



The Harvard SEAS/Poli-USP Collaborative Field Course for International Environmental Engineering Education

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Introduction

As modern society becomes increasingly globalized, engineers must adapt to a new variety of international-scale problems¹. This adaptation includes developing and applying technical solutions that are effective on both the local and global scale, as well as collaborating with international peers. It is increasingly important for engineering students to develop a global professional perspective during their training, and an international educational experience is an exceptional way to allow students to gain an understanding of engineering within the context of another culture. This paper describes the fourth edition of the annual SEAS/Poli-USP Collaborative Field Course, a joint program of Harvard's School of Engineering and Applied Sciences (SEAS), the Escola Politécnica of the Universidade de São Paulo (Poli-USP), and Harvard's David Rockefeller Center for Latin American Studies (DRCLAS). This innovative course, which brought together 13 students from Harvard and 15 students from USP, was held in Brazil in January 2013 and focused on the "Global Challenges of Energy Production." Course participants attended lectures and discussions with leading energy researchers and professionals and visited a variety of energy facilities. The site visits included a hydroelectric power station, a nuclear power plant, the control center for Brazil's national electric grid, a landfill gas to energy project, and the manufacturing facilities of two engineering firms specializing in the development and production of wind and hydropower turbines.

Collaborative Field Course Background

The innovative field course model used in the SEAS/Poli-USP Collaborative Field Course was originally developed and deployed by Harvard University (including DRCLAS) and Brazilian partners in 2008, with the first edition of their field course studying public health in Brazil^{2,3}. This novel course structure pairs together an equal number of students from each university and integrates the students completely throughout the multi-week experience. The immersive nature of the course puts students in direct contact with relevant professionals in Brazil and divides the contact time between technical lectures and in-depth visits at field sites. Additionally, the course is conducted in English to reduce any potential language barriers between participants.

Coincident with the success of the inaugural public health course, which has continued to be offered annually, SEAS began to look for new ways to offer international experiences for its engineering undergraduates. Due to the rigorous course requirements of the engineering program, it is often difficult for students to spend a semester abroad and stay on track with their academic timeline. The recent change to Harvard's academic calendar to create a Wintersession term in January opened the door to a new range of possibilities. Many faculty members in the Environmental Sciences & Engineering program at SEAS had on-going research projects with Brazilian collaborators, and the timing match of summer break in South America was an attractive fit. Poli-USP was an excellent match for a partner institution because it is the largest and most prestigious engineering school in Brazil. An additional benefit of the location was that DRCLAS had recently opened their Brazil Office in São Paulo, which could provide on-the-ground support for the course.

The first SEAS/Poli-USP Collaborative Field Course was held in Brazil in January 2010, and it has been offered each successive year on a different topic related to environmental engineering (see Table 1 and reference 4). While the course was initially developed as an international experience for Harvard students, the value of alternating the location between Brazil and the United States quickly became apparent. In January 2012, the course was held in the United States for the first time, and the new idea of seeking out student carry-over from year-to-year was implemented. While each course has been individually developed to educate students about its specific international engineering focus, students who participate in multiple courses are able to develop an even greater appreciation for the international nature of engineering by experiencing the similarities and differences of engineering practice in both host nations.

Table 1. Number of participants, location, and topics for all offerings of the SEAS/Poli-USP Collaborative Field Course.

<u>Year</u>	<u>Location</u>	<u>Students</u>	<u>Course Title</u>
2010	Brazil	26	Energy, Water, and the Environment
2011	Brazil	29	Engineering and the Urban Environment
2012	United States	21	Engineering, the Environment, and Extreme Events
2013	Brazil	28	Global Challenges of Energy Production in the Coming Decades

Educational Objectives

The educational goals for the Collaborative Field Course can be divided into the specific educational objectives of the 2013 course focusing on energy production, as well as the long-term collaborative objectives of the on-going annual course.

The specific Educational Objectives for the 2013 course were:

1. To evaluate current and future energy generation technologies that are relevant on both a local and global scale, including the associated environmental and social impacts
2. To compare the similarities and differences of the energy systems and production in Brazil and the U.S., as well as the driving forces behind energy decisions in each country
3. To provide students with a hands-on learning experience through site visits of energy generation facilities and related engineering firms
4. To have students work as international teams to address topics in energy engineering

To accomplish these goals, course participants attended lectures and discussions that were highly integrated with the site visits and active student participation was required for all aspects of the course. Additionally, the students were grouped into five integrated teams (each team with half of the students from Harvard and half from USP) that were assigned a topic to evaluate throughout the course and present at a closing symposium.

