Global Engineering and the Liberal Arts

Steven H. VanderLeest, Edward G. Nielsen
Calvin College

Abstract

Design that targets emerging global markets requires not only good business sense, but also requires an understanding of foreign cultures. Students can achieve this broad understanding of society and humanity through education in the liberal arts. We have developed a new course that integrates global engineering and the liberal arts by immersing the students for one month in the engineering, business, and cultural aspects of a foreign (European) society. The course combines a number of creative approaches, including visits to a wide range of engineering sites in the commercial, academic, and government domains; a multidisciplinary team of faculty; and involvement of a larger segment of the home campus through a set of Internet web pages. Students achieve a number of important outcomes: discerning cultural differences, cultivating non-technical interests, developing critical thinking, and understanding global markets.

Introduction

The liberal arts component of an engineering education is important. Engineering educators know it. Working engineers know it. Engineering managers know it. Unfortunately, engineering students do not. In the student's mind, liberal arts courses are mere obstacles to be overcome in their academic program, offering no lasting value or merit. A variety of creative approaches have been attempted in the past to clarify the significance of the liberal arts course in the engineering curriculum [1-4]. In this paper, we offer an alternative approach that provides the student with important skills in the area of global engineering while at the same time instilling an appreciation of the liberal arts. These two important academic areas complement each other remarkably well. We have developed a course, described in this paper, that combines the two – global engineering and the liberal arts – and the combination produces measurable improvements in student perceptions.

Why are the liberal arts important for the engineering student? Because the products they design are not designed in a vacuum, but rather are designed within a complex social fabric. Designs must not only meet technical specifications, but must also satisfy an intricate web of requirements that depend on the broader context of the product and the user ▲ the economic, political, philosophical, aesthetic, theological, and historical milieu. For example, understanding political climates can help the engineer design a product that will meet current standards as well as probable future standards. Understanding the historical background of a locale allows the engineer to design a solution that meets user's expectations and enables understanding of the uses of the product.

Why is an international experience important for the engineering student? Because the products they design can no longer be provincial: their products are increasingly sold in a complex global market. Products made at home can be sold abroad, and competitors from around the world can come into the local market. Today's engineer must be perceptive about what the customer needs and how the customer perceives the product purported to meet that need. The problem specification, the allowable design alternatives, the marketing of the product, and even the disposal of products after their useful life are all culturally conditioned.

The liberal arts provide a strong foundation for understanding global engineering in that they teach a student to think more broadly and less colloquially. They show the student how to locate their technical knowledge in a broader scheme of life. This allows them to evaluate technologies for their appropriateness in a given situation. In turn, global engineering education provides a concrete application of the skills developed in the liberal arts. It connects abstract learning to real world details in a meaningful way. Engineering students often see traditional courses in the liberal arts as requirements to complete and forget. Our course on design for the international market ties in the liberal arts by promoting a real interest in the broader issues of life as they come to bear on engineering. The students learn the practical importance of the liberal arts and begin to see the sweeping scope of life in which engineering operates. They are persuaded to take ownership of their own education and career development.

A Broad Approach

In order to combine the concepts of liberal arts and global engineering in a way that would allow cross-fertilization, we developed a new course with several unique approaches that broadened the perspective of our students. First, we focused on engineering practice. The abstractions and models of academics often intentionally hide the "messiness" of reality, simplifying problems to help the students understand. Unfortunately, such methods also let students lose touch with reality, obscuring the inter-relatedness of real-world design problems, i.e. how the various aspects of the problem connect with and affect each other. Even when an explicit attempt at integration is made[5], the students can lose sight of how the various disciplines are involved in a real problem (versus one artificially crafted for the purpose of demonstrating integration). By concentrating on engineering practice, we put the student's academic learning into perspective.

