# Capstone Design Experiences Across National and Cultural Borders: Course Development

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Abstract

It is well recognized that the world is becoming a global village. Today's undergraduates will occupy workplaces and communities that have been transformed by globalization; they must learn to make connections across disciplinary, national, and cultural borders. To address the challenge of providing exposure to global/international dimensions without sacrificing technical content, we have previously proposed to use case studies in sophomore engineering science classes. In this paper, we extend the concept to capstone engineering design courses by focusing on solutions to global/international problems. Additionally, a Web-based instructional tool (WebCT) is used to enhance global/international awareness as well as intercultural communication skills. WebCT is also used to "take students there," through movie clips.

## Introduction

Afonso (1994) has described three points that underpin the "internalization" of American higher education. First, the ability of our students to live and perform in an increasingly international context will greatly determine the extent to which the United States will prosper in the future. Second, although no clear-cut definition exists for concepts such as "global competence" and "international awareness," educators and administrators largely agree that these are the types of characteristics for success in a global economy. Third, colleges and universities have a responsibility to provide workers, scholars and leaders with these characteristics.

It is a challenge to provide meaningful experiences to students in technical and professional disciplines like engineering that are highly content-driven (Vas, 2000). Study abroad programs do not seem be attractive to these students. Based on data collected by the Institute of International Education, the so-called average study-abroad student is a white female in her junior year at a research institution, whose major is in the social sciences or humanities, and who chooses a program that lasts for one semester or less (Coffman, 2000). The trend toward decreasing the total number of hours required to graduate in most majors makes adding specialized courses a non-option. We have previously proposed use of case studies in existing required sophomore courses as a viable option. The case study approach as proposed has potential to provide students with global competence without compromising the syllabus content and time to graduation (Kisaalita, 2002a).

We are now extending aspects of the idea – focusing on solutions to global/international problems from global/international customers – to a senior course, the capstone engineering design. A senior design course was found attractive for several reasons. First, it is a required course that affords exposure to a large proportion of students in the program. Second, it is conducive to real-life, open-ended thought problems. Open-ended problems are ill-defined questions to which there is on specific "right answer," but more than one defensible solution. "Thought problems" require higher order thinking abilities and attitudes and tend to facilitate the exhibition of intellectual curiosity (Reeves and Laffey, 1999). Third, it is conducive for crossdisciplinary teams. The purpose of this paper is to describe how we are implementing the idea in a special international section of the Fall 2002 senior design, ENGR 4920.

The prerequisite for ENGR 4920 is ENGR 2920 Engineering Design Methodology, in which students are introduced to the design process as well as related tools for decision-making. In regular ENGR 4920 sections, students are expected to complete a design project under the supervision of an instructor. Sections are formed around design problems that are sometimes contributed by contacts in industry. The format is traditional; the student design team meets with its instructor(s) regularly. The general expectations listed in Exhibit 1 are distributed to each instructor and student at the beginning of the semester. The Spring 2002 course schedule for the International section is shown in Exhibit 2.

## 2. Elements of ENGRR 4920 International Section

When UGA undergraduate students are asked what locations they would prefer for study abroad experiences, their choices in decreasing order are: Western Europe, Asia/Pacific, Latin America, Africa and Eastern Europe (Kisaalita, 2002b). These responses are consistent with other survey results throughout North America (Desruisseaux, 1999). Coincidentally, the US Department of Commerce has designated the emerging markets of Latin America, Europe and Asia/Pacific as "Big Emerging Markets (BEM)" because over the next two decades, these markets will hold the greatest potential for dramatic increases in U.S. exports and commercial opportunities (AIChE, 2001). It can be argued that since BME are also the preferred location by students, they are the most desirable locations to find customer sources of design problems). The student reasons for the choice are probably not rooted in commercial benefits but rather in language and cultural compatibility as well as low safety risks. The preference for neighboring countries may be justified on the basis of cost and likelihood of stronger economic ties. However, the advantages of physical proximity are fast being eroded by developments in information and communication technologies. The linkages between U.S. and Indian software companies are a case in point. In light of this, the argument that it may not matter where the customer is located as long as the course objective of enhancing global competence/international awareness is met has merit. Additionally, less desirable locations may provide intercultural experiences that cannot be found elsewhere. Such experiences have become even more valuable in the aftermath of the September 11 incident in New York.

