THE GLOBAL AND SOCIETAL CHALLENGE – AN INNOVATIVE APPROACH TO ABET CRITERION 3.H AND BEYOND[*]

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Abstract

The new ABET criteria combined with an increasing concern about engineering jobs moving "off shore" are causing some engineering schools to seriously consider an international experience as part of their educational program. These could involve a range of alternatives from "teaser" trips of two or three weeks, an international co-op or internship opportunity, participation in a virtual design experience, or extensive study abroad opportunity. While the traditional study abroad experience has centered on an immersion type program, we propose that a global studies experience can be equally valuable, and, if designed appropriately, may be more valuable to the engineering student.

We describe a ten-week global studies experience that we have designed and taught for engineering and business students as part of the summer Semester at Sea Program. In particular, we describe how an engineering topic - manufacturing and the global supply chain - can best be studied if classroom work is combined with truly multidisciplinary team projects and well-designed field visits at each country on the itinerary. Further, if engineering coursework is integrated with parallel courses and units that address culture, political, and other societal issues, then the overall experience exceeds what is typically learned on a "land-based" campus. Hence a lecture on IP issues in China might be followed by visits to a Japanese firm considering relocating certain manufacturing process in that country. Teaching courses that address problems beyond engineering require different resources than would a manufacturing course that focused only on local companies. Finally, to best reinforce student learning, especially in a course that focuses on cross-cultural learning and experiences, it is necessary to have students reflect on their experiences. We summarize these reflections and their assessment of the program and address educational research questions that have emerged as the result of such a program.

The Need For An International Focus For Engineering Education

In commenting on ABET's newly adopted criteria (EC-2000), Prados noted that the major drivers had included the country's shift from defense to commercial competition with a resultant

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impact on engineering employment, the exploding information technology growth, corporate downsizing, outsourcing of engineering services, and the globalization of both manufacturing and service delivery. To Prados, employers now recognized that success as an engineer required more than strong technical capabilities; it also required were communication skills, the ability to lead and work effectively as a team member, and an understanding of the non-technical forces that affect engineering decisions [1].

Eight years later, these same drivers – rapidly changing technology, especially information technology, corporate downsizing, outsourcing, and globalization – are even more critical. Particularly if industry continues to view an increasingly larger portion of the science and engineering labor pool more like a commodity then a profession. Consequently, less developed countries with lower wage rates and an abundance of young, intellectual capital are competing for work that until recently was performed by higher paid U.S. engineers, many of whom were then in short supply. This has created a new dilemma for engineering educators: How to best ensure that our graduates will continue to bring value to a marketplace in which their salary demands are three to six times greater than their international competitors? [2] (See the two articles by McGraw in Prism for additional discussion of these issues [3, 4].

Oberst and Jones have put the question succinctly: "[It] is no longer just whether engineers are being treated as commodities, but how engineers and other highly educated technical people shape and are shaped by the emerging realities of a truly global workforce. Engineers as a professional group are thus the canaries in the mineshaft of the new world economy. Whether engineers manage the transition from local to international workplace environments will determine if the profession remains attractive" [5]. To them, what is needed is an understanding of how the growing social consciousness around the world is making it imperative that engineering students understand the implications of their work [6].

A growing number of engineering programs are now recognizing the importance of an international exposure as part of the undergraduate education experience and, as a result, are designing highly innovative educational programs to meet this need. While traditionally few engineering students study abroad or co-op/intern abroad – the most recent data indicate that only 4,670 students (2.9 percent) participated in a study abroad program in 2001-02 [7] –this may soon change as more programs are designed to provide engineering students with needed global and social experiences, and more universities recognize its importance. The recently released NASULGC report *A Call to Leadership: The President's Role in Internationalizing the University* also should provide further motivation for this, especially among land grant and other public universities [8]. In addition, Georgia Tech's bold initiative to ensure that 50% of its graduates (the large majority of which are engineers) have an international experience should spur its competitor schools to action.

In addition, engineering faculty are anecdotally reporting that students who have participated in study abroad programs are better problem solvers, have strong communication and cross-cultural communication skills, and are able to work well in groups of diverse populations and understand diverse perspectives. Living overseas creates graduates who are more adaptable to new environments and have a greater understanding of contemporary issues as well as engineering

solutions in a global and social context [9]. However, further research is required to fully support these findings.

Shuman, Besterfield-Sacre and McGourty have reviewed a number of the exemplary programs designed to give students an international exposure [10]. We note a few of these below. The prototype model for integrating international experience into an engineering education is the University of Rhode Island's (URI) International Engineering Program in which students combine an undergraduate engineering degree with a degree in languages (German, French or Spanish). All students do an industrial internship in a country where they must use their language skills, and many also do at least one term of study in that country [11, 12].

Worcester Polytechnic Institute (WPI) is one of the leaders in enabling its students to study engineering within a global and social context [13, 14]. Students are able to do their eight-week junior or senior projects at a number of international sites. As a result, more than half of the WPI students now complete at least one degree requirement internationally.

A promising, comprehensive program is Purdue's Global Engineering Alliance for Research and Education (GEARE). This unique eighteen-month program, developed in partnership with Karlsruhe and Shanghai Jiao Tong Universities, integrates language education, cultural orientation, three-month domestic and three-month international internships at the same partner firm, study abroad, and a two semester face-to-face multinational design team project, with one semester abroad and one at home. The bilateral program involves equal numbers of students from each university participating in the paired exchanges [15, 16].