Our Initial Course Offering

Title: Design for the International Market
Instructors:

- Computer engineering professor
- Mechanical engineering professor with extensive engineering management and sales experience
- Engineering manager (guest instructor)

Students: 30 engineering and business students
Cost: $2850 per student
Transportation: air to Amsterdam, bus and driver while in Europe
Countries: Netherlands, Belgium, France, Germany
Activities & Visits during the Course:

- Engineering businesses
- University engineering departments
- Cultural, historical, and religious visits as a group
- Individual excursions (students on their own)

Duration: 24 days

Such inter-relatedness of the design problem and environment lead to our next focus: a multidisciplinary approach. We used an interdisciplinary team of instructors: a mechanical engineering professor, a computer engineering professor, and an engineering manager retired from industry. We sought students from a variety of engineering disciplines as well as business majors. This provided lively discussions as the students worked out the connections between their own specialties and those of others. We also selected a variety of sites to visit (governmental, commercial, and academic) that included multiple engineering disciplines. We spoke not only with practicing product and manufacturing engineers, but also with engineering managers, plant managers, company presidents, researchers, sales people, and many others. This provided a well-rounded exploration of the entire design problem. Interspersed with the engineering businesses, we visited a number of cultural, historical, and religious sites.

Another unique feature of the course was our use of Internet web pages to teach and inform a larger segment of our student body than just those enrolled in the course. We assigned a different student each day to use a digital camera to document the events of the day. The resulting images were downloaded with accompanying text to a web site linked from the engineering department's home page. During the course, these web pages received hundreds of "hits" daily from interested students and faculty (as well as parents of the enrolled students). The web pages allowed others to benefit through our student's experiences. (These pages can be viewed on the Internet at http://engr.calvin.edu/courses. This includes our detailed trip itinerary.)

Liberal Arts with an International Flavor

During our course, we visited a number of engineering companies, research sites, academic engineering departments, and government engineering institutes. While each site provided a wealth of new insights and opportunities to see how engineering fits into the bigger picture of life, for this paper we have selected five examples to demonstrate what can be accomplished within the scope of one foreign-travel engineering course.

Case-France manufactures excavators and backhoes at its plant in Crépy-en-Valois, France. While certain aspects of the backhoe are the same for both the American and European models (the cab is basically the same), there are also some significant differences. The hoe rotates about a central pivot point for both models, but the European model also includes a slide plate. The operator can position the bucket on the ground and then engage the rotation control. Because the bucket is pinned to the ground, the pivot point then slides along the slide plate. Thus, the operator has both linear and rotational freedom of movement. This feature is important for many European construction sites. Ancient European city streets were built for pedestrians, not automobiles, and thus are often quite narrow. The ability to move the backhoe pivot point linearly to the left or right allows the operator to dig snug against a wall – something the American model cannot do. The students discovered several important liberal arts constraints to the backhoe design. The historical environment in which the machine operates restricted the physical range of movement available to the operator. The cultural climate restricted excavation from damaging existing walls of the historic buildings. Most Europeans highly value the aesthetics of the buildings and thus the best design of excavating equipment allows for preservation of structures in close proximity to the excavation site. At the same time, the design must be a close derivative of existing products to maintain economic competitiveness. The slide plate is an inexpensive, clever design feature that uses some simple physics to add vital flexibility of movement to the machine.

Steelcase Strafor, located in Strasbourg, France, designs furniture for the European market with a different emphasis than its American counterpart. The French favor aesthetics more than functionality. Thus, the French office systems feature more stylistic flair. Desks, tables, and cabinets are not as squared off. The artistic features may occupy slightly more physical space, but the components still work together to form an efficient work area. The students observed that the design of office equipment to compete in this market required a keen intuition about the user's habits and expectations. During our visit, we met with three managers with engineering backgrounds, two Frenchmen and one American. The Frenchmen had previous experience in the United States as well. Together, they offered an interesting perspective on meetings. Americans, in their opinion, meet to agree. The meeting is called to confirm a pre-existing consensus. Europeans meet to debate issues, coming to a resolution from contending viewpoints and dispute. Understanding these differences in corporate culture allows an employee of a multi-national business to quickly fit in and contribute.

