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## **AC 2011-1145: COLLABORATING TO PREPARE STUDENTS FOR THE GLOBAL WORKPLACE**

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# Preparing Students for the Global Workplace

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## Introduction

In the past the engineering profession has tended toward the development of specializations which has resulted in the “broad spectrum of technical disciplines” that exist today according to De Graaff and Ravesteijn (2001). More recently, however, the pendulum has swung in the other direction and De Graaff and Ravesteijn suggest that although pressure towards differentiation still exists it has been superseded by an increasing demand for “complete engineers” who have a “sophisticated and practical knowledge of ‘technology and society’” as well as “globalization and the related internationalization of enterprise.” As a result, one of the crucial challenges facing engineering educators is the need to train future engineers for careers in a multi-faceted, global community that faces enormous energy and environmental problems (NAE, 2005; 2008).

Unfortunately, as Carol Del Vitto (2008) points out “university engineering programs often focus on ‘hard’ technical skills” in spite of the fact that “it is becoming increasingly evident that in order to compete in a global environment” engineering students must develop “soft skills” that will allow them to understand other cultures and respond to the demands of the global workplace. Researchers such as Grandin (2006) and Camuti (2006) echo Del Vitto’s concerns about current educational approaches and argue the importance of preparing students for the global workplace. Del Vitto believes that the problem is especially pressing for American students. “If Americans want to be globally competitive,” she contends, American engineers must be able to work effectively overseas. She further argues that America is not rising to the challenge as well as other countries are. “In contrast to Americans, Europeans and Asians have taken the need for global competition very seriously.”

There are several ongoing European Programmes addressing these issues either at the National or at European level. Among these are initiatives targeting staff and students mobility as well as overall academic cooperation such as i) Erasmus for Higher Education within the Lifelong Learning Programme ([http://ec.europa.eu/education/lifelong-learning-programme/doc80\\_en.htm](http://ec.europa.eu/education/lifelong-learning-programme/doc80_en.htm)); ii) Erasmus Mundus, aims to enhance quality in higher education through scholarships and academic cooperation between Europe and the rest of the world, and; iii) Bilateral Cooperations aimed at establishing “joint study programmes with industrialized countries (particularly in North America and the Asia-Pacific region) that provide financial support for student mobility. Such co-operation enhances the quality of higher education and vocational training for both partners and promotes greater intercultural understanding” ([http://ec.europa.eu/education/external-relation-programmes/doc74\\_en.htm](http://ec.europa.eu/education/external-relation-programmes/doc74_en.htm)). An example of the latter is the Atlantis Programme where the European Union and the United States

of America have been co-operating in higher education and vocational training since 1995. Although these initiatives are admirable, in general engineering educators need to do more to address this problem, but American faculty especially need to make strides.

## **Statement of Purpose**

Dewey's theories about the importance of cultivating reflective practice (1993) have had enormous influence on classroom teaching strategies and methods. Walkington, et al (2001) argue that developing reflective practices is just as important to teachers as it is to students. They advocate reflective practices and self-evaluation for educators. They also suggest that collaborating with colleagues can enhance the results of reflective practices. Educators, they argue, often "operate in a vacuum, constantly 'reinventing the wheel' ". They suggest that collaborating with other teachers is a valuable and often neglected reflective practice that can improve pedagogical effectiveness. This paper describes the collaboration between a European professor who has been weaving topics of global significance into her engineering courses for a decade and an American professor introducing those topics for the first time in a study abroad course to American students. The results of that collaboration accomplishes what Walkington (2001) and her colleagues suggest, and in addition to saving one teacher from reinventing the wheel it allows two teachers to reflect on and evaluate their own practices in a new and effective way.

