
AC 2011-1348: GLOBAL INTERESTS AND EXPERIENCE AMONG FIRST-YEAR CIVIL ENGINEERING STUDENTS

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Global Interest and Experiences among First-Year Civil Engineering Students

Abstract

Globalization is one of the desired outcomes for civil engineers articulated in the ASCE Body of Knowledge (BOK2). However, the general level of awareness and interest of our students in global issues is poorly understood. Student interest in and awareness of global issues may impact the ease with which programs can instill the requisite globalization knowledge, comprehension, and application competencies in our students. This project explored global awareness among students enrolled in a first-year introduction to civil engineering course. First, students completed a voluntary survey at the beginning of the semester where they self-reported whether they had lived in and/or traveled to three or more countries, and whether or not they had participated in service activities outside the U.S. These same students answered Likert-based opinion questions related to international project aspects and stakeholder interests. Student opinions on the importance of globalization relative to the other outcomes in the Body of Knowledge (BOK2) were gathered. In addition, the students indicated their preference for term-paper topics that ranged from local to national to international. Content analyses of other course assignments were conducted to look for evidence of students' interest/awareness of global issues. Overall, it appeared that many first year civil engineering students were interested in global issues and aware of its importance. Future studies are needed to measure students' level of achievement against the BOK2 globalization outcome as they graduate with their B.S. degrees.

Background

The importance of global competency for U.S engineers has been articulated by numerous groups. The Engineer of 2020 report from the National Academy of Engineering (NAE)¹⁹ included an entire chapter entitled “Societal, Global, and Professional Contexts of Engineering Practice” and one of the four specific scenarios was based on “Global Conflict or Globalization.” Within the ABET accreditation criteria¹, program outcome h requires students to “understand the impact of engineering solutions in a global, economic, environmental, and societal context.”

Interest in global engineering education is strong and has risen substantially in the past decade. The Annual Colloquium on International Engineering Education began in 1998, sponsored by the Fund for the Improvement of Postsecondary Education (FIPSE) and the University of Rhode Island. The focus of the meeting was on how to internationalize curricula and educate students in an era of globalization, and from this meeting *The Newport Declaration to Globalize U.S. Engineering Education* emerged.¹² The number of papers from the American Society for Engineering Education (ASEE) annual conference that included the terms “global” or “international” in their titles has been increasing, as shown in Figure 1. The diversity of this literature cannot be fully described here. However, the papers fall into a few general categories:

- International experiences via exchanges, study abroad, and service projects
- International collaboration via distance models
- Developing student skills to work internationally
- Assessing global competency

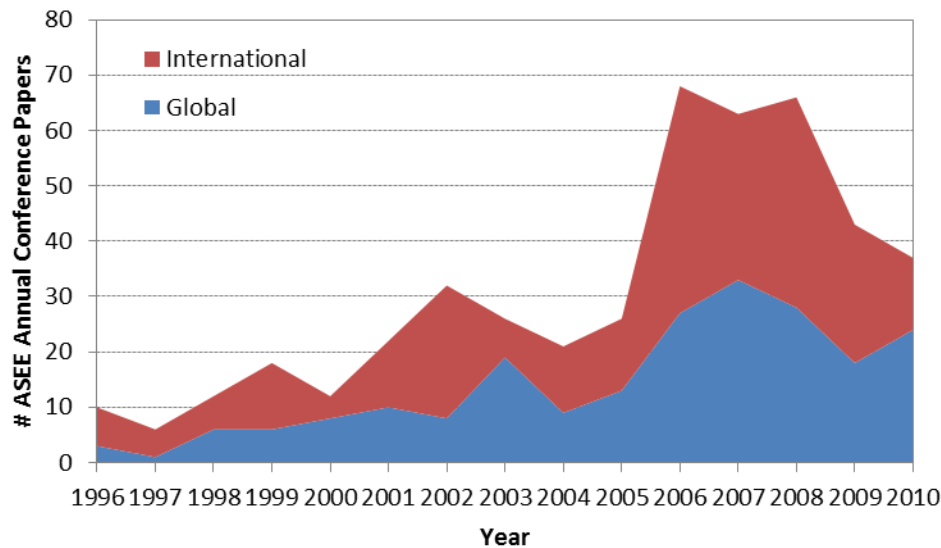


Figure 1. Number of papers in the ASEE Annual Conference Proceedings that included global or international in the title

There are threats, challenges, and opportunities for U.S. engineers associated with globalization. Threats include the large numbers of engineers now being educated in China and India, which far outstrip the number of engineering degrees awarded in the U.S.^{11,13} The engineers in these developing economies are generally paid lower wages¹³, posing a threat due to the outsourcing of engineering jobs. What attributes of U.S. engineers will justify commanding higher salaries? The argument has been made that U.S. engineers must be leaders and innovators⁸, so-called dynamic engineers¹¹, with broad professional skills, rather than “transactional” engineers doing largely rote and repetitive technical tasks. Creativity and entrepreneurship have also been stated as important skills for engineers in a global economy²². Simpson²⁴ stated that civil engineering jobs were the least likely to be outsourced to out of the country due to the type of work and how it is performed; in contrast, computer and electrical engineering jobs are the easiest to outsource.

The large growth in infrastructure needed in rapidly developing countries provides an opportunity for rewarding civil engineering work. Many large U.S. engineering consulting companies do a significant amount of their business internationally. For example, CH2M Hill has offices in 30 countries and has conducted projects in more than 116 countries (<http://www.ch2m.com/corporate/worldwide/default.asp>). Working on projects abroad will require additional skills to enable the engineers to perform effectively on teams across language barriers, cultural differences, and varying political constraints.