The long-term goals for the annual course are:

1. To develop future global engineers via an immersive international experience
2. To encourage students to identify topics of personal interest and pursue follow-on projects for their senior design projects or independent research projects
3. To foster cooperation between universities, including relationships between faculty members that can lead to productive research collaborations
4. To build a long-term international professional network for students

The course functions as a non-traditional catalyst for strengthening networks and fostering international collaborations. To help meet these goals, Harvard and USP participants were fully integrated in the classroom, on field visits, in hotels, and throughout their social interactions. Participants were encouraged to experience the culture of the destination cities during the free time and organized group outings. Additionally, students were given information about potential funding opportunities for international internships and were encouraged to talk with faculty members about their academic and career goals.

Course planning and pre-departure preparations

In order to plan an effective course that encompassed these comprehensive goals, a long-term collaborative effort by a dedicated team of faculty and staff members from the three sponsoring institutions was necessary. Discussions of the course topic for the year and potential site visits began early in the summer and were continued throughout the fall semester. A core team of staff and lead faculty members talked frequently, and multiple conference calls were held with all the participating faculty members as well. In all, 10 core personnel were intricately involved with the development and execution of the course in Brazil, including 3 professors from Poli-USP, 3 professors and 2 staff from Harvard SEAS, and 2 staff from the DRCLAS Brazil Office.

The course was publicized to students via announcements and information sessions beginning in September, and the application deadline was October 7. After the deadline, faculty and staff from each university reviewed their own applicant pool. The selection criteria centered on identifying academically strong students with a demonstrated interest in energy systems. Any current Harvard student was eligible to apply, and an attempt was made to balance a selection preference for SEAS students with the desire to diversify the academic background of the students. In prior years, Poli-USP had limited the course to environmental engineering students, however, students from other engineering disciplines were eligible for the 2013 course due to the cross-disciplinary nature of energy engineering. Because the course is conducted in English, the DRCLAS Brazil Office held conversational language interviews with the Brazilian candidates before the final selections were made.

A total of 28 exceptional students (15 from Poli-USP and 13 from Harvard) participated in the 2013 Course. While the majority of the students were undergraduates, the group included two Ph.D. candidates as well as a Master's student from Harvard's Graduate School of Design. The 15 Poli-USP participants were studying Environmental Engineering, Electrical Engineering, and Architecture, Urbanism & Civil Engineering. Harvard students were pursuing degrees in Environmental Sciences & Engineering, Biomedical Engineering & Computer Science, Electrical Engineering, and Mechanical Engineering & Material Science. The group was diverse in terms of nationalities as well, with students representing Belgium, China, Colombia, Italy, Nigeria, Palestine, and Zimbabwe, in addition to the United States and Brazil.

Starting with the January 2013 course, selection preference was given to students who had participated in the prior course to maintain student continuity between years. In total, 4 students from Harvard and 3 students from Poli-USP participated in both the 2012 and 2013 courses. The benefits to this decision were clearly evident, as students who knew each other were quick to re-establish their friendships. This particular group of students gelled much faster than in prior years, likely due to the fact that students who already knew each other were able to introduce

their friends to others from both schools. Additionally, many of the Harvard students from the prior year came to Brazil early and stayed with their peers before the course began. Bringing students together for multiple shared experiences goes a long way toward the objective of building a long-term international network for the participants.

Two new pre-departure requirements were implemented for the 2013 course. First, a video conference call was held in early December to allow the students to introduce themselves and meet the other students, faculty, and staff. Additionally, this meeting provided an opportunity to disseminate important information about what to expect during the course and for students to ask any remaining pre-departure questions. The second change was to assign the students a set of required readings. In prior years, suggested readings were provided, but to ensure that all students had a baseline background for high-level lectures and site visits, the readings were required for the 2013 course.