Several options are available to identify customers. On top of the list are multinational corporations with links to the academic institution. Other options include international agencies, overseas industries, governments and academic institutions. Overseas contacts can easily be obtained from the institutions' international programs office. The Spring 2002 problem shown in Exhibit 3 was obtained through contacts made from existing research collaborations between faculty at UGA and faculty at Makerere University of Kampala, Uganda.

The end result of an engineering effort - generally referred to as design - is a device, structure, system, process or service that satisfies a need. A successful design is achieved when a logical procedure is followed to meet a specific need. The procedure, called the design process encompasses the following activities, all of which must be completed: a) identification of the need, b) problem definition, c) search, d) constraints, e) criteria, f) alternative solutions, g) analysis, h) decision, i) specification, j) communication (Eide et al., 1998). As the design team proceeds through each step, new information or knowledge may be discovered and new objectives may be specified for the design. If this is the case, the team must backtrack (feedback loops) and repeat the steps. The design process is therefore iterative as represented in Exhibit 4.

Given the distant nature of the problem source, it was logistically impossible for the students to travel at the beginning of the spring 2002 semester to conduct their own customer interview (for establishing the need or design problem). The instructor conducted two customer interviews during the summer to be available on the first day of spring semester. In the first interview, the production manager provided a historical overview of the company, where the company is heading, production costs and his perception of the challenges and opportunities ahead. In the second interview, the western regional manager answered questions patterned after the items listed in the interview work sheet (Exhibit 5). All interviews were recorded with a Canon digital video camera (GL1). Also, the instructor acquired additional footage of key elements of the process from the rudimentary function decomposition shown in Exhibit 6, to acquaint students with background practices and knowledge pertaining to the problem as rooted in the local environment.

The idea of the in-country peer supporter mentioned in Exhibit 2 was justified from the perceived need for the students on the design team to have some one on the ground other than the customer that they can turn to for frequent cultural or technical questions and quick local information searches. The peer support student, an agricultural engineering major of senior standing at Makerere University, was recruited during the summer. It was anticipated that he/she would be helpful in situations where the customer is not responding to students' questions in a timely manner by personally finding the customer and/or obtaining the necessary information. Being of senior standing, he/she should relate well to what the student design team is trying to accomplish.

As shown in Exhibit 2, the design team is scheduled to travel during spring break to present their solution concepts to the customer. This is a pivotal element of the course in that students gain first hand exposure to the country, the people (from a culture different from their own) and meet the customer face to face. After presenting their solution concepts, the student team manager provides lead in a round table discussion with the customer and/or the customer representatives to agree on the best concept to further pursue. The team has to successfully communicate with the customer and/or the representatives. To prepare for this encounter, students are receiving formal training in intercultural communication. Also, their understanding of globalization is enhanced by participating in an online discussion of four papers on the subject.

Training in the intercultural skills of presentation and communication is provided via four modules (one lecture each) implemented during the first four weeks of the Semester. The first module explores factors that facilitate or impede effective communication between members of different cultural groups. The second module considers interactions between people from different nations as well as co-cultures within the same nation. The third module covers the effects of differing world-views, value systems, language varieties, nonverbal codes, and relational norms. The fourth module facilitates the development of skills for disseminating ideas across cultures and building intercultural competence. To be able to cover a lot of ground in a short time, Web-based companion resources for each module are made available for students to study further in their own time.