Globalization is one of the desired outcomes for civil engineers articulated in the ASCE Body of Knowledge (BOK2).² There is a broad diversity in the definitions of globalization, with 25 definitions relevant to civil engineering included in the BOK2 (Appendix M). BS degree students are expected to achieve the first three levels of achievement (LOA) of Bloom’s taxonomy with respect to this outcome (as quoted from the BOK2):

Knowledge: describe globalization processes and their impact on professional practice across cultures, languages, or countries

Comprehension: explain global issues related to professional practice, infrastructure, environment, and service populations (as they arise across cultures, languages, or countries)

Application: organize, formulate, and solve engineering problems within a global context

The BOK2 also notes that three areas pertaining to global topics are of importance: the globalization process, global issues, and global professionalism.

Although there is fairly widespread agreement that global competency is important, the means to achieve this outcome among our students is less clear. A 2009 review of 10 engineering programs identified fulfillment of the globalization outcome to be the weakest of all of the 24 BOK2 outcomes⁹. Only 5, 3, and 1 of the 10 schools reportedly fulfilled *all* of the BOK2 outcomes for globalization at LOAs 1, 2, and 3, respectively. *Most* of all of the outcomes for globalization at LOA 1, 2, and 3 were fulfilled by 6, 6, and 4 of the 10 schools, respectively. These results indicate that changes will be needed in many civil engineering curricula to achieve the globalization related outcomes. While many believe that study abroad and international service activities such as Engineers Without Borders (EWB) may be particularly relevant, cost and resource issues have led some universities (Penn State²⁷, Brigham Young University²¹) to conclude that such experiences are not practical for all students. Further, other research has found minimal growth in the cultural competency of students derived from short-term abroad experiences⁶ or study abroad¹⁴.

Student interest and awareness of global issues may impact the ease with which civil engineering programs can instill the requisite globalization knowledge, comprehension, and application competencies in our students. But the general level of awareness and interest of our students in global issues is poorly understood. The high number of students volunteering to participate in EWB provides some evidence for global interest in students, but it is unclear how widespread this interest extends.

This project explored issues related to globalization among students enrolled in a first-year introduction to civil engineering course. Elements of the course introduce students to the application of civil engineering in international contexts, and survey and direct assessment of student work provides insight into students' interest and awareness of global issues. Other educators have also targeted first year courses for the incorporation of international elements into engineering curricula⁷.

Research Methods

The research was executed in a first-year, 1-credit Introduction to Civil Engineering (CVEN) course at the University of Colorado at Boulder (CU). All engineering students at CU are required to take a 1-credit introductory course to their major. For CVEN students, this is the only civil engineering course in the first semester; many students are also enrolled in a 3-credit first-year engineering project course. Students generally take two or more CVEN courses in the following semesters. The introductory course used a similar structure and survey instruments from 2006 to 2010. The class met for 50-minutes once per week over the 15 weeks of the semester. The demographics of the students enrolled in the course are presented in Table 1. The students enrolled in the course who were not civil engineering (CVEN) majors were primarily students in the college of engineering who had not yet selected a specific engineering major.

Students who transferred into CVEN as sophomores often took the course, while some students classified as sophomores by the university due to transfer and AP credits were in fact first year students.

Table 1. Summary of student demographics in the first-year civil engineering course

Course year	# students	% female	% URM	% international	% first year	% CVEN majors
2006	51	14	4	10	67	57
2008	56	18	6	4	86	79
2009	78	17	13	8	65	53
2010	59	14	5	5	68	66

URM = under-represented minorities; Hispanics, Black, Native American

The learning goals for the course were intended to enable students to describe civil engineering, apply engineering ethics, and understand sustainability. Although not an explicit learning goal, some global issues were introduced in the course. Table 2 shows the course components from 2010 that included global issues; similar elements were also present in 2009. In 2008 and 2006 the course did not include the sustainability module. In 2007 the course had a different instructor and the content may have deviated significantly from what is shown. The guest speakers who represented various sub-disciplines within civil engineering were not prompted to include global issues in their presentations, but the fact that all individually chose to do so in 2010 indicates the importance of a global perspective.

Table 2. Summary of international issues included in the first-year course

Lecture	International component	Assessment / student work
1. Introduction	International examples of civil engineering projects (tall buildings, Three Gorges Dam, Chunnel); BOK2 outcomes including globalization	Homework 1: civil engineering definition, current project, most important skills and knowledge
2 & 3. Sustainability and sustainable development	Quotes from the NAE Engineer of 2020 ¹⁹ report regarding sustainable practices in industrialized and developing countries, and adapting solution in an ethical way to constraints in developing countries; five pillars of sustainability for the developing world ¹⁶ ; UN Millennium Development Goals ²⁵ and global lack of basic services; global poverty rates and land footprints; global urbanization; climate change; human development index (HDI) of different countries vs. their per capita energy consumption ¹⁵ ; global water consumption	Homework 2: sustainable development principles, UK case study
7 & 8. Ethics	N/A	Homework 4: one of the three moral exemplar cases (Cuny) conducted international development work

9. Curriculum and learning outcomes	CU CEAE Department mission statement, Engineering for Developing Communities secondary concentration; ABET outcomes criterion 3-H	Homework 5: student rating of BOK2 outcomes in the curriculum
10 & 12. Controversies, disasters, and Successes	Six international project/event examples with brief overview by professor and then student presentations with ~3 slides to small groups	Homework 6: Project/problem overview; engineering solution; non-technical issues; interest in this project for career
11. Guest speaker: geotechnical engineering	Some international project examples, such as Leaning Tower of Pisa, sinking Bellas Artes in Mexico City, energy piles in the UK, Dubai excavation flood, sinkhole in Guatemala City	<i>May be discussed on homework 7</i>
13. Guest speaker: structural engineering and mechanics	International examples of structures and societies (pyramids in Egypt and Mexico; global tallest buildings in Dubai, Taipei, Shanghai; Roman arches); structural analysis history (Babylon, Greek, Roman, Hagia-Sophia Istanbul); structural engineers and architects (Eiffel, Maillart, Nervi; Isler; Calatrava)	<i>May be discussed on homework 7</i>
14. Guest speaker: water resources	Global water demand and supply maps; water and population dynamics; global water scarcity maps; climate change impact on water supply	<i>May be discussed on homework 7</i>
15. Guest speakers: construction engineering & management	Global development and urbanization; China pre-fabricated buildings rapid construction example	<i>May be discussed on homework 7</i>

Student interest and awareness of global issues were assessed via questions on a pre-survey and from their submitted homework assignments. The surveys are described below to provide a context for interpretation of the results. Very little data is available from 2006 because the students submitted hard copies of assignments, and they were no longer available for examination. In 2007 the course had a different instructor, so beyond the initial survey data no other information will be presented for that cohort.