The University of Kentucky has created a combined B.S. Engineering – M.B.A. program with a strong international component directed at producing manufacturing engineers and engineering managers [17]. During the summer prior to the fifth year, students participate in a study abroad program designed expressly for the program, thereby enhancing and broadening their cross-cultural experiences. For the summer of 2004, the Kentucky students participated in the University of Pittsburgh's Manufacturing and the Global Supply Chain in the Pacific Rim as part of the Semester at Sea Program [18]. This latter program is the major focus of this paper.

Amadei at Colorado has become a leader among the engineering educators now looking at sustainability issues in the less developed world [19]. He is helping to create a program in Engineering for Developing Communities that will eventually address a wide range of issues – water provision and purification, sanitation, health, power production, shelter, site planning, infrastructure, food production and distribution, communication, and jobs and capital for various developing communities.

A somewhat similar program is being developed at Colorado School of Mines (CSM), with a focus on "humanitarian engineering." With support from the William and Flora Hewlett Foundation, its goal is to nurture a cadre of engineers that is sensitive to social contexts and committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels and locations around the world [20].

The need to train engineers to collaborate with their colleagues around the world, working effectively in geographically distributed, multicultural teams was a motivation for Union College's creation of an International Virtual Design Studio (IVDS) in 1996. The IVDS initially brought together the mechanical engineering departments at Union College and Mideast Technical University (METU) in Ankara, Turkey, with Queen's University (Kingston, Ontario) joining a year later. [21]. At Northern Arizona, language and engineering faculty are combining to utilize virtual reality to develop a pilot "Global Engineering College." When successfully implemented, it will inject international perspectives throughout the curriculum by leveraging technological developments to create a "virtual" engineering college [22].

Another model is the short "teaser" program designed to provide students with an international exposure over a period of two to four weeks, under the premise that this will motivate students to then seek out longer-term international experiences. One notable example has been created at the University of Pittsburgh where its School of Engineering and College of Business Administration (with sponsorship from the International Business Center) have created an innovative post-freshman year experience – Plus3 (three additional credits beyond the respective introductory business and engineering courses). Here rising sophomores from Engineering and Business participate in a two-week study tour under the direction of a faculty member. In addition to attending pre-visit sessions, students must complete a multidisciplinary team project that focuses on an industry in the country visited. Last year the visits were to Chile, China, the Czech Republic, and Germany. This year Brazil is being added and France will replace the Czech Republic. The program was just selected to receive the Institute of International Education's Andrew Heiskell Award for Study Abroad for 2004-2005 as the "best practice" in international education. It is an example of an IFTA (integrated field trip abroad) that services as another model for providing students with international exposure in less than a semester. Experience to date indicates that a number of those who have participated in the Plus3 program are following it up with additional language courses and more extensive international opportunities.

The Semester At Sea Program

The above programs are for the most part considered "immersion" programs. That is, students typically study in only one country or culture. This provides an opportunity for an in-depth exploration of that environment. If it is a non-English speaking country, the student also has an opportunity to further learn and utilize a second language. While there are many advantages of such programs, we feel that there is also a need for another, equally valid model, that provides an opportunity for comparative studies on either a regional or global basis. Such an opportunity is offered through the Semester at Sea Program.

Specifically, Semester at Sea is a study abroad program designed to incorporate a full global semester (fall and spring) or a nine-to-twelve credit summer program into the student's undergraduate experience. As academic sponsor of the program, the University of Pittsburgh grants full academic credit for participation in Semester at Sea. All faculty and courses are approved through the respective Pitt departments within Arts and Sciences, Business Administration or Engineering. A University appointed Academic Dean is responsible for academic planning, faculty hiring, course selection and implementation of the program for each

voyage. Credits earned meet the required standards for transfer to over 250 participating institutions. A typical Fall or Spring voyage will have 620 to 640 students and 25 to 30 faculty offering 70 to 75 courses; Summer voyages have 400 to 450 students and 16 to 18 faculty offering 30 to 35 courses.

The shipboard curriculum provides the student with insights into various cultures and societies, allowing each to analyze and reflect upon what he/she observes. Students develop the ability to understand the new cultures encountered, and gain the intellectual tools to relate past experiences to future situations. In addition to their elective coursework, all students examine crucial issues of global concerns, including those relating to environment, population, foreign policy interrelationships and economics, in the context of the nations visited as part of a mandatory *Global Studies* course. The ship is a campus where students work in a traditional classroom setting, using the world as a laboratory from which 20% of the credit earned for a course is fulfilled. This integration of classroom and international fieldwork enables Semester at Sea to provide a unique learning environment. Consequently, this requires a particular type of faculty; people who can relate well in this academic environment and look forward to being with the students 24/7. Faculty are recruited for each voyage from colleges and universities throughout the country and internationally. "Interport lecturers" periodically join the ship and present seminars, participate in informal discussions, and provide in-class presentations that better prepare students for more effective field experiences.