The four readings on globalization are assigned, one per week, during the first four weeks of the semester. The reading occurs outside the classroom and group discussion of each reading is conducted online. The reading selection for Spring 2002 are as follows: 1) "The new system" (Chapter 1) in Friedman (2000), 2) "And the walls came tumbling down" (Chapter 4) in Friedman (2000), 3) "Dream deferred: A story of high-tech entrepreneur in a low-tech world" by Maddy (2000), 4) "Africa's ringing revolution" by Ashurst (2001). The first and second readings provide a deeper understanding of what globalization is and how it came about. The third reading provides insights on obstacles to conducting technology-driven business in emerging markets. The fourth reading in an example of how new technology, if fully adopted, can have far reaching impacts.

## 3. Grading, Course Evaluations and Learning Outcomes Assessment

Communication forms account for 60% of the final grade. As shown in Exhibit 7, half (30 points) are awarded for written communication (final report and contribution to online discussion) while the remaining half goes to verbal communication (midterm and final presentations and contribution in meetings). 30% of the final grade is devoted to the design process, which includes proper use of engineering science principles, published information, experimentation, decision-making tools, etc. Ten points are awarded to encourage critical thinking.

Pascarella and Terenzin (1991) have noted that critical thinking has been defined and measured in a number of ways "but typically involves the individual's ability to do some or more of the following: identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions from information or data provided, interpret whether conclusions are warranted on the basis of the data given, and evaluate evidence of authority." In the Winter et al. (1981) study, students who followed a course of study that required the integration of ideas and courses across disciplines showed greater gains on a measure of critical thinking than students who took the regular courses in the general areas but without the integrative emphasis. Forrest (1982) reported similar evidence. It has been observed that college graduates, who demonstrate an advanced ability to think critically and communicate effectively, will increase their ability to solve problems (National Education Goals Panel, 1991, p. 5). A search for critical thinking assessment instruments revealed that the most applicable instrument (for engineers) required a trained person to administer and score (Reeves and Laffey, 1999). Also, the costs of general instruments were prohibitive for classroom use (e.g., Watson and Glaser, 1994; Paul and Elder, 2001). There seems to be a need for an instrument that addresses engineering/science student critical thinking assessment.

Pre and post course international awareness is assessed with the Global Awareness Profile (GAPTest). This instrument is designed to measure students' awareness and knowledge of global issues (Corbitt, 1998). In a similar fashion, intercultural communication is assessed with the Interethnic Communication Apprehension Test. Based on 25 years of research, this instrument measures the fear or anxiety that students feel when confronted with communicating with peers from different cultures or ethnic groups (Neuliep & McCroskey, 1997).

In addition to standard course evaluation forms, input from the customer and peer supporters is solicited in the form of the following questions: What was done well or what did you like most about this project? If you were to participate in the project again what would you like to see done differently? In what ways did your participation benefit you, your institution or your country? Do you have any comments not covered in the above questions?

## 4. Instructional Technology Affordances

There are numerous Web-based platforms for teaching and learning in the higher education market. Examples include, WebCT, Blackboard, and Lotus Teaching Space. A campus-wide committee of teaching faculty selected WebCT as the application to provide Web-based instructional resources for UGA. WebCT is the market leader in the Web-based learning higher education market. As of September 1999, WebCT had more than two million student users at more than 800 colleges and universities in more than 40 countries. WebCT is a tool that facilitates the creation of sophisticated Web-based educational environments. It can be used to create entire on-line courses, or simply publish materials that supplement existing courses.