Results

Pre-survey

A voluntary survey was administered on the first day of class in 2006-2008 and 2010, with 5-minutes provided in-class for students to complete the survey [the survey was not administered in 2009]. Relevant results are summarized in Table 3. In 2007, 2008, and 2010 the survey

included an initial question that asked the students whether they had lived in and/or traveled to three or more countries; 56-66% of the students answered affirmatively to this statement. The male students showed decreasing international travel over time compared to an increase over time among the female students. Only a small fraction of the students reported that they had participated in service activities outside the U.S; less than ~10%. These data are similar to the results of a survey of 435 first-year engineering students at Penn State University where ~63% had previously traveled outside the U.S. and over 15% had lived abroad for a month or more²⁷. In a Purdue survey with 231 respondents that included all engineering majors and levels (first year through graduate students), 34% reported previous extensive international travel as a tourist and 16% previous international volunteer work¹⁴.

Table 3. Pre-survey results from first-year introduction to civil engineering course

Year	Gender	# survey respondents	% lived in or traveled to ≥ 3 countries	% participated in service activities outside the U.S.	Overall UDO score Average \pm std deviation
2010	male	44	55	5	13.1 \pm 1.5
	female	9	63	0	13.8 \pm 1.8
2008	male	31	61	10	12.8 \pm 1.8
	female	9	56	11	13.4 \pm 2.0
2007	male	32	71	13	12.6 \pm 1.6
	female	10	50	0	13.5 \pm 1.1
2006	male	44	NA	NA	12.3 \pm 1.8
	female	6	NA	NA	12.7 \pm 1.4

NA = not asked in that year of the survey

The same survey measured students “universal diverse orientation” (UDO) using the previously-validated MGUDS-S instrument.^{10,18} UDO is “an attitude toward all other persons which is inclusive yet differentiating in that similarities and differences are both recognized and accepted.”¹⁸ The three constructs that comprise UDO are: seeking diversity of contact, relativistic appreciation of self and others, and comfort with differences. UDO may correlate to student interest and comfort in different cultures. This instrument is comprised of 15 statements for which students rate their level of agreement on a 6-point Likert scale (strongly disagree to strongly agree). The maximum possible UDO score is 18. The results indicate a slightly increasing trend in the average UDO of the students over time. This should be a positive indicator of ability to work across cultural differences. When the data from all four years of the survey were pooled, female students had a significantly higher UDO than male students (2-tailed t-test, DF 183, $p = 0.039$). Also, among the male students in 2010 there was a higher UDO for students who had traveled to three or more countries (average UDO 13.5) compared to less widely traveled students (average UDO 12.6) (2-tailed t-test, DF 42, $p = 0.047$).

The same survey also asked students to rate their level of agreement with 12 other statements related to international aspects, stakeholder impacts, and/or societal impacts of engineering (including four questions from the PFEAS⁴) using a 6-point Likert scale. The four statements most closely related to international issues were:

1. I would be equally comfortable teaming with an engineer from the U.S. as one in India or China to work on a project.

2. The technology that is used in the U.S. is likely the best technology to use to solve similar technical problems in other countries.
3. I expect that a water treatment plant designed for a 100,000 person city in the U.S. would also be a good solution for a 100,000 person city in China if the inlet water quality were similar.
4. Engineers are able to design good solutions to engineering problems if given sufficient technical data, even without visiting the community or talking with stakeholders.

The student response results in 2010 are shown in Figure 2. The responses to the first question showed that many students were not highly uncomfortable with the idea of working on multi-national teams. The second question showed that more than half of the students may under-appreciate the difficulties transplanting engineering technologies into other countries. On question 3, however, the largest number of students disagreed with the statement, indicating some appreciation that local conditions could differ substantially in another country. Finally, an unfortunately high number of the students did not feel that meeting with project stakeholders was necessary, which could lead to false-confidence if working on projects for international clients.

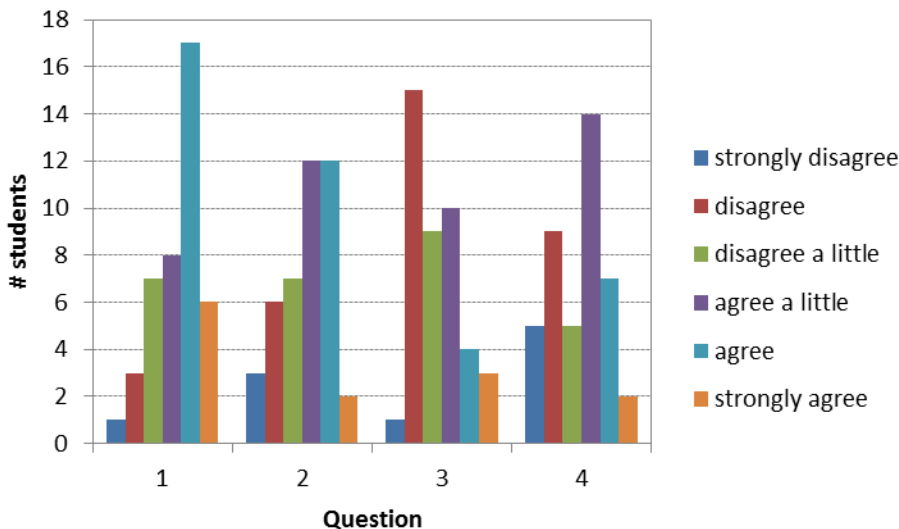


Figure 2. Likert-ratings of the 2010 students to the four pre-survey questions

Statistical analyses were conducted to determine if the responses were significantly different among the students who were more widely traveled internationally. Of the four questions, previous international travel only had a significant impact on the response for question 2 (among male students 2007-2010 pooled, not widely traveled averaged 3.5 versus more international travel averaged 4.1; significantly different via two-tailed heteroscedastic t-test with $n=97$, $DF\ 95$, $p=0.02$).