Professor Carvalho, who teaches Mechanical Engineering at the Lisbon Engineering Institute, in Portugal, strives to cultivate "soft skills" such as communication skills, effective collaboration, and critical thinking along with technical content of her courses. Professor Moore, who teaches Engineering Communication at the University of Texas at Austin, Texas, collaborated with Professor Carvalho to develop assignments and strategies for teaching that would enrich international study for her students and help them develop an awareness of global issues. The purpose of this paper is two-fold. First, we will describe assignments and strategies in a course taught by Professor Carvalho that will illustrate the pedagogical techniques she has developed to help students analyze the relevance of global issues to the engineering profession. In particular, we will focus on a research assignment that requires students to compare energy and environmental problems (and solutions) in different countries. Second, we will describe Professor Moore's study abroad course in Spain in the summer of 2010 and the assignments that she developed in collaboration with Professor Carvalho.

## **Discussion**

### Professor Carvalho's Course

The course Professor Carvalho teaches at Instituto Superior de Engenharia de Lisboa addresses students enrolled in Energy Production and Management as part of their master degree. It is a compulsory course for Mechanical Engineering students (Energy profile) entailing 63 teaching hours over 14 weeks. The course is attended by both day and evening students (working students) and although the classes are delivered separately to

both groups all students “meet” and interact online.

Since its earlier days in 2004 the course was designed to assist students learn “how to learn”, to increase their engagement and responsibility in the learning process, and to promote higher levels of interaction that would allow for a collaborative working environment. An overview of the course development along the last years and on the exercises and the short and long term assignments as well as on the several engagement techniques is provided elsewhere (Carvalho, 2006; 2007; 2009; 2010).

Although the course curriculum is wide and fairly standard, the main goal of the Energy Production and Management course is to confront students with the advantages and disadvantages related with the usage of different technologies and fuels for energy production. To raise awareness and promote understanding the links between Energy and Environment and Policy and Economy and to become acquainted with the ongoing research in this field (Technology Platforms and International Projects) at National, European and World wide levels. The energy efficiency topic is embedded in most of the learning activities and course assignments along the semester. The course is designed and delivered in a way that allows students to experience a variety of teaching environments: i) traditional lectures; ii) invited speakers and field trips; iii) short formative assignments; iv) individual and team long term assignments with a strong collaborative component, and; v) an online environment (Learning Management System) for course resources and materials, information and assignments sharing and several discussion boards.

As students are used to more traditional assignments they tend to feel uncomfortable when they are asked to make decisions, share information and get actively involved in peer review and even in peer assessment. Assignments as these allow for better results if they are embedded in an already less traditional way of teaching and learning. Students need time and instructor’s examples to get acquainted and deeply involved with these assignments. Therefore, the first five weeks of the semester are devoted to get students acquainted with active and collaborative learning (in-class and online) by means of short formative assignments (graded) which are a part of another individual course assignment. Time is allocated for students to discuss and relate course topics, share their views and speak up in front of the class. Through instructor mentoring the students come to accept that learning will take place at individual and team level as well as at the entire class level. All inputs are analyzed and put into the place chosen by the learning community – the whole class.

The specific research assignment above mentioned is chosen from a list of Energy related topics. This assignment goes on for six weeks with an online collaborative component. Students are requested to research, to engage in information management and validation, to establishing comparisons and decide on what works best in each case, share (facts and figures) and discuss (supporting arguments) with their peers. At the end of the semester the students need to write a report and prepare a presentation to be delivered in-class for formative and summative assessment.

The research assignment chosen from a list of Energy related subjects (e.g., Cogeneration, Wind, Solar, Biomass, Nuclear, Hydrogen, Fossil Fuels, etc.) is presented to the students and detailed information is provided in-class:

- It is a group assignment (three students)
- It is structured in a stepwise weekly approach (topics)
- It includes mandatory weekly tasks (minimum of two per week)
- It builds on positive interdependence
- It is collaborative in nature
- The final deliverables are an in-class presentation and a written report

After the groups are formed and the subject chosen the “Week One Topic” is released and students need to immediately engage in research to successfully fulfill Task 1 which consists of an original contribution related to their own subject. In order to fulfill Task 2 each group needs to read their peers’ inputs for Task 1 get also engaged in research within another subject and answer to any one of the other Task 1 contributions. Each week has a different Topic, as shown in Table 1, with the purpose of guiding the students through the entire research assignment.