An Opportunity For Engineering Education

It is within this environment that we created a program targeted at those engineering and business students interested in issues related to the global supply chain, manufacturing and operations management. The lead author (Shuman) had earlier served as Academic Dean and the second author (Bidanda) served as the interport lecturer for India on the Spring 2002 voyage. Both recognized the potential as well as the need to offer a program for engineering students. (A third author – Thomes – had served as the librarian on an earlier voyage.) Although two engineering courses were offered on that Spring 2002 voyage (*Professional Ethics* and *Introduction to Environmental Engineering*), there were only seven engineering students out of 620 onboard. As a result, science and business majors made up the bulk of the students in both courses. Nevertheless, this provided an opportunity to create engineering oriented courses that would be "voyage relevant" and would integrate field experience with coursework. That voyage which began in Miami and ended in Seattle visited ten countries – Cuba, Brazil, South Africa, Mauritius, India, Singapore, Vietnam (with an opportunity to also go to Cambodia), Hong Kong, China and Japan as it circumnavigated the globe. While the ethics course was comparable in subject matter to land based engineering ethics courses, the various ports provided opportunities for students to discover or explore ethical dilemmas on a personal basis. These included the stealing of cigars by factory workers (which were then sold on the black market to tourists) in order to support their families (Cuba), large squatter villages (Brazil), an examination of apartheid and the unsuccessful efforts of US corporations (South Africa), child labor (India), pirating of CDs and DVDs (Vietnam and China) and the one child policy (China). Comparable field opportunities were also created for the environmental course. Case studies were used to further relate subject matter to the countries that would be visited.

In addition, students were offered other important educational opportunities. These included an audience with Fidel Castro, learning about poverty under both communism (Cuba, Vietnam and China) and in democracies (Brazil and India), side trips to visit the Amazon, going on safari, visiting the Taj Mahal, Ankor Wat, the Great Wall of China, and the Forbidden City, learning about the culture of Japan while visiting such cities as Kyoto, Nara, and Hiroshima.

This experience provided the motivation to create a true program for engineering students that would enable them to fulfill both the letter and spirit of ABET 3.h (understanding the impact of engineering solutions in a global and societal context) as well as 3.j (knowledge of contemporary issues). This would also provide an opportunity to master the other four ABET professional skills (e.g., multidisciplinary teams, ethical and professional responsibilities, communication, and life long learning).

Working in conjunction with the University of Pittsburgh's International Business Center (which had already created a Global Studies Certificate as part of the Semester at Sea experience) and the Department of Industrial Engineering as well as the Institute of Shipboard Education (the parent company for Semester at Sea), a program was designed that would attract an increased number of engineering and business students who recognized the valuable educational opportunity that would be provided.

Hence "Following the Global Supply Chain" was born. The program would be offered on the 65 day Summer voyage (rather than the 100 day Fall or Spring voyage), making it easier for engineering students to attend without missing important, sequential courses at their home institutions. The planned summer itinerary of the Pacific Rim (Alaska, Russia, Korea, Vietnam, Hong Kong, China, Taiwan and Japan) would be very attractive to study global supply chain and manufacturing issues up close. Finally, the Summer voyage with its special program for law students, would offer an additional opportunity to explore such critical issues as intelligent property and patents, especially critical in conducting business in such countries as China and Vietnam.

As noted, motivating factors included: First, a need to focus on the globalization of engineering and engineering jobs. Second, our concern that US engineering graduates must bring value to the market that may be dominated by low cost competition from lower cost countries including India and China. These concerns have led us to propose that future US engineering graduates must be able to:

- Work closely with customers, manage research teams and creatively improve business operations; systems integrators
- Work cross-culturally; acquire the people skills needed to work overseas
- Innovate; analyze other cultures' needs and design products and services to fit those needs

Hence, we needed to design a program that would:

- Present engineering and business students with an opportunity to study manufacturing and the global supply chain while visiting a series of Pacific Rim countries.
- Enable students to take 9 to 12 credits of "voyage relevant" course work
- Ensure that academics would be as demanding as a land-based program

Our specific educational aims for the initial program would then be to:

- Provide an in-depth examination of the Pacific Rim countries with a focus on manufacturing and the global supply chain.
- Visit Korea, Taiwan, China, Hong Kong, Japan, and Vietnam in order to better understand how these countries relate to each other and two US manufacturers.
- Visit manufacturing facilities in each country, meeting with managers and manufacturing engineers to learn first hand about operating in a global environment.

As the program planning evolved, we were able to obtain additional sponsorship from three corporations – Kennemetal, H.J. Heinz, and Sima, all of which had extensive facilities in the Pacific Rim. With these three industrial sponsors, a GOALI proposal was submitted to and funded by the NSF to enable us to use the program as a way of further studying issues related to the off shoring of engineering jobs. We would be able to examine relevant issues from both a faculty and student perspective. One of the co-authors (Bidanda) agreed to serve as the lead faculty member on the voyage, adapting two land-based courses for delivery at sea. (See [23] for additional insight into how one of these courses was adapted.) A second co-author (Thomes) served as the librarian for the voyage. The lead author (Shuman) would serve as an interport lecturer for a small portion of the voyage.

As noted, the Pacific Rim itinerary would provide a varied, rich setting for such a comparative study experience focusing on supply chain issues. Specifically:

- **Alaska** is rich in wildlife, minerals and natural resources including oil. Field trip(s) could focus on fishing and seafood processing industries. Students could study the production and movement of Alaskan seafood into the US mainland and the rest of the world.
- We were unsure what Petropavlosk, **Russia** could offer. We wanted to see the extent that this somewhat isolated Russian Pacific Rim territory would be involved in the global supply chain.
- **Korea** has a large manufacturing and industrial base. It is one of the leading countries in the world not only in shipbuilding, but also in the manufacture of automobiles and electronics. Korean industrial policy today has been shaped by chaebols that were propagated by President Park Chung in the 1960s and 1970s when a few companies were selected to grow by giving them preferential treatment. There are approximately 45 chaebols including four 'super chaebols' (Hyundai, Daewoo, Samsung, and Lucky Goldstar). We wanted to visit a chaebol to learn first-hand of their underlying rationale and growth pattern, and also a ship building yard to study not only the production processes in building seagoing vessels, but also the emergence of South Korea as a shipbuilding power.
- **China** is arguably the world's manufacturing leader. Industrial policies formulated by the Chinese Communist Party have helped establish free-trade zones that have led to the emergence of Shen-Zheng (near Hong Kong), and Suh Zhou (near Shanghai) as worldwide manufacturing capitals. We wanted to study both the location process and location economics of Fortune 500 companies and also of regional Chinese companies that undertake contract manufacturing.
- **Vietnam** is characterized by a strong sense of entrepreneurship. We wanted to meet manufacturing entrepreneurs and discuss their vision, motivation, and strategic plans with a special focus on their interactions with US engineers and the US market. With its relatively

large population of 80 million and its very low labor costs, Vietnam may soon play an important role in the outsourcing spectrum.