First Homework

In the first homework assignment of the semester, students defined civil engineering, identified the main sub-discipline areas of civil engineering, selected a sub-discipline of particular personal interest, described a current civil engineering project in the news, explored the skills required to

be a civil engineer, and described the path to professional licensure. A basic word search of the student essays using Microsoft Windows Explorer revealed that about 50% of the students were already were thinking about global impacts of civil engineering, with results summarized in Figure 3. It was somewhat surprising that the percentages decreased from 2008 to 2010. The context in which these terms were used cannot be determined from the word search alone.

Therefore, all of the 2010 assignments were individually examined. Specifically, the countries in which the example civil engineering projects discussed by the students were located were noted; 62% U.S., 16% Middle East, 11% Asia, 7% non-U.S. Americas, 4% Europe. The most popular single project discussed by the students was the tallest building in the world, the Burj Khalifa in Dubai, UAE.

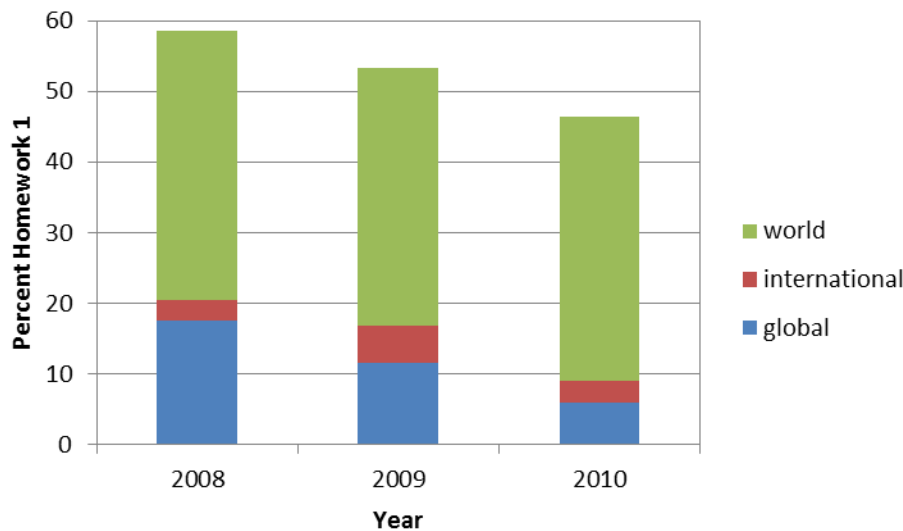


Figure 3. Percentage of student homework 1 assignments containing the keyword shown (when an individual assignment contained multiple terms, it was fractionally counted)

Body of Knowledge Globalization Outcome

Students stated the five knowledge areas or skills that they believed were the most important for civil engineers, in response to one of the questions on homework 1 in 2010. The students were given the BOK2 as a reference for the assignment. In fall 2010 only 3 of 55 students rated globalization in their top 5.

Later during the curriculum and outcomes assignment (homework 5) the students were asked to comment on which three BOK2 outcomes appeared to be the strongest and which three the weakest in the CU curriculum. The students were presented with information for each of the required courses and key electives that showed which of the BOK2 outcomes that each course helped fulfill. Earlier in the assignment the students had selected their four civil engineering proficiency courses (of five choices) and two concentration courses (for the student's selected specialization focus). Globalization was the most frequently cited weakest area of the curriculum; 25 of the 51 students included it among the three weak areas they were asked to list. The next most frequently cited weak outcome areas were humanities and social science by 19 and 18 students, respectively. Globalization was not selected by any of the 51 students as a

strongest outcome; the most frequently cited strengths of the curriculum were problem definition and solution, design and conduct experiments, mathematics, and design. Therefore, the students perceived that the courses in their curriculum did not strongly prepare them for competency in global issues.

On the same homework assignment, the students were asked to discuss how they might strengthen the competency areas that they identified as weak. Ideas proposed by the students included: taking specific courses as humanities/social science electives (Global Issues in Leadership, Geographies of Global Change, World Cultures, Global Economics, etc.; 14 students), study abroad (3 students), course-based service learning such as in senior design (2 students), participate in Engineers Without Borders (EWB; 2 students), and international travel (3 students). The activities identified by the CU students had some similarities to those identified by Penn State students²⁷: interacting with international students within courses (69.5%), course activities and assignments that focus on international issues (61.5%), interacting with international students outside of class (56.3%), study abroad (47.6%), and work abroad (29.3%).

Despite the availability of various international options outside of normal courses, fairly few CU CVEN students have historically taken advantage of these opportunities. For example, only 4% of all students in the College of Engineering at CU participate in study abroad. The International Engineering Certificates offered by the College starting in 2003 have been gaining popularity. These certificates are currently available in German, Italian, French, Spanish, Chinese, and Japanese. The certificates require language courses, culture courses, the International Engineering Seminar course, and may include an optional international internship. College-wide there were 65 students enrolled in these programs in 2008 (of a total undergraduate student population of 3022); but only 4 civil engineering students have received the certificate from 2008-2010. About 94 students participate in our student chapter of EWB-USA, including 66 civil engineering majors who traveled abroad on EWB projects from 2003 to 2010.