The tools and utilities available to a WebCT course designer are listed in Exhibit 8. "Content Assistant" allows adding material from Web addresses. "Upgrading Student View" allows updating the entire course or implementing changes to text, colors and action menus. In the third column of Exhibit 7 are the options used in the ENGR 4920 international section. Chat and Discussion options are expanding the learning space outside of the traditional team meetings, especially in a highly interactive activity like design. It seems to work very well for a student who does not verbalize very well in a group setting but is very comfortable online. Most importantly, it is making it possible to cover more ground (e.g., globalization readings and intercultural communication companion material). The quiz tool is being used for pre- and post-course assessment instruments. Students are able to take these tests at their convenience as long as they are taken within the allowed time window. By linking a web site that hosts the customer interviews to the WebCT course site, students can view the interviews and related materials at their convenience. The fact that short clips are used makes it easier to only view the desired items. Copyright problems do not arise because access to the WebCT site is password protected. Course management utilities are allowing the tracking of individual students and the gathering of statistics that will be invaluable to detailed evaluation, assessment and dissemination of the final project results.

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Instructional Technology Leadership Program. Mention of brand names is for information only and does not imply endorsement.

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Biographical Information

WILLIAM S. KISAALITA is an Associate Professor and conducts research in bioengineering with applications in the development of functional cell-based assay technologies. Also, Dr. Kisaalita applies instruction technology to the internationalization of engineering and science curricula. He was one of the 1999/2000 International Fellows and participated in the Instruction Technology Leadership Program at his institution. He has taught an introductory biological engineering course and other courses in engineering dynamics, engineering physiology, biological process control, and engineering design. He has been a mentor and an active supporter of undergraduate student participation in research.

Exhibit 1. General Expectations for ENGR 4920

At the end of the semester, the design team must prepare the following: a) written document detailing the deign solution, b) oral presentation with computer-based visuals, c) poster.

Each student must maintain a design notebook using the format as taught in ENGR 2920.

The instructor serves as a mentor for the team. The role of the instructor is to offer advice and encouragement but not to tell the students how to perform the design. The design problem must be open-ended.

A team manager can be elected by the team or selected by the instructor.

Periodic meetings between students and instructor are expected. The frequency of meetings and the form of interim reports provided by the students are at the discretion of the instructor.

The grading policy for the students in the section is determined by the instructor. The instructor must develop a method to determine the contribution of each team member to determine his or her grade. The students must be aware of this policy. Peer evaluation has been very effective in determining the contribution of the team members.

A mid-term status report from each design team will be held with presentations of 15 minutes with 5 minutes for questions.

The final presentations will be held at the end of the semester and will consist of 30-minute presentations and 10-15 minutes for questions.

Outside evaluators will be present for final presentations as well as UGA engineering faculty. The evaluators will also review the posters. Instructors may provide names of individuals who might serve as evaluators.

Exhibit 2. Schedule for ENGR 4920 International Section Spring 2002 Offering

| Week | Day | Activity/Milestone |
|---|---|---|
| 01 | M | Section assignments/Administer all pre testing/Choose team manager |
| | W | Team mtg/Intercultural communication 1st lecture |
| 02 | M | 1st Progress & plans memo to all/Intercultural communication 2nd lecture |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 03 | M | MLK Holiday |
| | W | Team mtg/Intercultural communication 3rd lecture |
| 04 | M | 2nd Progress & plans memo to all/Intercultural communication 4th lecture<br>Post 4 globalization-reading units online and initiate online discussion |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 05 | M | Team mtg/End of 1st globalization unit discussion |
| | W | Team mtg/End of 2nd globalization unit discussion |
| 06 | M | 3rd Progress & plans memo to all/End of 3rd globalization unit discussion |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 07 | M | Team mtg/Eng of 4th globalization unit discussion |
| | W | Team mtg - on your own |
| 08 | M | 4th Progress & plans memo to all |
| | W | Concept presentation to whole class |
| 09 | M | Spring Break - Travel |
| | W | Spring Break/Present concept(s) to customer |
| 10 | M | 5th Progress & plans memo to all |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 11 | M | Team mtg - on your own |
| | W | Team mtg - with instructor |
| 12 | M | 6th Progress & plans memo to all |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 13 | M | Team mtg - on your own |
| | W | Team mtg - with instructor |
| 14 | M | 7th Progress & plans memo to all |
| | W | Individual mtgs - grade for exhibiting critical thinking |
| 15 | M | Final report due |
| | W | Team mtg - with instructor |
| 16 | M | Final presentation and poster |
| | W | Team mtg - with instructor/ Administer all post testing |
| 17 | M | Last day of classes/Mail presentation video and final report to customer |