- The *Made in Taiwan* labels that were ubiquitous only a decade ago have given way to *Made in China* labels. The rise and fall of **Taiwan** in traditional low cost manufacturing would provide an important case study, where students would be asked to identify the drivers that led to this decline. We would focus on Hsin Chu, the new Taiwanese Silicon Valley that house companies such as Flextronics and also study the tribulations of regional Taiwanese industries that now sub-contract their manufacturing to China and Thailand in the pursuit of lower costs.
- The J**apanese** economy may finally be emerging from a slump, having been mired by high labor costs and a lack of capital investments for much of the past decade. We would discuss drivers that led to this decline and compare and contrast this with Taiwan, whose economy is enjoying a relatively healthy growth. The industrial base of Japan would be profiled along with its unique manufacturing environment. The transformation of the four large *Zaibatsus* (Mitsubishi, Mitsui, Sumitomo, and Yasuda) into the newer keiretsu that go beyond a typical industrial conglomerate by focusing on vertical relationships of closely linked suppliers would be studied. Visits could include a study tour of a keiretsu and to its smaller suppliers that are lower on the 'manufacturing' chain.

Two courses engineering courses were then designed, one of which was cross-listed through the College of Business Administration.

IE 1661: Global Manufacturing Systems Engineering.
This course presented the development and application of modern manufacturing engineering principles, methods, and tools, using the Pacific Rim ports as a field laboratory. Students first acquired knowledge of basic manufacturing process and principles, learning the principles of operating (and evaluating) shop-floor and manufacturing operations. This provided students with the ability to analyze and visualize manufacturing engineering challenges and opportunities around the world. Plant visits and interfaces with practicing engineers allowed students to understand the importance of various professional characteristics: ethics, the ability to work with others, an appreciation for other disciplines, adaptability, and an appreciation for life-long learning.

IE/BUSQUOM 1662: Manufacturing Cultures in the Pacific Rim
This course focused on manufacturing and distribution organizational hierarchies with a view towards understanding unique organizational dynamics within different organizations and different cultures. It allowed students to gain an understanding of the unique manufacturing culture of each country visited at both the organizational and policy levels. Students studied a variety of cross-cultural manufacturing paradigms ranging from the Vietnamese spirit of entrepreneurship, the Korean chaebols and super-chaebos, and the Japanese keiretsu. The course also focused on the complexities of problems in global operations and supply chain management.

The format for these courses included:

- Itinerary based lectures
- Case Studies (Daewoo and Korean Chaebols, Japanese Auto Industry and Keiretsu, Vietnamese entrepreneurs, Hsinchu (Taiwan), Acer Computers in PRC)

- Outsourcing Models and Engineering Economic Analyses
- Projects (two for each course)
- Faculty Developed Practicum (integrated field visits; two per course)

The ship actually provided the setting for one of the projects – a re-engineering of the ship's cafeteria. To do this student teams spent two weeks collecting data, visited the kitchen, and interviewed the hotel director and executive chef. This study was needed because the ship had been converted from a cruise ship to a floating university less than three weeks before the start of the program. Consequently, flow through the dining areas was much less than desirable. There was considerable interest from the entire shipboard community in this particular project which further motivated the students. (See Figures 1 and 2.)