The first year student evaluations of the BOK2 outcomes are similar to the results from a BOK2 survey given to senior civil engineering students in fall 2009; none of the seniors ranked globalization in their top five most important BOK2 topics. The seniors also ranked globalization 7th among the BOK2 outcomes needing the most improvement in their curriculum at CU, with 13 of 58 students rating globalization as one of the top three areas requiring the most improvement⁵.

Sustainability Assignment

Global sustainable development challenges, particularly the need for water and sanitation, and the human development index were discussed in-class during the sustainability lectures. This module was added to the course for the first time in 2009, and modified somewhat in 2010. The students looked at the principles for sustainable development from the Royal Academy of Engineering (UK)²³ and the Hannover Principles (Germany)¹⁷. In addition, one of the sustainability case studies analyzed in the assignment was in the United Kingdom.²³

In 2009, the sustainability assignment required a reading and discussion on global climate change and its impacts on civil engineering. However, most students were already aware of and concerned with climate change, so that portion of the assignment was removed in 2010. A 2010 in-class response (aka. Clicker) question asked students ‘*How severe you think problems related to global climate change will be?*’ The multiple choice options and student responses were: none, climate change not occurring (0 students); minimal (3 students); some effect, but technology will allow us to adapt so minimal problems will occur (10 students); moderate effect (20 students); severe effects (14 students); thus, most CVEN students rated climate change as likely to cause moderate effects.

The sustainability assignment also required students to read and discuss the ASCE Infrastructure Report card³. When presented with the overall sector grades during the lecture, students asked what the infrastructure ratings were in other countries. Students were referred to an additional reading on this topic²⁵, from which highlights were presented at the beginning of the following lecture. The overall infrastructure ratings of 139 countries from the World Economic Forum Report²⁵ ranked the U.S. as 15th overall, and the sub-category rankings in various transportation sectors were also discussed.

Using the word search function in Microsoft Windows Explorer and searching for ‘*global, globe, international, or world*’, it was found that 26% of the student essays from 2010 contained one or more of these terms. The same search with the 2009 essays found ‘*glob(e/al)*’ in 64% of the essays; it is not surprising that this percentage was higher than in 2010 because in 2009 the students were explicitly required to discuss the impacts of global climate change on civil engineering. When the combination of all three search terms was used, 82% of the 2009 student essays contained one or more of these terms. Thus, specific assignments can be fairly easily configured to emphasize global issues.

Ethics Assignment

As part of the homework for the ethics unit, the students selected one of the three moral exemplar cases to read and discuss.²⁰ The choices were William LeMessurier, Inez Austin, and Fred Cuny. Fred Cuny worked in international aid and development; 31%, 33%, and 31% of the students in 2008, 2009, and 2010 selected to discuss the ethical issues related to Cuny’s work. This indicates that for about one third of the students the international development work was of interest equal-to or greater-than the structural design problem encountered by LeMessurier or the environmental issues faced by Inez Austin.

For the Cuny case, the students were asked to answer three specific questions: (1) provide three specific examples of various types of civil engineering work that Cuny conducted; (2) discuss three examples of ethical behavior citing relevant specific parts of the code of ethics; and (3) discuss three examples of non-technical challenges faced by Cuny. An analysis of the student essays from 2010 identified the most commonly discussed non-technical issues, as shown in Figure 4. Almost all of the students had some discussion of political issues, and the fact that Cuny educated local individuals to build more earthquake resistant structures. The local constraints of war and poverty were also discussed.

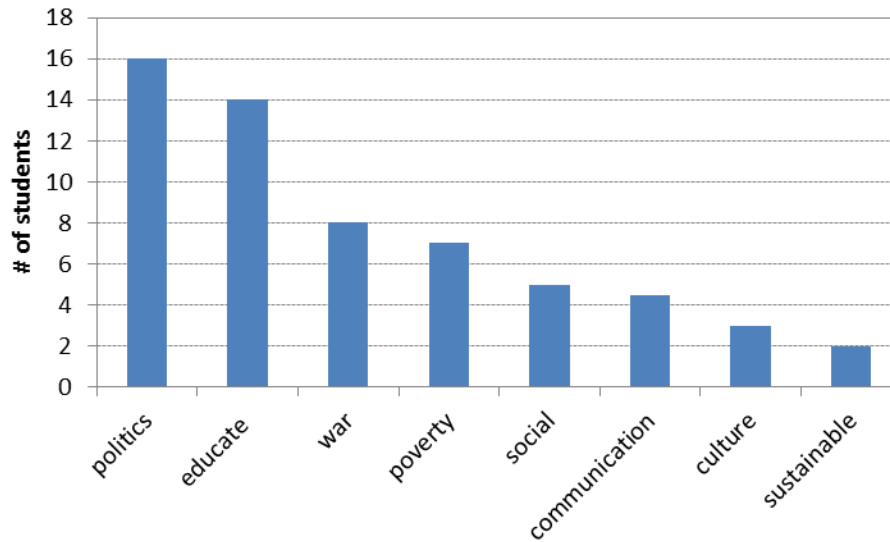


Figure 4. Common non-technical themes in the ethics essays on Cuny

Some example student quotes on these various topics are provided below:

“In Guatemala, Fred Cuny taught the locals the principles of earthquake resistant construction with “housing pictographs” in the wake of a natural disaster so that they could rebuild to their own standards and customs.”

“Cuny faced harsh political climates in almost every situation. The governments were resistant to his changes because they would lose power so it became extremely difficult for Cuny to succeed.”

“In Ethiopia, Cuny worked with restructuring the refugee camps in to concentric circles rather than grids to improve social coherence”

The student work provides direct evidence that the students integrated the international context with BOK2 outcome 11 (contemporary issues and historical perspective) and ABET outcome H.