Course structure in Brazil

Course participants were required to arrive in São Paulo on Sunday, January 6, and departed two weeks later on Saturday, January 19. The course program started the first evening with a group dinner, and the educational component began the next morning. The course schedule (Table 2) included 6 days in São Paulo, followed by 2 days in Paraty, one day in Angra dos Reis, one day in Rio de Janeiro, and the final 3 days back in São Paulo. A chartered bus was used to travel between locations, including intercity travel and local transportation from the hotel to the daily destinations. The staff members from DRCLAS and SEAS participated in the entire two-week itinerary, while the professors spent varying amounts of time with the course. For example, Professors Porto and Salles from Poli-USP participated almost every day, while others gave a single lecture or spent a few days with the students. The Harvard professors each spent around a week with the course. Past experience demonstrated that it can be difficult for faculty members to commit to the entire 2-3 week duration of the course. However, participating for around one week provides a sufficient amount of time to get to know each student personally and to greatly enhance the educational experience. Additionally, care was taken to ensure that at least one faculty member from each university would be present during each day of the course.

The pacing of daily lectures and site visits was brisk and the days were long and fulfilling. In general, each day began with students and staff meeting in the hotel lobby and boarding the charter bus by 8:30 am, and they typically returned to the hotel around 6 pm. During the time spent in São Paulo, the USP campus served as base of operations, including the classroom used for many lectures and the final symposium. In an effort to meet the objective of fostering collaborations between the universities, and as an extra incentive to encourage faculty participation, external meetings for the visiting professors were arranged with Brazilian researchers and other professional contacts.

The daily mix of integrated lectures and site visits is a unique strength of the Collaborative Field Course model, as it provides an opportunity for students to experience the direct application of the material presented in the classroom. To further encourage active participation of all students with the lectures and the site visits, integrated student teams were assigned a topic to evaluate and present in a final presentation. These topics were chosen to span the array of energy systems covered in the course so that students needed to synthesize and compare material from the entire

experience. The topics were: distributed versus centralized generation; economics of power generation technologies; environmental impact of power generation; integration of power generation technologies, including networks and smart grids; and comparison between electricity production and capacity for different sources. Students were given two dedicated afternoon sessions and an entire day at the hotel in Paraty to work on their projects, and faculty members circulated between the groups at these times. On the final day of the course, the student teams each gave a 20 minute presentation that addressed their assigned topic and included a comparison of the topic in the United States and Brazil. While the presentations were not formally assessed via grades, all of the participating professors were invited to the symposium, and there was general agreement that the students performed very well.

Table 2. Schedule of lectures and site visits for January 2013 Collaborative Field Course.

<u>Date</u>	<u>Lectures</u>	<u>Site Visits</u>
7-Jan	Global & Local Challenges of Energy Production	Poli-USP Environmental Engineering Labs
8-Jan	Wind Power Generation Hydropower Generation	Poli-USP Photovoltaic Laboratory
9-Jan		Billings Reservoir & Henry Border Power Plant
10-Jan	Hydropower Development in Brazil (Odebrecht Energia)	Voith Hydro
11-Jan	Waste-to-Energy Technologies Nuclear Electric Power	Bandeirantes Landfill Gas to Energy Project
12-Jan	Impacts of Energy Production on the Atmosphere and Climate	Harvard DRCLAS Brazil Office Travel to Paraty
13-Jan		Mandatory group outing for all participants
14-Jan	All day to work on group projects	
15-Jan	Lecture by Site Host	Eletobrás Angra 2 Nuclear Power Plant
16-Jan	Lectures by Site Hosts	Empresa de Pesquisa Energética Operador Nacional do Sistema Elétrico
17-Jan	Expert Panel Discussion on Innovations in Ethanol	Centro de Células a Combustível e Hidrogênio do Instituto de Pesquisas Energéticas e Nucleares
18-Jan	Smart Grids Solar Energy Technologies	Tecsis Wind Turbine Blades
19-Jan	Online course evaluations Group presentations	

Many of the long-term objectives are attained by encouraging integration of the participants throughout all aspects of the course. For example, all of the students stayed in the same hotel, and roommates were assigned to place Harvard and USP students together. Additionally, group dinners were arranged every few days at a variety of local restaurants, which offered a great chance for students, faculty, and staff to relax and socialize. The rest of the evenings were left as free time, and the students typically self-organized a group outing to experience the local culture. Additionally, a few faculty and staff dinners were planned on these evenings as well.