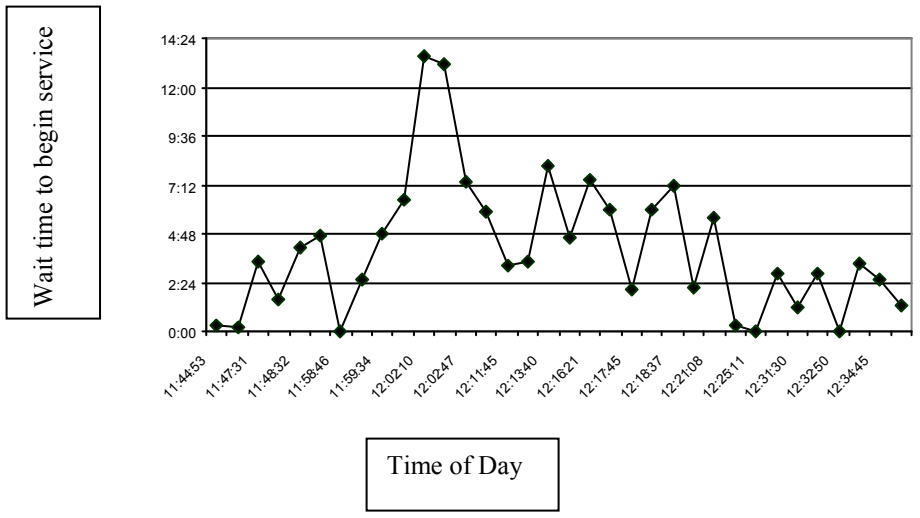

Figure 1: Wait time to begin service in cafeteria

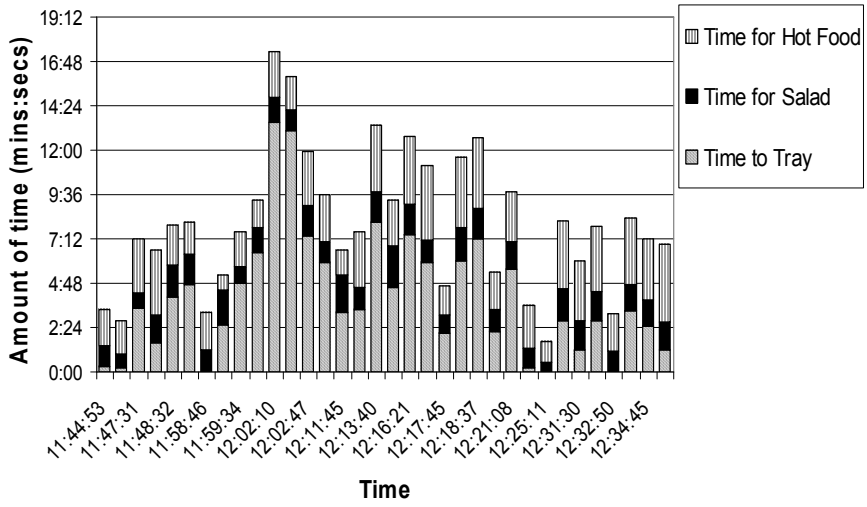

Figure 2: Time to go through line.

This type of project provided engineering students to work with business students as part of a truly multidisciplinary team. It required them to perform a complete analysis of the problem and develop a solution acceptable to the decision makers (ship management and the academic management). For most of the engineering students they learned to use important data collection and analyses techniques. The resultant solution required a slight adjustment to the class schedules that would relieved some of the congestion, combined with a revised layout of the cafeteria and the placement of the various foods and utensils as shown in Figure 3. Unlike many student projects, in this case the student teams' collective results were implemented following the conclusion of the voyage.