Exhibit 3. Problem Statement

Customer: Dairy Corporation Limited (DCL) of Uganda

Background: Until very recently, the Dairy Corporation of Uganda (DCU) was a parastal body with the countrywide monopoly for collecting, processing and marketing milk. Because the average dairy farmer in Uganda is not large enough to afford a milk chilling facility, DCU established milk-cooling plants in close proximity to groups of farms all over the country. Milk from individual farms is transported to these plants and kept at 4°C before being transported to the only processing plant in the capital of Kampala.

As a result of the Uganda Government's macro-economic policy on liberalization, a statutory body (Dairy Development Authority) was created under the Dairy Industry Act No. 11 of 1998. Following a dairy master plan, DCU has been restructured into a commercial company (DCL).

According to the new DCL Managing Director, their single largest expenditure is represented by energy consumed by the milk chilling plants. Diesel generators (15 - 250 kVA) power most chilling systems. Where hydroelectric grid supply is available, the generators are also used as stand-by against the frequent power supply interruptions. Among possible reasons for the unacceptable energy costs are: 1) the escalating unregulated cost of diesel fuel, 2) the unreliable supply of diesel fuel, 3) difficulties in monitoring and controlling intended diesel fuel usage, 3) the unreliable supply of electricity, and 4) the recent deregulation of the power industry that has resulted in the doubling of electric power rates charged to consumers in some cases.

To be competitive in a deregulated environment, without the near monopoly DCU enjoyed over the years, energy costs have to be contained. The customer is interested in an affordable solution. Since milk chilling plants all over the country seem to face the same problem, the customer anticipates that the solution for one plant, with minor modifications, will be applicable to the rest of the 200 plants currently owned by DCL.

Special Notes: Customer interviews were conducted by Dr. Kisaalita last September and are available on the course WebCT site. Design team members will be encouraged (or required) to travel to Uganda during Spring Break to present their design concepts to the customer. Under a collaborative agreement between UGA and Makerere University (MU), an MU agricultural engineering student will serve as in-country peer supporter for the design team. The peer supporter will be someone, other than the customer; the design team will turn to for frequent cultural or technical questions and quick local information searches. He/she will particularly be helpful in situations where the customer is not responding the team's questions in a timely manner. Communication among the design team, the customer, and the peer supporter will be mainly by e-mail.

Ideal Design Team Size: Three engineers and an agricultural economist?

