. As part of the formative process, they included interviews with students after their exchange was over and had students write reflective essays describing their experiences. The overall assessment was that students, in general, enjoyed their study abroad experiences. They also noted that “students were pleased with the fact that they did not lose time since the courses they took in Brazil transferred back to their degree program”. Annual reports were written and submitted to FIPSE describing the program achievements, any problems and associated solutions.

- **Assessment of students.** Student learning in courses was assessed using the standard grading system at the Brazilian universities. The students were enrolled in regular courses and had to do the same work and take the same exams as the Brazilian students. To make this possible the faculty prevented students from taking engineering courses considered to be too conceptually difficult. “They had initial problems reading the engineering textbooks and following the lectures due the fact that they were novice Portuguese language students. We felt it would ensure failure if they also took the conceptually most difficult engineering courses.”

- **Unanticipated outcomes.** One of the parents commented that, “This is an amazing accomplishment but without a formal certification how does any prospective employer know they did this?” NCSU thus initiated an International Engineering Certificate that includes a minor with coursework with an international focus, a foreign language competency, study abroad, coursework in humanities and a final presentation. The certificate appears on the student’s transcript and was developed in time for most of the NCSU exchange students to also qualify for the certificate.

The exchange program meets the ABET accreditation requirements, which has a specific student learning outcome for globalization, Criteria H, that states that all engineering programs need ‘to demonstrate that graduates have the broad education to understand the impact of engineering solutions in a global and societal context. The exchange program clearly falls into this outcome category. Thus, the FIPSE exchange program work was included in the 2004 self-study report written by one of the participating ISE programs.

Some other US/Brazil FIPSE projects have adopted the approach initiated by this program for developing student’s Portuguese language capabilities.

The exchange program also prompted some curriculum revisions at one institution, where global standards for engineering and quality have been introduced to appropriate courses.

At both institutions other engineering disciplines have begun to encourage students to participate in study abroad programs.

Close relationships have been developed between the Study Abroad program on the US campuses and with the two universities in Brazil.

One faculty member noted that, “The project demonstrated that engineering students are excellent language students, contrary to a popular myth.”

- **Institutional collaboration.** The project enhanced already good collaboration between the two US institutions, as well as with the two Brazilian institutions. The course transfer process that was put in place early on worked efficiently and effectively. PIs also reported that there was good support from administrators in the respective Colleges of Engineering and from the Study Abroad Offices.

**Evaluation processes**

The project PIs undertook informal formative evaluation, including making changes to the project as issues emerged and by having students write reflective accounts upon their return to the US. However, this author only conducted the summative component of the evaluation and was not involved in formative processes. So, for instance, it was not possible to conduct surveys with students before and after they went on the exchange visit, which would have been a valuable addition to the overall evaluation process. While project progress reports to FIPSE noted constraints and changes made during the project and these reports were used in formulating the summative evaluation, the formative processes were not directly linked to the summative evaluation.
For evaluation to be a meaningful and holistic process there is merit in linking formative evaluation to the summative process. Evaluation results should be utilization driven [4] so that data is used for ongoing decision making processes and program improvement. For this reason, in the next phase of the project, this evaluator will be closely associated with the formative evaluation processes. In this way, formative evaluation will inform summative evaluation. The next phase of the project is also funded by FIPSE and is titled “The development of a global engineering certificate program” [5].

CONCLUSIONS

In relation to the main objectives of the project, the evaluation showed that:

1. The project met its first objective in providing 18 engineering students from the two US institutions with the opportunity to participate in an exchange program to one of two universities in Brazil. These students took classes in Portuguese and earned between 9 – 12 credits towards their US degree program.

2. Learning to speak a new language, studying university coursework and living in a Portuguese country presented challenges to students in the exchange program. Two out of the eight students felt they had not learned sufficient Portuguese early in the program to enable them to communicate effectively. However, all students were ultimately successful in learning the language sufficiently well to enable them to complete their courses and to interact with professors, other students and the local population. Thus, this objective was also accomplished.

3. The highest survey ratings by students were given to questions relating to the impact the exchange program had on their understanding of different cultures, values and perspectives, showing that this objective was achieved. Students learned how different social perspectives, cultural values and contextual conditions can impact the way in which a problem is approached, as well as how these may impact its ultimate solution. These lessons can be transferred into future situations they encounter as engineers.

4. Similarly, all students were confident in their abilities to work in multi-national teams and in emerging industrialized contexts, indicating that this objective was also met by the program.

Overall, the Brazilian exchange program was successful in achieving its specific objectives. There were also several unintended outcomes, such as (a) the creation of an International Certificate Program, (b) the provision of assessment data for ABET purposes, (c) advancement of student marketability for employment, (d) curriculum changes to include globally relevant content, (e) closer relationships between universities in Brazil and the US, and (f) the recognition of the value of and expansion of exchange programs into other engineering disciplines. These added further value to the overall project.

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REFERENCES


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