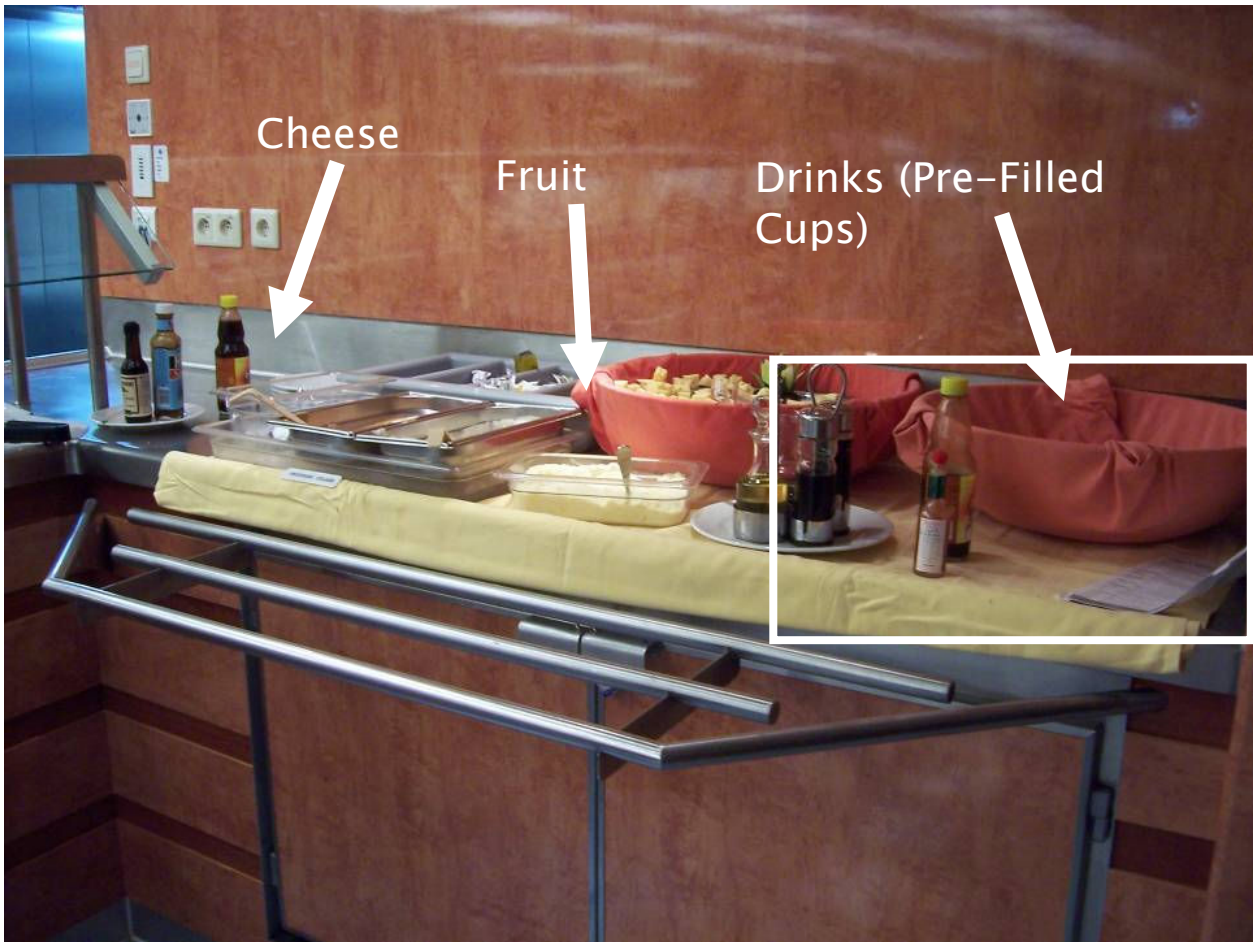

Figure 3: Part of proposed layout for cafeteria

The faculty developed practica included visits to Hyundai Ship Building (Korea), Hyundai Automobiles (Korea), Kennametal Inc. (Shanghai), Chroma/DynaScan (Taiwan), IEI Computers (Taiwan) and Mitsubishi Electric (Japan). In total, students and faculty visited eight factories in five countries. While some plant tours were fascinating, others were proved not to be very different from comparable visits in the United States. The real value of these plant visits came after the tours, in structured discussion sessions where workers, supervisors, and plant executives discussed issues of interest with students. Questions from the students ranged from routine (how many hours is a work week is China?) to controversial (why are there not any women executives

at this factory?). Many students also established mental role models for themselves after meeting American executives who seamlessly work in multiple countries and multiple cultures. These interchanges had been an important, planned component of the program.

Specifically, our plan was for data collection to focus on expectations (of corporations, academics and students), perceptions (of students), and extrapolations (of what the future would be). This three-pronged data collection would involve US academics, industry executives and students soliciting information in each country from engineers and managers, workers and academics as shown in Figure 4. As shown in the Figure, while we would be collecting data from our counterparts in industry and academia, we also wanted to encourage an information exchange among all the entities. In addition, participating students kept journals that enabled them to reflect upon their changing career and voyage expectations as the progressed around the Pacific Rim. At the end of the voyage they were encouraged to reassess their professional expectations and further reflect on how the voyage has impacted their career goals.

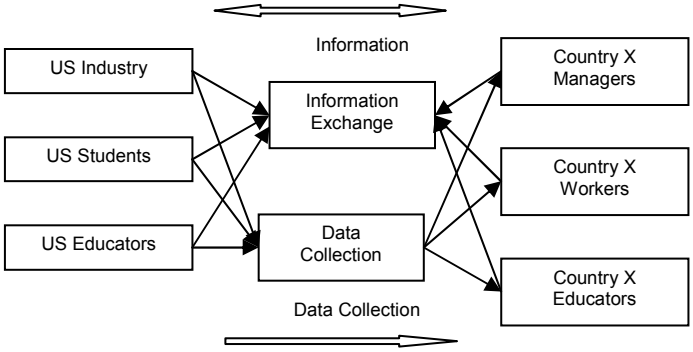

Figure 4: Overview of Data Collection and Information Exchange

In addition to the two engineering courses, a complementary course was offered by a political anthropologist. When combined together, students were then offered a solid grounding in manufacturing and the manufacturing culture within the Pacific Rim.

ANTH 1787: Special Topics – Political Economy of the Pacific Rim
This course focused on the interdependence of politics and economics in the countries of East Asia, and how the "East Asian miracle" and later "Asian Crisis" reflected the political economy context that led to the rapid development of China, Japan, Korea, and other smaller states in East Asia. The course also overviewed theoretical perspectives in political economy that inform different understandings of economic development, the relationship between politics and economy, and the impact of globalization and new technologies on the region as a whole. To explore the political economy of the Pacific Rim, students read particular East Asian case studies such as the computer and information technology industry, the steel industry, and the condition of industrial workers in East Asia.

Library Issues

In order to support the academics, library resources became an important consideration. While the Semester at Sea Program purports to have the largest library collection afloat, traditionally

the curriculum has focused on religion, culture, history, and political issues of countries throughout the world. Consequently, the shipboard library collections emphasize these areas. In addition to print material, the library also provides access to a multidisciplinary scholarly database with full text journal articles. However, since engineering in general, and manufacturing and the global supply chain are new disciplines to the program, they were not deeply represented in the library collection. The Summer 2004 voyage presented an opportunity to see how the existing library collection worked for engineering and business and to clarify what additional materials and resources would be useful to successfully support these disciplines on future voyages.

On every voyage, faculty recommend specific books and other resources to supplement the regular library collection. Engineering was no different, and several textbooks on manufacturing systems and processes were sent to the ship for inclusion in the course reserves collection.

What we discovered is that students could find broad, national level statistics and demographics from several of the reference volumes in the library, and that finding information on religions and cultural norms was relatively easy to do as well. The multidisciplinary database was also quite effective. In other words, the library successfully delivered the types of information it had historically been designed to provide, and the supplemental materials on course reserve were useful as well. However, the engineering and business students also needed different types of information: current statistics and data on specific industries, markets, processes. Much of this they had to get using the Internet. However, Internet access, while available at sea, was relatively expensive during the Summer 2004, and the connection was frequently lost, especially during the first half of the voyage.

Because Summer 2004 was the first voyage on a new ship, and there had been less than three weeks to convert the cruise ship into a campus, several desirable functions and services, including the IT infrastructure, were not fully implemented during this voyage. As the IT infrastructure is made more robust, Internet access will be more reliable, and additional electronic resources can be made available. So, while some challenges and frustrations presented themselves during this voyage, it is realistic to expect the library will be able to support shipboard engineering and business courses to a comparable extent that other disciplines are supported.

Results and Findings

A goal of attracting 25 students for the first year program was set, and exceeded when 31 students from 18 different institutions participated in the program. These included seven engineering students from Kentucky's innovative BS/MBA program described above. Seven engineering students from the University of Pittsburgh also participated.