At several different sites we visited, we saw the European implementation of Just In Time (JIT) manufacturing. JIT dictates that each assembly line is fed with a very small inventory that is stocked "just in time." This reduces cost by reducing the amount of space necessary for inventory stock. JIT also reduces cycle time – there is little unused stock to clear out, thus a new product or a different customization can quickly be implemented. The ability to customize implementations is important to maintain competitiveness (especially for large, complex products). Our students questioned the manufacturing engineers and managers in several plants we visited that stressed JIT. During a subsequent class discussion, the students identified an important weakness of this manufacturing approach: vulnerability to supplier delays. The entire assembly line is stalled as soon as any supplier misses the schedule. Thus, successful JIT requires close cooperation and communication between the manufacturer and all its suppliers.

In Wittenburg, we spoke with local residents about German unification. Although the people generally spoke well of the process, the students detected some specific tensions. For example, a company from the former West had built a large water treatment plant for the city. The plant was built with excess capacity for future growth. While the designers felt that this was a wise investment, some residents of Wittenburg resented the outside "intrusion" that forced a plant on them that was too large and costly (in their view). This was despite the fact that western funds financed the plant. The East German culture of this city played a formative role in shaping how the new technology was accepted or rejected. At the same time, many people in the former East are dissatisfied with the rate at which the unification is occurring. The western media has taught them to expect luxury and high technology at their fingertips. The western culture of consumption has been quickly adopted without a full understanding of the high resource requirements.

Finally, one of the sites we visited that sparked the imagination of all the students was the Storm Surge Barrier in Rotterdam. Rotterdam is the world's busiest harbor. Unfortunately, it is also the weak link in the chain of dikes and barriers that protect the Netherlands from the capriciousness of the North Sea. Ever since the severely damaging flood of 1953, the Dutch government has been building storm dikes to protect them against future floods. Rotterdam represents a unique challenge: the design must prevent massive flooding during a storm but at the same time minimize the impact on shipping. We learned about a number of alternative designs for the Storm Surge Barrier, and toured the nearly complete winning design. This colossal feat of engineering provides the final link in the chain to defend Holland against the sea. It consists of two huge, slightly curved movable dams, called retaining walls, which are 22 meters tall and 210 meters long (see Figure 1). A system of trusses supports the curved retaining walls, concentrating the force of the sea on the wall to a central pivot point. If a storm surge is predicted, the walls are floated and rotated out into the Rotterdam channel. Once the two halves meet in the center, they are sunk onto concrete sills to form a barrier against a storm surge. The truss system is made up of pipes (up to 1.8 meters in diameter) and transmits the force of the sea (up to 70,000 tons) to a massive ball joint located at the focus, or pivot point. Each of the two ball joints is 10 meters in diameter and weighs 680 tons. The students were very impressed by the sheer size of the project as well as by the careful planning and research that went into the engineering of the system. The design had to account for a variety of political, historic, and economic constraints as well as the more familiar technical constraints.

Figure 1 Model of Storm Surge Barrier

Practical Hints for Managing a Foreign-Travel Engineering Course

Before the trip

- Arrange site tours/meetings yourself , but let your travel agency arrange the airfare, hotel accommodations, etc.
- Use a hired driver/tour guide who knows the language(s). This frees you to teach and plan rather than finding your way through traffic.
- Incorporate variety to peak the interest of all the students. Work out visits that include discussions with practicing engineers, managers, marketing people, etc. Schedule meals with your hosts whenever possible to allow the students to talk with them informally. Intersperse technical visits with historical or cultural sites.
- Clearly layout your expectations for student behavior and set strict guidelines. Make everyone aware of the penalties for offenses.
- Assign pre-trip homework to students that involves researching one of the sites you will visit

- Have a contact person back home that can receive and pass on emergency messages. Provide them with a detailed itinerary (hotels, phone numbers, etc.) and detailed class list.
- Make 2 sets of photocopies of each participant's travel documents (passport, etc.). Carry one set of copies with you on the trip, give the other set to your contact person.
- Provide opportunity for each student to purchase a packet of money in advance, in a variety of denominations for each country you will be visiting.