**Table 1 – Structure of the assignment**

<b>Week</b>	<b>Topic</b>	<b>Deliverables</b>
ONE	Introduction	Task 1 – Group Original Contributions Task 2 – Interact with at least one of the other groups
TWO	Technologies	Same as in Week 1 within Week 2 Topic Same as in Week 1 within Week 2 Topic
THREE	Applications	Same as in Week 1 within Week 3 Topic Same as in Week 1 within Week 3 Topic
FOUR	International	Same as in Week 1 within Week 4 Topic Same as in Week 1 within Week 4 Topic
FIVE	National	Same as in Week 1 within Week 5 Topic Same as in Week 1 within Week 5 Topic
SIX	Conclusions and Future Trends	Same as in Week 1 within Week 6 Topic Task 2 - Optional
SEVEN	----	Reflect and prepare for in-class presentation
EIGHT / NINE	----	In-class presentation with peer discussion
2 weeks after the end of the semester	----	Report delivery and upload all Presentations and Reports into the LMS

Recently the more technical subject driven assignment was replaced by “Countries” as, e.g., France, Italy, Spain, UK, Germany, Canada, Japan, etc. A similar procedure was followed as in Table 1. At this stage the students were quite lost on how to carry out their research assignment without a technical frame. Time had to be spent in class and online to assist students for the first two weeks. From the analysis of the outcomes and also students’ feedback this assignment presently incorporates a hybrid choice of subjects that better assist students’ technical and “soft skills”: Australia and Iceland; Canada and

Japan; China and India; Coal, Oil and Natural Gas; Micro generation; Nuclear Energy; Transports Sector; Buildings Sector; European Union; US; etc.

### Professor Moore's Engineering Communication Course in Spain

Professor Moore teaches Engineering Communication at the University of Texas (UT Austin). A required course for all Engineering undergraduates, Engineering Communication focuses on helping engineering students develop effective written and oral communication. In the summer of 2010, Professor Moore taught a modified version of that course in Santander, Spain. The course was offered to UT Engineering students as part of a larger UT study abroad program that takes up to 50 biology, engineering, and business students to Spain for a 6-week course of study. The program is especially beneficial to engineering students who are not always accommodated by study abroad programs which often only offer liberal arts courses that do not allow engineering students to progress in their programs. Engineering Communication has proved to be an excellent course for study abroad because it allows students the opportunity to complete a required course in their degree plan. Because it is a communication course it also allows some flexibility in terms of topics. Fifteen students took the course in the summer of 2010 and came from Austin, Texas to Santander, Spain.

The stated goals of Engineering Communication are to help “engineering students develop effective written and oral communication skills with a focus on the following areas:

- gathering, organizing, and evaluating data;
- drafting, composing, and revising written documents;
- improving delivery in oral presentations;
- understanding, analyzing, and composing effective arguments”

An added goal for the study abroad course was to help students understand “the social and global impact of engineering communication, research, and practice.” To achieve this last goal, Professor Moore collaborated with Professor Carvalho to develop assignments and strategies for teaching that would enrich international study.

### **Collaborating on Teaching Strategies**

The collaboration between Carvalho and Moore was possible because of electronic communication tools such as email and Skype. The discussion began with a request from Professor Moore for help developing the assignments in her study abroad course. Her goal was to get the students thinking about global issues. The initial vision was that students would write reflection papers on their experiences in a foreign country, present summaries of articles that analyze global engineering challenges, and write research papers on topics related to energy, the environment, or infrastructure. Professor Moore specifically asked Professor Carvalho for help creating assignments that would enable to

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· Goals are excerpted from the syllabus for the course.

students to analyze the connection between the technical aspects of engineering, the social and economic impact of engineering, and the global factors that complicate that impact. Areas of research such as transportation, food production, energy infrastructure, water supply, and waste disposal were at the top of the list of possible topics to have students investigate.