Student expectations were surveyed at the beginning of the voyage and again at the end. Students initially believed that they would find:

- Factories that would resemble that of a sweat shop with poor working conditions.
- Archaic technology along with out of date facilities, particularly in China.
- Poorly educated work force and managerial staff.

- Lack of creativity
- Male Dominated industries
- In the higher developed countries such as Taiwan and Japan, products would be produced solely by robots.
- They did expect to find at Mitsubishi Electric (Japan):
    - A high level of technology
    - A focus on meticulous details

As we anticipated, student impressions did not necessarily match their expectations. What they found was:

- High-tech factories
- Strong work ethic
- Educated working force
- Innovation and emphasis on R&D; much more so than with many US companies they had visited.
- Efficient and clean manufacturing facilities
- Competitive companies that have the ability to be leaders in their respective industry
- The importance of protecting intellectual property, especially when doing business in China
- The need to understand the culture of the country

However, they also observed that:

- Management was still male dominated
- Some workers did highly repetitive but very intricate jobs

Two examples of student reflections were:
Student A
What were your expectations for the program at the start of the voyage?
I expected to gain an initial understanding of the industrial engineering discipline. I also expected to see how engineering factors into to the global/Asian economy.

Were your expectations met, exceeded, or not met? Please explain.
My expectations were exceeded. I feel that I learned a tremendous amount about not only engineering but also its role in the countries we visited. The class added to my enjoyment of visiting the countries and to my success in other classes.

What were your expectations for the program at the start of the voyage?
Student B
I didn't really have many expectations. I just wanted to learn by seeing and doing. I expected to have a good time and learn a lot.

Were your expectations met, exceeded, or not met? Please explain.
My expectations were blown away. I didn't even think the academic program would be as intense as it was. It was really neat having school and the world all to deal with.

We observed that when in port students interacted with the local community more easily than we had anticipated. In each country, students interacted with factory workers, engineers and local

businessmen outside of the academic environment. Having students relate these experiences in classes revealed their growing understanding (as the voyage progressed) of Asian cultures, philosophies and also the potential impact of Asian economies on the United States. These experiences were unique and unattainable in a traditional land based campus.

At a few of the ports, visits to local universities and meetings with engineering students were arranged. We found that both the plant study visits and other in-country experiences were more meaningful for students when they interacted with local faculty (as they did with professors at the Tung Nan Institute of Technology, Taipei) and students (from the University of Ulsan, Korea). Internet cafes at the ports were useful information gathering stops for class projects.

Other findings:

- In general, student evaluations for the instructor were quite high - IE1661 received a score of 4.13 (out of 5.00) and IE1662 a score of 4.41. These were higher evaluations than the instructor typically received at the University of Pittsburgh. Further, the courses were judged to be as demanding as those on land, even thought the Semester at Sea environment provided no weekends. (Classes were held every day at sea; in port, students were expected to participate in FDPs, see the country and interact with the people.) It suggests that this form of "very active" learning is extremely effective.
- The very serious, highly motivated engineering/business students were welcomed by the other faculty. For a number, it was the first time that they had taught engineering students and were pleasantly surprised as to how interested, and academically prepared they were. In many cases the engineering students were the most outstanding students in the non-engineering courses.
- The FDPs (field visits) were extremely well received; all were oversubscribed. Further, the companies went out of their way to make the visits a valuable experience. For example, a Mitsubishi executive came down from Tokyo to serve as the host of the visit in Osaka and made himself available for the question and answer session. Companies typically provided traditional lunches and gave students small gifts at the end of the visits. This gave students an opportunity to see the role of gifts in certain business dealings and cultures.
- Having 36 law students and two law faculty onboard provided opportunities for special sessions, including a combined law/engineering session that focused on intellectual property issues with an emphasis on China that drew very positive evaluations from both the engineering and law students. It suggests that on future voyages, more programs of this type should be done.
- Engineering students who have participated in other Semester at Sea programs have discovered during co-op or permanent job interviews that this is always a major topic of discussion. While anecdotal, the experience is that these students tend to receive the jobs they interview for, although this may be also related to the type of student that chooses to go on the Semester at Sea (or other Study Abroad programs).

In short, we have judged the program to be a success and will be offering it for a second time this summer. An additional challenge will be present due to a change in the itinerary that will now focus on Northern Europe (Iceland, Norway, Russia, Poland, Belgium, England, Ireland and Spain). Although we will not be going to the Pacific Rim, we believe that we can create a comparable program. We anticipate finding problems in the more developed countries (England,

Norway and Poland) comparable to those facing US manufacturers and the US global supply chain, while the countries with lower cost of living (Russia, Ireland and Poland) should be facing issues comparable to less developed countries throughout the world that are competing for manufacturing jobs while addressing the rise of such countries as China and India.

Obviously, this is only one type of international program for engineering students and it remains relatively expensive for those in-state students attending public institutions. For students attending private schools, the total cost is typically less than they would pay for tuition and room and board. However, we feel that this type of program provides a very rich, intensive experience for those engineering students who choose to participate.

Research Areas

This type of program suggests a number of research areas. Certainly an examination of the alternative pedagogies would be in order. This type of program requires that 20% of the course be outside the classroom, requiring the student to take more responsibility for his/her learning. Consequently, what students get out of the program is directly related to their motivation and how much they put into it. Which pedagogical approaches would best facilitate student learning? An important part of this is how to best structure the field program; e.g., the company visits so that they move beyond simply "show and tell." The best visits were those in which students were given sufficient time to both question and debrief managers and engineers. These visits provided an opportunity for the diverse mix of students – ranging from marketing and advertising majors to the various engineering disciplines – to expand upon what they learned in class and what they saw on the plant floor. Issues raised by the students included the importance of protecting intellectual property (something they may not have anticipated) and the role of women as both assembly line workers and managers.