During the trip

- Allow free time for students to explore on their own.
- Require students to travel in groups of two or more for safety.
- Be flexible about where and when you hold discussions (use travel time or evenings at the hotel). Ask the students pointed questions; encourage critical evaluation.
- Require students to keep a journal of daily activities. Provide specific questions they must answer in their journal for each day.

Changing Student's Perceptions

The course was taught for the first time in the winter of 1997. As the course progressed, we noticed a marked improvement in the student's perception towards a variety of liberal arts subjects. We encouraged them to see the importance of subjects such as language and history to the design process. In order to quantify the significant change in attitude we observed, we surveyed the first group of students to complete the course. We were quite pleased with the results. Figure 2 shows how the students rated the course. They did this evaluation by comparing the course to two different groups: (a) all courses they have taken, and (b) all courses within their major. Even against courses only in their major, our course came out as one of the best, with many students rating it the single best course they had ever taken. A non-technical course might be thought to have less educational value than a standard engineering technical course, but this was not the perception of the students. Most students rated the educational value of our course as "Better than average", even compared to courses in their major.

We also wanted to learn how such a course changed student attitudes towards various academic subjects. It was our hypothesis that the course would improve student perception of the value of liberal arts courses. This was borne out by the survey data. We asked the students to rate the value of 54 different academic topics, such as history, geography, verbal communication skills, and aesthetics. For each topic the student was asked to rate the value of the topic on a scale of 1 to 5, where 1 was "highly valuable" and 5 was "of little value". They made this evaluation for before and after the course, estimating the change in their own attitudes toward the subject.

Our students were probably representative of most engineering students, in that they rated a number of non-technical subjects with relatively little value. The lowest five topics (least valued first) as rated for "before the course" were:

- Philosophy (3.8)
- Language arts (3.2)
- Art (3.2)
- Sociology (3.1)
- History (2.9)