Because the research project was the biggest component of the class, much of the collaboration between Carvalho and Moore concerned that project. Professor Carvalho responded to initial requests from Moore for advice by suggesting first that students work in teams of three to five that contained a mix of students from different departments, such as aerospace, mechanical, and electrical engineering, so that people in the groups would bring different perspectives to the project. Second, she suggested making the research projects a comparison of countries. The comparison, she advised, could be done two different ways. One possibility was to have students compare energy issues in pairs of countries such as Australia and Iceland, Canada and Japan, or China and India. Professor Carvalho's experience guiding her own students in research had taught her that certain combinations of comparisons worked better than others. The other way she suggested approaching the research paper was by identifying topics and then comparing the U.S. and Spain to each other and to a third country.

#### Assignments Created through Collaboration

In the end there were three categories of major assignments in the study abroad class. The first were Reflection Papers. Students were required to write four one-to-two page, single-spaced reflection papers on selected readings and observations of life in Spain. For example, students were asked, in their first week in Spain, to write about something to do with urban infrastructure or transportation that was different in Spain and reflect on the impact of the difference. The second assignment was a Reading Analysis Presentation that required students to do a critical reading of a chapter from a book that discussed global engineering, energy, and environmental issues and present an analysis of that chapter to the class. The third major assignment was the Research Project which involved a comparison of particular energy issues in three different countries.

The study abroad class met twice in the spring before the trip to Spain. In the first meeting the students brainstormed about global, regional, and local concerns related to energy. From a long list of possible topics on the blackboard at the end of the brainstorming session, the students voted on and selected the following five topics:

1. Traditional Sources of Fuel
2. Alternative Energy
3. Consumption of Energy
4. Impact on Environment
5. Business and Politics of Energy

Students then chose the topics from that list that they were most interested in and the class of 15 was divided in that initial meeting into 5 groups of three. Groups were

balanced with students from different departments on each team. Their first assignment was to gather sources that would allow them to compare the U.S. and Spain and to start identifying the most pressing and interesting issues related to their topics. With guidance and suggestions from Professor Carvalho, Professor Moore chose for each group a third country that students would compare with the U.S. and Spain (shown below in Table 2). For the project on Traditional Sources of Fuel, for instance, Brazil was chosen as the third country because Brazil is an oil-producing country and one of the largest producers of hydroelectric power in the world. For Alternative Energy, Sweden was chosen as the third country because Sweden is a leader in alternative energy initiatives and successes. For Consumption of Energy, the United Arab Emirates was chosen because the UAE is one of the highest consumers of energy per capita in the world. China was chosen to compare with the U.S. and Spain in terms of Impact on the Environment because urban pollution is such a pressing problem in China. Finally, Nigeria was assigned to the group researching the Business and Politics of Energy because multinational oil companies are based in Nigeria and the government has been accused of corruption.

**Table 2. Comparison Topics for Research Project**

<b>Topic</b>	<b>Countries Compared</b>
Traditional Sources of Fuel	Spain, U.S. and Brazil
Alternative Energy	Spain, U.S. and Sweden
Consumption of Energy	Spain, U.S. and United Arab Emirates
Impact on Environment	Spain, U. S. and China
Business and Politics of Energy	Spain, U.S. and Nigeria

In the second meeting before students went overseas and the course actually began, Professor Moore reviewed the initial sources they had gathered for the research project, lectured and lead a discussion about credible sources as the foundation of responsible research, and gave the students their next assignment: an annotated bibliography. The annotated bibliography was an individual assignment that each student (not each group) had to complete and turn in on the first day of class in Spain. Students were also required to bring the actual hard copy of the ten articles they chose to summarize. Once the class actually began in Spain, students were working on the research project weekly. Even when other assignments, such as reflection papers or reading presentations, were due, they continued to work on the research and were given both collaborative and individual tasks along the way to keep them on task. The weekly assignments are outlined in Table 3 below.