Another research area is an assessment of the value of such a program. How much additional learning takes place under this type of comparative study environment? While we believe the benefit and value of such a program far exceeds both the cost and any resultant loss of summer income, can this be better documented? To what extent will such a program produce US engineering graduates who are more cross-culturally aware and able to work in different environments? How much have students gained in terms of self-confidence, independence, and flexibility? To what extent will such a program encourage students to seek more international opportunities or broaden their education to include more international course work and languages, something students' reflections indicated would happen.

Finally this type of program differs from almost all other study abroad programs because it is focused on global, comparative themes rather than the more traditional immersion type program where students spend substantial time immersed in one country and culture. We do not claim that Semester at Sea provides a better experience; rather we propose that both are equally valuable for the student. Certainly, a formal, comparative examination of these two types of programs would be in order. Clearly, engineering educators would like to know how this type of program really does stack up against the single-country opportunities in terms of student learning and experiences. We hope to begin such a study in the near future.

Bibliography

[1] Prados, J.W., "The Editor's Page: Engineering Criteria 2000 – A Change Agent for Engineering Education," *Journal of Engineering Education*, April 1997, pp 69-70.

[2] Shuman, L.J., M.E. Besterfield-Sacre and J. McGourty, "The ABET "Professional Skills" – Can they be Taught? Can they be Assessed?" To be published in the *Journal of Engineering Education*, January 2005.

[3] McGraw, D., "My Job Lies Over the Ocean," *ASEE Prism*, 13(4), December, 2003.

[4] McGraw, D. "Putting it into Perspective," *ASEE Prism*, 13(5), January 2004.

[5] Oberst, B.S. and Jones, R.C., "Canaries in the Mineshaft: Engineers in the Global Workplace," *(CD) Proceedings, 2004 American Society for Engineering Education Conference.*

[6] Oberst, B.S. and Jones, R.C., "Megatrends in Engineering Education," *(CD) Proceedings, 2003 American Society for Engineering Education Conference*.

[7] Institute of International Education, *http://opendoors.iienetwork.org/?p=35981*.

[8] NASULGC, A Call to Leadership: *The Presidential Role in Internationalizing the University,* Report of the NASULCG Task Force on International Education, October 2004.

[9] Machotka, M. and Spodek, S., "Study Abroad: Preparing Engineering Students for Success in the Global Economy," *(CD) Proceedings, 2002 American Society for Engineering Education Conference*.

[10] Shuman, Besterfield-Sacre and McGourty, op. cit.

[11] Grandin, J. and Viets, H., "International Experience for Engineers," *International Journal of Engineering Education*, Vol. 9, No. 1, 1993. pp. 93-94.

[12] Grandin, J. and Dehmel, E.W., "Educating Engineers for the Global Workplace: A Study of Cross-Cultural Issues," *Journal of Language for International Business*, Vol 8, No. 2, 1997, pp. 1-15.

[13] Vaz, R,F, and Pederson, P.C., "Experiential Learning with a Global Perspective: Overseas Senior Design Projects," *(CD) Proceedings, 2002 American Society for Engineering Education Conference*.

[14] DiBiasio, D. and N. Mello, Multilevel Assessment of Program Outcomes: Assessing a Nontraditional Study Abroad Program in the Engineering Discipline, Frontiers: The Interdisciplinary Journal of Study Abroad vol. 10, 237-252 (2004).

[15] Hirleman, E.D., Atkinson, D., Groll, E.A., Matthews, J., Xu, L., Aller, B., Hong, W., Albers, A., Wittig, S.L.K., Lin, Z.Q., and Xi, L.F., "GEARE: A Comprehensive Program for Globalizing Engineering Education," *(CD) Proceedings, 2004 American Society of Engineering Education Conference.*

[16] Hilerman, E.D. and Groll, E.A., "The Purdue GEARE Program," Presented at the Seventh Annual Colloquiium on International Engineering Education, Providence, R.I., Oct. 2, 2004.

[17] A Joint Degree Program of the College of Engineering and the Carol Martin Gatton College of Business and Economics of the University of Kentucky, *http://www.engr.uky.edu/research/students/bsmba/index.html*.

[18] Semester at Sea, *http://www.semesteratsea.com/voyages/summer2004/index.html*.

[19] Amadei, B., "Program in Engineering for Developing Communities: Viewing the Developing World as the Classroom of the 21st Century," *(CD) Proceedings, 2003 Frontiers in Education Conference*, Institute of Electrical and Electronics Engineering.

[20]Gosink, J., Lucena, J., and Moskal, B., "Humanitarian Engineering at the Colorado School of Mines: An Example of Multidisciplinary Engineering," (*CD) Proceedings, 2004 American Society for Engineering Education Conference*.

[21] Notash, L. and Garriock, M., "International Virtual Design Studio (IVDS) Program: Overview, Challenges, and Students' Perspectives," *IEEE Transactions on Education*, Vol. 46, No. 3, Aug. 2003, pp. 345-349.

[22] Doerry, E., Doerry, K., and Bero, B., "The Global Engineering College: Lessons Learned in Exploring a New Model for International Engineering Education," *(CD) Proceedings, 2004 American Society for Engineering Education Conference.*

[23] Bidanda, B., L.J. Shuman, K. Thomes, and O. Arisoy, "Adapting Engineering Coursework For Increased Global Relevance," *(CD) Proceedings, 2005 American Society for Engineering Education Conference.*