There are many challenges associated with the coordination of a group of around 35 people for a dense two-week schedule at multiple locations. A substantial amount of advanced logistical planning was necessary to keep things running smoothly, which was done by the DRCLAS staff. To aide with on-the-ground coordination, a course packet containing a detailed schedule was provided to the students when they arrived. Additionally, the students and staff were added to a

private Facebook Group to facilitate communication during the course. Past experience has shown this to be the most efficient and effective way of disseminating information quickly through the group, and it also allowed for students to easily coordinate their evening plans. The Group page remains active after the completion of the course so that students have an easy way of getting back in touch with their peers. Additionally, this proved to be an especially useful tool for the Harvard students who planned to arrive early in Brazil, as they had a centralized place to work out the details of who they could stay with.

Publicizing the success of the course is another great way to work towards achievement of the long-term collaborative goals. The 2013 course was covered by a variety of news outlets in Brazil, including articles in the popular online news sites *GI Globo*⁵ and *Terra*⁶. Additionally, a daily blog written by the students was implemented in the 2013 course as a real-time outreach tool⁷. The blog posts were shared via the SEAS Facebook and Twitter accounts and they offered an opportunity for others to follow the progress of the trip. Each day, a few students were asked to write a short post about their experiences, often while on the bus or during some other down-time in the schedule. Following the course, the blog has served as a great resource for people interested in learning more about the experience.

Student Feedback

In addition to evaluating attainment of the educational goals from personal interactions with students throughout the course and the final presentations, the students were required to fill out an anonymous course evaluation. To ensure 100% participation, the students were asked to bring their laptops with them to the presentation room before the final symposium, and they were given 30 minutes to complete the online survey. The student evaluations were overwhelmingly positive for the overall course experience (Fig. 1). When asked about the academic content of the course, the students again responded very positively. Commonly cited themes included the high value of the site visit experiences and great discussions with the knowledgeable lecturers. When asked for weaknesses of the course, students most frequently noted that the days were long and tiring and that additional pre-departure information would have been helpful. Representative student comments include:

Harvard student: *“The course covered an almost unimaginable number of topics in a very short amount of time. We were afforded many bonding opportunities. The trips were fantastic and the speakers were very knowledgeable. We lived very well while we were here: the accommodations were terrific and the resources outside the course's scope were great.”*

Poli-USP student: *“I think that the course would certainly help me develop some skills which it would be harder to find in Poli, such as interpersonal skills, and motivate me to study in the USA (even better if it was at Harvard). The opportunity of meeting not only the teachers and staff involved in the organization of the course, but also the Poli and Harvard students was a fantastic experience”*

When asked about the impact of this course on their future plans, students again provided overwhelmingly positive feedback (Fig. 2). Students also responded positively about the importance of the interaction between international students. Of the 28 participants, 27 selected the highest category (“Very positive”) for the question of “Overall, how was the participation of

foreign students in the course?” Common themes of their responses to questions about the longer-term goals of the course were the benefit of building an international engineering network and the value of learning with and from students of such varied backgrounds. Representative student comments include:

Harvard Student: *“Having Brazilian students with us in the course is what makes this course such a unique experience, and I think it really made the trip what it is. Getting to learn about and see Brazil with students from here was really fun.”*

Poli-USP student: *“The program has a lot to do with my primary interests in Environmental Engineering, which are renewable energy and waste management, and eventually both of them linked. In this way, I feel like it will have a huge impact in my professional life. Networking is also a consequence of the program that will impact in both my personal and professional lives. The cultural exchange has an impact in my personal life too.”*

Harvard Student: *“This course gave me a lot of inspiration for my senior design project that I will be starting next year and it provided me with excellent contacts both for future professional opportunities in the form of internships and eventual employment. The students that I met on the trip were extremely generous and hospitable and I fully intend to support them next year should they return [on the 2014 course at Harvard]”*

Poli-USP Student: *“All the Harvard students seemed to be very interested in learning things from our culture, language, history, etc. I’ve had a great time trying to explain as much as possible to them and I think that they’ve enjoyed it too. During the lectures and site visits it was very good having them, because it made it possible for us Brazilian students to have an opportunity of getting an overview of the Americans’ point of view concerning the subject.”*