**Table 3. Weekly Assignments Related to Research Project**

<b>Week</b>	<b>Assignments</b>	<b>Comments</b>
Week 1	Draft Annotated Bibliography due first day of class	Each student is required to summarize at least 10 credible articles that will contribute to research



	Finalized Research questions	Group members collaborate to draft and then revise research questions
Week 2	*Progress Report ?????????	Each group meets with instructor to review status of research and compose an outline
	Final Annotated bibliography (list of at least 15 credible, relevant sources for each topic with summaries)	Group members identify the sources that will contribute to their research and turns in a revised annotated bibliography
Week 3	Annotated outline	Using the annotated bibliography and the outline that was created in the progress report meeting with the instructor, each team identifies the sources that will contribute to individual sections of the paper
Week 4	Drafts and peer critiques	1. At the beginning of the week each group brings a draft of the Statement of Problem. Groups exchange drafts and do peer critiques 2. Mid week each individual brings a draft of his or her section in the body of the paper. Students exchange drafts with their own group members for peer critique
Week 5	Drafts and peer critiques	At the beginning of the week each group brings everything they have and exchange with another group for peer critique
	First Iteration of Research Report due	This paper is graded and counts 15 % of the final grade. Students are then able to revise it. The revision is the final paper
Week 6	Presentations	Groups present their research to the class
	Final Research Report due	

### Translating Lessons Learned

Creating a new course with new assignments is a challenge that all educators are familiar with. In this case, Professor Moore benefitted from the experience of a colleague who was willing to share the fruits of that experience. Although educational evaluation usually focuses on assessment of student learning outcomes, this discussion will focus on an evaluation of teaching outcomes. Through trial and error Professor Carvalho has identified several strategies that have worked for her in courses. In discussions about the assignment she made several specific recommendations that fostered the success of the assignment. This section will discuss briefly how those strategies were applied in Professor Moore's Engineering Communication course.

First, Professor Carvalho recommended giving students **Open-ended topics that are not strictly technical**. The topics on energy and the comparison of three countries promoted integration of horizontal topics such as Environmental, Economic and Political issues. All of the research groups addressed political, economic, and social impact of energy systems in their papers. Early discussions in the class did focus on the impact of engineering decisions and design, but the actual integration of non-technical aspects of energy issues was not explicitly required in the assignment. Meeting with students before the study abroad session actually began and allowing them to brainstorm about topics and choose the final topics allowed them to feel invested in the project.

At the same time, Professor Carvalho's recommended early in the collaboration that Professor Moore **choose some aspects of the topic for the students** and strive to engage students in investigation subjects other than the traditional ones. As a result, Professor Moore limited the general topic to energy and then chose the third country students would compare with the U.S. and Spain rather than leaving that decision to students. Making those choices pushed students into richer research than they might have discovered otherwise. Focusing on energy exclusively gave all the students in the class some common ground in class discussions. Giving each group different angles and different countries to investigate meant that each group had unique perspective to bring to the table. Ultimately, the focus of the topic provided students with different and wider perspectives related with technology usage and application.

Professor Carvalho also suggested **making the project collaborative** which provided opportunities for discussion and analysis. In addition it engaged students in the learning process, not just the final product. Overall students increase their learning and communication skills by teaching their peers.

Following Professor Carvalho's advice to give the students a **tightly structured sequence of assignments** allowed them to stay on task, helped them to focus rather than scatter, and gave them the opportunity to succeed in spite of the fact that six-week course was jam-packed with work and extracurricular activities. In the end the sequence of incremental assignments and exercises improved the quality of the final presentation and report.