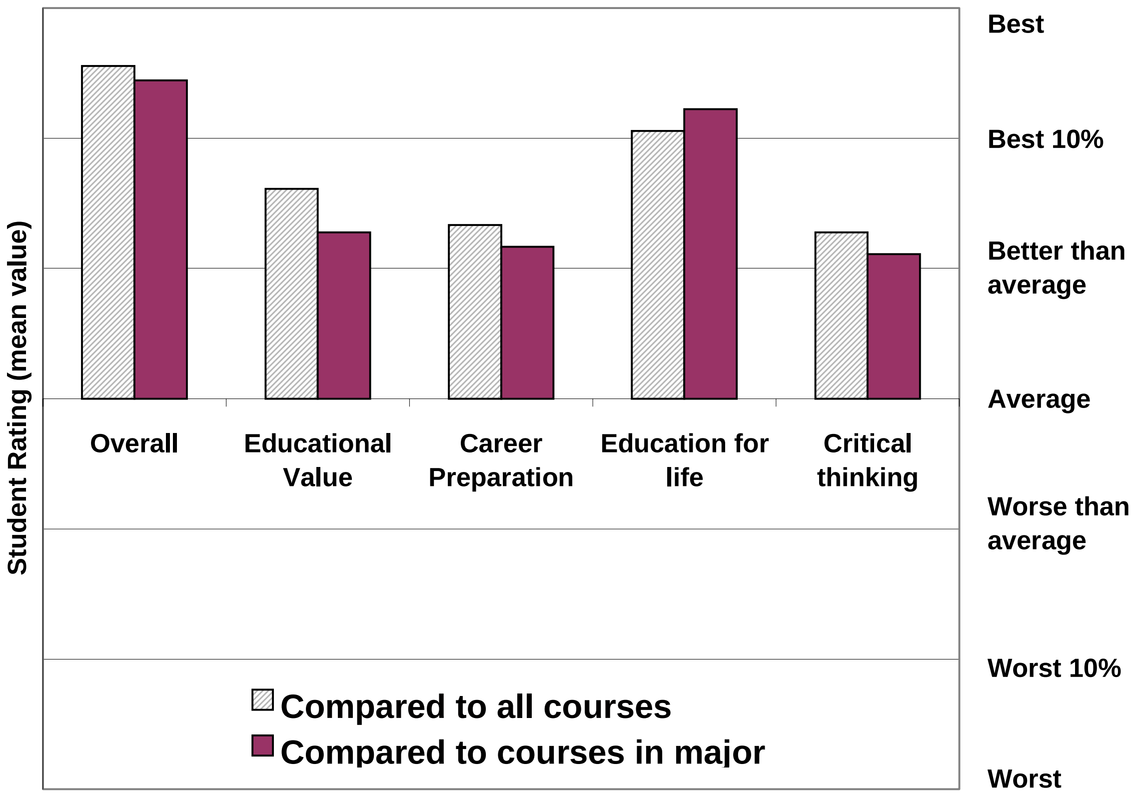

Figure 2 Student Comparative Evaluation of Course

The number after the topic is the average score on a scale of 1 to 5, (5 being the worst). We then analyzed the change in perception for each topic due to the course. The perception of the students changed dramatically in a number of areas. The largest change occurred for "language arts". This was not unexpected since many of our hosts stressed the importance of understanding the language of the customer for whom the design is intended. The top 15 areas, rated by improvement in student perception of value were:

- Language arts (28%)
- Global marketing (24%)
- Art (21%)
- History (19%)
- Cultural sensitivity (19%)
- Appreciation of cultural differences (19%)
- Geography (17%)
- Multiculturalism (16%)
- Aesthetics (16%)
- Civil engineering (15%)
- Verbal communication skills (13%)
- Non-verbal communication skills (13%)
- Computer engineering (13%)
- Political science (11%)
- Electrical Engineering (11%)

The number after each topic is the average improvement (on a scale of 1 to 5, a 20% improvement would be a one “step” increase in value on average). One of the most important aspects of this result is that the student’s attitude improved over a very broad spectrum of academic topics. Few other courses could claim to provide positive reinforcement for so many distinct academic areas. Other benefits were harder to quantify, for example, although we did not include such a question on our surveys, we also observed that a number of students became interested in graduate school after seeing the advanced facilities of a university graduate program.

Conclusions

Our course provides engineering students with the opportunity to experience a foreign culture and put their engineering education in perspective. We have found it an invaluable addition to our engineering curriculum. The course integrates multiple disciplines, providing students with the broad perspective necessary for engineering in today’s world. Every student who took the initial offering of the course found it one of the most worthwhile experiences of their college career. Finally, the course measurably improved the attitude of most students toward the liberal arts component of the engineering curriculum.

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Authors

STEVEN H. VANDERLEEST (Ph.D., University of Illinois at Urbana-Champaign, ’95) is an Associate Professor of Engineering at Calvin College in Grand Rapids, MI. His research interests include appropriate technology, design for the international market, engineering and business use of the web and intranets, and high-performance computer architecture. He can be contacted by email at svleest@calvin.edu.

EDWARD G. NIELSEN (M.S.E. University of Michigan, ’66) is an Associate Professor of Engineering at Calvin College. Mr. Nielsen spent 28 years in the aerospace and construction equipment industries. He worked as a project engineer for navigation equipment used on the F-111 and the Lunar Rover and was a pioneer in the use of lasers in construction, for which he has received 17 US patents. Contact him by email at nnielsen@calvin.edu.