Term Papers

For their homework 6 term papers in 2008 to 2010, students were presented with a range of local to global civil engineering related events and topics to research and discuss. The specific topic options that were available to students are shown in Table 4. Students rated the topics that they were most interested in learning about. Their relative interest in these topics indicated the degree to which the first year students were interested in global civil engineering projects and related events. The available topics varied somewhat from year to year (as shown in Table 4). In addition, not all of the students in the course signed up for topic preferences. The total interest scores shown in Table 4 were calculated based on the formula:

$$\text{Interest score} = \frac{[(3 * \# 1^{\text{st}} \text{ choice ratings}) + (2 * \# 2^{\text{nd}} \text{ choice ratings}) + (\# 3^{\text{rd}} \text{ choice ratings})] * 100}{(6 * \# \text{ students who rated topic preferences})}$$

Because there were only 12 project options available in 2008 compared to 15 topic options in 2009 and 2010, on average the topic rating should be higher in 2008 (8% vs. 7%). The average score for each topic are shown in Table 4, and these topic scores were then averaged for the in-state projects, out-of-state U.S. projects, and international projects resulting in scores of 3.6, 6.1, and 8.2, respectively. The in-state projects were the least popular, perhaps because they were not topics in recent news that the students had heard about.

International projects were rated in the top three by 89% of the students (127 of the 142 total). In 2008, 2009, and 2010 only 3, 4, and 8 students, respectively, did not have at least one international project listed as one of their top three project choices. This indicates a high level of interest in international projects, considering that international projects represented only 5, 6, and 6 of the 12, 15, and 15 total projects available each year, respectively. In addition, 14 of the 142 students (10%) selected all international projects for their top three choices, indicating a very strong international interest (7, 3, and 4 students in 2008, 2009, and 2010, respectively).

Table 4. Student preference scores for different research paper topics

Project locations	Civil Engineering Event (year) or Topic	2008 n=44 ¹	2009 n=47	2010 n=51	Average
In-state (CO)	Alamosa contaminated water ('08)	0.8	3.2	0.7	1.6
	Poudre River Dam (proposed)	7.6	2.5	2.3	4.1
	US36 corridor improvements	6.2	4.0	NA ²	5.1
Domestic (USA)	World Trade Center ('01)	15.5	14.1	10.1	13.3
	Minneapolis bridge collapse ('07)	11.6	11.6	10.5	11.2
	New Orleans Katrina flood ('05)	3.5	5.8	12.1	7.1
	Deep Horizon Gulf Oil Spill ('10)	NA	NA	11.4	11.4
	Boston's Big Dig (~'92-'06)	NA	4.3	6.2	5.3
	Midwest levee failures ('08)	1.9	1.1	NA	1.5
	Tennessee Dam collapse ('08)	NA	1.8	NA	1.8
	Orange County CA groundwater replenishment (~'09)	NA	NA	1.3	1.3
International	WI Lakeshore Environmental Enhancement (~'09)	NA	NA	1.6	1.6
	China Olympic structures ('08)	17.8	17.4	7.5	14.3
	Three Gorges Dam, China	17.6	8.7	7.2	11.2
	Sichuan China earthquake ('08)	13.2	4.3	6.5	8.0
	Hong Kong bridges	NA	NA	5.2	5.2
	Beijing, China, air pollution	3.1	1.4	NA	2.3
	Palm Island, Dubai	NA	14.5	11.4	13.0
	Dam Failures in Romania, Spain	NA	NA	6.2	6.2
Arsenic in India/Bangladesh drinking water	4.7	6.5	NA	5.6	

¹ n represents the number of students who provided project preferences

² NA = project topic not available to students in that year

Students may have selected topics based on the sub-discipline area of civil engineering that they were primarily interested in rather than the domestic versus international element; therefore the analysis was also conducted by topic preference as summarized in Table 5. Structures projects appeared the most popular, with two “disaster” topics and two “exemplar” projects. The international and domestic projects were of similar interest, indicating that the topic itself may have been more important than the location. This is not unexpected since the majority of the students (51-57%) indicated that their primary sub-discipline of interest was structures on the first homework assignment of the semester. For the highly multi-disciplinary topics such as dams and levees, the international projects were of higher interest. Here the disaster and failure type projects seemed less popular. Finally, environmental topics seemed to have the lowest interest overall. The Gulf oil spill was a hot news item in 2010 and seemed to generate good interest. Otherwise, comparing the two drinking water contamination issues, the international arsenic topic was significantly more popular than the local contamination problem. The lower interest in environmental topics correlates with the 5 to 17% of the students who indicated environmental as their primary civil engineering sub-discipline interest on the first homework assignment.

Table 5. Average project preference scores from 2008-2010 grouped by sub-discipline areas

Primary Civil Engineering Sub-discipline	Specific Research Topics	Domestic projects	International projects
Structures	China Olympic structures		14.3
	World Trade Center	13.3	
	Minneapolis bridge collapse	11.2	
	Hong Kong bridges		5.2
Dams, levees, earthquake damage: interdisciplinary	Palm Island, Dubai		13.0
	Three Gorges Dam, China		11.2
	Earthquake in Sichuan China		8.0
	New Orleans Katrina	7.1	
	Dam failures Romania, Spain		6.2
	Boston Big Dig	5.3	
	Poudre CO proposed dam	4.1	
	TN dam collapse	1.8	
Environmental	Midwest levee failures 2008	1.5	
	Gulf Oil Spill 2010	11.4	
	Arsenic in India/Bang. water		5.6
	Air pollution in China		2.3
	Alamosa water contamination	1.6	
	Groundwater recharge in CA	1.3	
	Wisconsin Environ. restoration	1.6	

A basic content analysis of the student essays from 2010 was also conducted. These were simple word searches of the electronic files using Windows Explorer. The search terms used were many of the non-technical criteria. Related terms (such as ethics and ethical; sustainability and sustainable; economic and economy; etc.) were grouped. Similar percentages of the student

essays on international and domestic topics discussed cost (70%), economics (60%), safety (41%), sustainability (33%), social/society factors (22%), infrastructure (20%), health (18%), and natural resources (13%). Topics with significantly different representation among the essays on international versus domestic topics are shown in Figure 5. Significantly more of the essays on international topics discussed environmental, energy, cultural, and ethical issues; a few more of the essays on U.S.-based topics discussed community, politics, and jobs (but only 6 to 8 of the 56 essays included these terms).