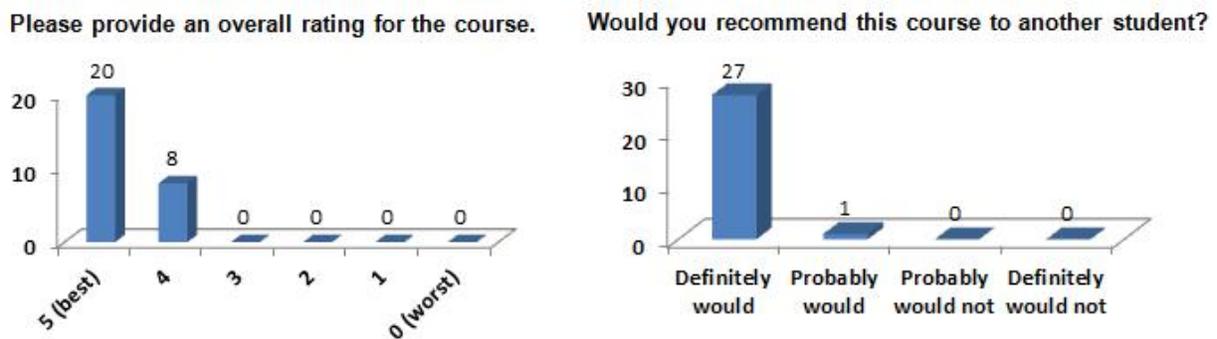


Figure 1. Anonymous student ratings of the 2013 Harvard SEAS/Poli-USP Collaborative Field Course.

Evaluating the long-term objectives

While the anonymous feedback suggested that students feel this experience will have a great impact on their professional lives, the best data to support the long-term objectives of the course come from success stories of previous participants. A prime example of the effect this style of course can have on university partnerships is the research collaboration that formed following the 2011 course between Professor Vecitis (SEAS) and Professor Mierzwa (Poli-USP). As part

of this collaboration, Professor Mierzwa spent a year visiting the Vecitis Lab, and an undergraduate from Poli-USP also came for 6 months. This collaboration has resulted in a number of co-authored manuscripts and a U.S. patent application. Additionally, they have continued to strengthen their collaboration through researcher exchange. A SEAS graduate from 2012 is currently spending one year in Professor Mierzwa's lab at Poli-USP as a research fellow. She is working closely with a doctoral student that is beginning his dissertation research and plans to spend time in the Vecitis Lab at Harvard in the future.

Do you anticipate that this course will have an impact on your academic, personal, and/or professional plans in the future?



Figure 2. Students overwhelmingly reported that they expect the 2013 Collaborative Field Course will have an impact on their future academic and professional plans.

The course has opened doors for other students as well. For example, a Brazilian student from the 2012 course spent a few months on an internship at Harvard's Graduate School of Design during the Spring 2013 semester. Additionally, many of the Harvard students from the 2013 course have shown a significant interest in returning to Brazil in a professional capacity. Four of the undergraduates have applied for summer internship opportunities in Brazil, with the support of the DRCLAS Brazil Office, and each of them also enrolled in a Portuguese language course at Harvard to help prepare for their potential return.

Future of the course

Planning for the January 2014 Collaborative Field Course, which will be held in the United States, has already begun. The organizers look forward to developing a new series of lectures and site visits around an international engineering topic. Now that a few years have passed since the first cohort of students participated, it will be useful to survey the alumni to assess what long-term impacts that the course has had on their professional and personal development.

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References

1. National Academy of Engineering, *Grand challenges for engineering*, Available online: <http://engineeringchallenges.org/?ID=11574>, Accessed March 5, 2013
2. Wilson ME, Ko AI, Reis MG (2011) Collaborative Teaching and Learning: A Model for Building Capacity and Partnerships to Address NTDs. *PLoS Negl Trop Dis* 5(3): e939. doi:10.1371/journal.pntd.0000939
3. <http://www.drclas.harvard.edu/brazil/publichealth-fortaleza-2013>, Accessed March 5, 2013
4. <http://www.drclas.harvard.edu/brazil/seas-poli-usp-2013>, Accessed March 5, 2013
5. <http://m.g1.globo.com/educacao/noticia/2013/01/usp-e-harvard-promovem-juntas-curso-de-ferias-de-engenharia-em-sp.html>, “USP e Harvard promovem juntas curso de férias de engenharia em SP” *G1 Globo*. Accessed March 15, 2013
6. <http://noticias.terra.com.br/educacao/alunos-da-usp-e-de-harvard-fazem-curso-colaborativo-em-sp,0383b7bcd8e3c310VgnVCM5000009ccceb0aRCRD.html>, “Alunos da USP e de Harvard fazem curso colaborativo em SP” *Terra Networks Brasil S.A.* Accessed March 15, 2013
7. <http://harvardinbrazil.blogspot.com.br>, Accessed March 5, 2013