Exhibit 4. Engineering design process

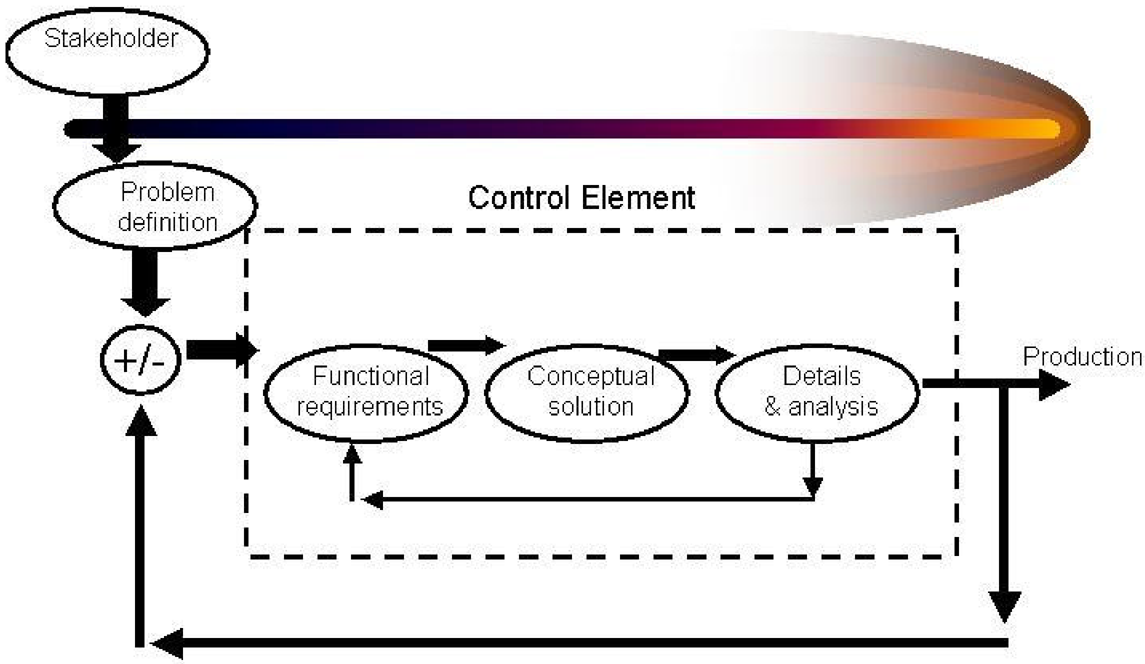

Table 5. Sample Interview Work Sheet

| |
|---|
| Process Technology: |
| Main components and their capacities |
| Sources of equipment/technology |
| Most problematic components and thoughts on solutions |
| Packaging/Distribution/Competition: |
| How accomplished |
| Competitive advantages |
| Threats |
| Practice: |
| A typical good day - open to close |
| How does Saturday/Sunday differ? |
| A typical bad day and how many of these a month or year |
| Top problems and thoughts on solutions |
| Income and Expenses: |
| Major costs – raw material, energy, labor, capital etc. |
| Income |
| Any problems in this area and thoughts on solutions |
| Future Plans: |
| One-year time-scale |
| Five-year time scale |
| Major constraints or impediments: |

Exhibit 6. Rudimentary Functional Decomposition of the Milk Handling Process.

| |
|---|
| Hand milking |
| Transportation to cooling plant |
| Receiving at the cooling plant |
| Laboratory testing |
| Loading into cooling tank |
| Cooling |
| Loading into transportation truck |
| Transportation |
| Receiving at processing plant |

Exhibit 7. Final Grade Criteria

| Points | Activity for which points are awarded |
|---|---|
| 10 | Bi-weekly memos and meetings - critical thinking (individual) |
| 10 | Contribution to online globalization discussion (individual) |
| 10 | Participation in nonscheduled and scheduled meetings (individual) |
| 30 | Design Notebook - proper use engineering science principles, published information and own experimentation (individual) |
| 10 | Mid-term presentation (team) |
| 10 | Final presentation (individual) |
| 20 | Final report (team) |
| 100 | (TOTAL) |

Exhibit 8. WebCT Course Design Tools and Utilities

| Tools | | | Utilities | | | Options added to the course |
|---|---|---|---|---|---|---|
| Content Assistant | Update Student View | Add Page Or Tool | Manage Files | Manage Course | Change Settings | Modify |
| | | Pages/URLs<br>Contents/related tools<br>Communication tools<br>Evaluation tools<br>Study tools | Upload Files<br>Create<br>Edit<br>Copy<br>Move<br>Rename<br>Delete<br>Zip<br>Upper case<br>Lower case<br>Download | Manage Students<br>Track students<br>Manage presentations groups<br>Manage teaching assistants<br>Track pages<br>Back-up courses<br>Reset course<br>Share access | Instructor name<br>Language<br>Welcome page<br>Course menu<br>Course appearance | Homepage<br>Organizer page<br>Calendar<br>Chat<br>Discussion<br>Syllabus<br>Homepages<br>Quiz |