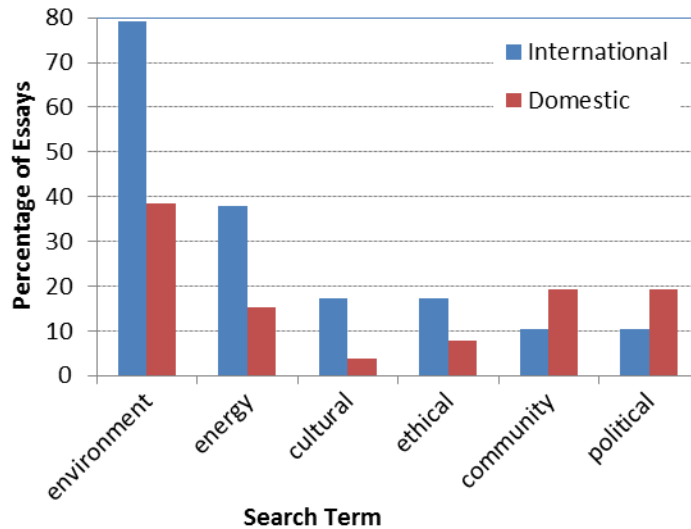


Figure 5. Differences in the percentage of student papers on international versus U.S. topics that contained selected key words

To determine if the differences noted above were due to the international versus domestic context or other project-specific differences, it was desirable to compare similar topics in both a domestic and international setting. The topics that had both international and domestic examples were dams, bridges, and building collapses. However, the U.S. dam project was proposed while the international dam projects were controversial (Three Gorges Dam) or collapse. The U.S. I-35 bridge collapsed while the Hong Kong bridges are new structures. More of the U.S. topics were disasters (New Orleans levee failures, Minneapolis bridge collapse, Deep Horizon oil spill, World Trade Center destruction; 19 essays) and the international projects were generally new project examples (Beijing Olympic structures, Hong Kong bridges, Palm Island; 14 essays). Within the disaster topics, the China earthquake damage and international dam collapse (9 essays total) were compared to the New Orleans levee failures and bridge collapse (10 essays). These seem somewhat comparable since the earthquake and levees are examples of extreme natural disasters meeting some engineering problems; the dam and bridge collapses were not under unusual natural conditions but more man-made problems. The small numbers of essays in each group reduces the ability of statistical analyses to find differences. The largest differences in the essays on international earthquake/dam vs. domestic levee/bridge were found for the search terms environment (6 vs. 1), energy (3 vs. 0), climate (0 vs. 2), and cost (4 vs. 6). The data indicate that the international context may encourage the students to consider a broader array of non-technical issues than domestic projects and events.

Previously in 2003, 2004, and 2006 all of the students were assigned to research a specific sub-topic related to the Three Gorges Dam in China. In that way, all students were required to think about an international project to some degree. This was another suitable model to teach students about globalization. The older Three Gorges Dam assignments were no longer available for content analysis as part of this research.

Final Reflective Essays

In the first part of the final essay assignment, students were required to write about one professional society meeting (such as ASCE, AGC, SWE, etc.) or professional development activity (such as the career fair, design expo, civil engineering graduate seminar) that they had attended during the semester. Of these options, EWB represents the opportunity that is the most obviously global in nature. The percentages of the students who chose to attend the EWB meeting were 36%, 22%, 16%, and 4% in 2006, 2008, 2009, and 2010, respectively. The trend of declining interest in EWB over time was somewhat surprising. About half of the students who attended the EWB meeting stated that they would be interested in joining the CU student chapter of EWB.

The bulk of the homework 7 essay assignment required that the students consider various aspects of civil engineering and ultimately state if they planned to pursue a career in civil engineering. The students were asked to define civil engineering, talk about what they learned about the civil engineering profession from the guest speakers, describe aspects of being a civil engineer that were personally appealing and unappealing, and discuss how their personal skills and attributes did/did not fit well with the civil engineering skills described in the BOK2. The content of these essays was evaluated using the word search function in Windows Explorer to determine if any obviously global elements were discussed; the results are summarized in Figure 6. In their final reflective essays on civil engineering, an increasing percentage of the students included the terms *global* or *world* in their essays from 2008 to 2010. Note that if a student refers to a specific country, such as their research on the Three Gorges Dam in China, there would be an international element in the essay that would not be identified by the simple word searches that were conducted. The last category shown in Figure 6 represents a number of word searches combined: Engineers Without Borders, EWB, developing countr(y/ies) [DC], developing communit(y/ies), developing world, third world. This may reflect the strong chapter of EWB at our university and a specialization track available for civil engineering students in Engineering for Developing Communities (EDC). Overall, in 2009 and 2010 nearly 70% of the students showed some recognition that global issues were important. The significant increase compared to 2008 may be related to the addition of the unit on sustainability in 2009 and 2010. It is also interesting to note that in 2008 the percentage of students discussing international issues in homework 1 versus homework 7 stayed the same, compared to significant increases in 2009 and 2010.