Building **peer interaction with other groups** into the course promoted more analytical investigations questions, stimulated the students towards higher interaction levels, and shifted the focus from the final product to the learning. Ultimately, it helped students develop communication skills formal and informal writing, presentation skills, reflective thinking, synthesis, summarizing.

## **Reflections**

Although both professors involved in this collaboration teach engineering students, the fact that one teaches technical courses and one teaches a communication course means that their approaches to teaching are different which opens up many opportunities for the teachers to become the students. Both Carvalho and Moore have modified and continue

to modify their pedagogical techniques as a result of the collaboration. For instance, in the past Professor Moore's students have always spent focused time in and out of class brainstorming topics for the research paper. It would have been impossible to spend that much time discovering a topic in a course as short (6 weeks) as the summer school course. Because students came to Spain with a topic already defined and sources collected, the class was able to focus on other complexities of the research and writing process: evaluating the credibility of sources, developing logical arguments, analyzing evidence. In addition, Moore learned that the tightly-structured sequence of tasks and exercises Carvalho recommended enabled students to stay on task and facilitated collegial collaboration in spite of everyone's tight schedule. Because many of the exercises were turned in as individual assignments that counted as a homework grade the professor was able to ensure that collaborators were contributing responsibly to the project.

Perhaps most important, Professor Moore was able to pilot a research topic that proved to be engaging and thought-provoking and globally relevant. The comparison of energy issues in three different countries spurred each group to look at the intersection of technical and social issues, domestic policy and international standards, environmental and economic impact. Since the course involved peer critiques and culminated in formal presentations of the research projects, students learned from other groups.

All engineering students – those studying at home as well as those studying abroad – need to develop global literacy. Professor Moore is currently modifying teaching materials in her Engineering Communication course to incorporate international research topics. She plans to use a comparison of energy and environment issues in different countries in the fall of 2011 and will use a very similar assignment in the next study abroad course in the summer of 2012.

As a result of the collaboration with Professor Moore, Professor Carvalho has developed teaching strategies as well. From the successful outcome of Moore's research assignment and discussions about the assignment, Carvalho reevaluated her course assignment and modified it by incorporating new elements from Moore's structure. As the use of credible sources has always been a problem during and at the end of the course assignment Carvalho decided to integrate "evaluating the credibility of sources" already at Week 1.

Furthermore, since Carvalho's course is focused on engineering technology in contrast to Moore's course which focuses on communication, Carvalho and Moore are now collaborating on a communication assignment in Carvalho's course that encourages students to analyze the intended and unintended consequences of engineering decisions and practice. This exercise, developed and used by Moore in her ethics courses, is currently in the pilot phase.

For both Carvalho and Moore their collaboration establishes a mutual mentorship that is enriched by widely different perspectives and experience. The benefits for them is that they have new eyes to review, and perhaps improve, practices they have developed; new, and yet-tested strategies to try in their courses; and evaluators to help assess the merit of particular exercises, assignments, or approaches.

## Conclusion

There is little doubt that future engineers will have work in a global arena if they are going to be successful. They need to be willing grapple with complexity and difference: understand the impact of engineering design and decisions on economic and social structures; and recognize the importance of cultural and political context. Although traditional approaches to engineering education are valuable, they are specialized and insular, qualities that actually undermine some of the skills that global engineering students need to cultivate. New approaches to combining the technical education, which is crucial to engineering, with the “soft skills,” which are necessary in the global workplace, are being developed by engineering professors in classrooms across the globe. As Walkington, et al. suggest developing one particular soft skill -- reflective practice -- is just as important for teachers as it is for students. Effective teaching involves knowing “how to learn.” By recognizing and understanding different learning styles, attitudes, motivations and by evaluating and analyzing results in the classroom, teachers can also “learn” and “learn how to teach”. Sharing what we learn as teachers, collaborating on pedagogical innovations, and learning from each other can be one vital step in teaching our students the most important soft skill – recognizing the wisdom of those whose experience is different than our own.

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