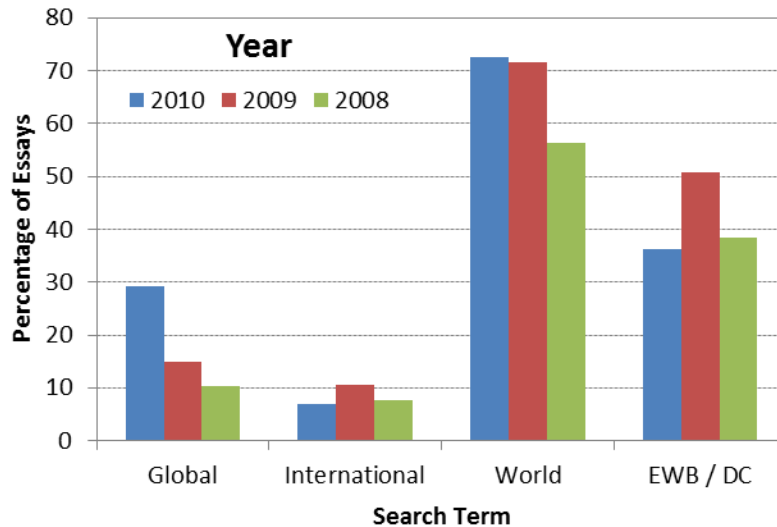


Figure 6. International elements evident based on a word search of student reflective essays.

In addition to the basic presence/absence word search, some essays were explored for the frequency that global issues were mentioned and their context. Twelve of the 2010 essays were selected for more detailed analysis based on the fact that three of the six search term clusters were present in the essay. A word search within the individual files was conducted in Microsoft Word. Of these 12 students with strong global discussion elements, 10 indicated an interest in working outside the U.S., primarily in developing countries. The frequency that the global terms were found in individual essays ranged from 2 to 11, and averaged 5 (as low as 2 since the previous search method could count an essay once with “world” and again with “third world”, double counting the same concept within an essay). Example quotes from the 12 essays are shown below:

I want to focus on the more environmental and water aspect.... I would like to travel to a third world country and help improve their quality of life and water supply.

This course has made me aware of the other great benefits of civil engineering that I looked over before. Civil engineering can help people. It can lead to better lives for people in third world countries as well as those in developed countries.

In this class we had a guest speaker from EWB. I think this day was probably one of my favorite days of class. Seeing how civil engineers can go and apply what they learned in the outside world to help those in need is something I am really interested in.

I've actually become a member of the Engineers Without Borders Rwanda team. This semester, we're attempting to design an irrigation system for an orphanage in a rural town in Rwanda. I have really enjoyed working with EWB so far. It feels great to be a part of a team that is working to positively affect the world in a place that is in such desperate need of it. I hope to continue working with EWB for the rest of my time here at CU because I feel that it's a great opportunity to gain hands-on experience while doing something good with my engineering education.

Another thing that really interests me is the developing nations. I would like to work on something for the betterment of the life of the needy. The developing world is in more need of engineers than the United States is. I can see myself working in countries where daily tasks are made difficult because of the lack of resources in the community.

Hopefully though I can learn more than I think that I will and be able to take all of the BOK and use it to help people around the world.

The engineering skills and attributes per the ASCE Body of Knowledge that are my strengths/things that I enjoy are: Mathematics, ... Globalization....

After taking this class I have become aware that the world is in deep need of engineers. There is a need for more sustainable construction practices and for structures like schools and hospitals in third world countries.

I really like to build, and design things, and think it's an awesome idea to be able to combine these skills with helping out society. I would love to be on a team to build a skyscraper or bridge, or be on a team to go to a developing country and plan a water purification process.

The major global aspect that was of interest to the students was helping build infrastructure to serve society in developing countries. Many of these students planned to develop their global skills via extracurricular activities such as EWB. Some of the students also stated that they were planning to take foreign language classes in college to better prepare them for international career paths.

Overall Course Assessment

The students rated the introductory course overall at the end of the semester on Faculty Course Questionnaire (FCQ) forms required by the University. Results are summarized in Table 6. The students rated overall elements of the course from 1 to 6; the first four questions in Table 6 are common to all engineering courses at CU. The overall course ratings were similar to the department average of 4.1 and similar to other 1-credit introductory courses at CU for general engineering, chemical engineering, and environmental engineering. The intellectual challenge of the course was rated lower than a typical 3-credit CVEN course (4.3), but higher than the other 1-credit introductory courses for other engineering majors at CU (range 2.0-3.0, average 2.4) with the exception of environmental engineering (3.5-3.6). The amount learned was again lower than a typical 3-credit course in the department (4.4) and slightly lower than the average of all introductory courses in engineering (4.2). The improved understanding of the engineering profession was near the average of all engineering introductory courses at CU (4.9).

Table 6. Student ratings of the course at the end of the semester (average \pm standard deviation)

	2008	2009	2010
Course overall	3.8 \pm 1.0	3.9 \pm 1.3	4.0 \pm 1.1
Intellectual challenge of course	3.1 \pm 1.2	3.2 \pm 1.2	3.0 \pm 1.3
How much you learned in course	3.9 \pm 1.0	3.8 \pm 1.4	3.6 \pm 1.2
The course improved my understanding of the engineering profession	4.7 \pm 1.0	5.1 \pm 0.8	5.0 \pm 1.0
The course improved my understanding of realistic constraints on design such as economic, environmental, and sustainability	Not asked	4.9 \pm 1.2	4.9 \pm 0.9
The course improved by understanding of ethics and professional responsibility	Not asked	5.2 \pm 1.0	4.9 \pm 1.0
The course improved my understanding of the impact of engineering on society	Not asked	5.0 \pm 1.1	4.9 \pm 1.0
The course helped me understand the need for lifelong learning	Not asked	4.7 \pm 1.2	4.8 \pm 1.1

NA results are included into the average as 0.

Starting in 2009, the department added extra questions to all CVEN undergraduate courses to assess the ABET A-K outcomes. The students rated these on a scale of NA (not applicable) to 6; NA responses were averaged into the total as zero. The four highest-rated outcomes for the course are shown in Table 6. These ratings indicate significant contribution to the curriculum overall, in comparison to the ratings for all required CVEN courses in the curriculum. For example, in 2010 this introductory course had the 3rd highest ratings for *impact on society*, *ethics*, and *realistic constraints* among all of the CVEN courses in the curriculum (below senior capstone design, introduction to construction, and/or hydraulics, depending on the outcome). A specific question on globalization was not included on the course FCQ forms. Globalization has not been evaluated systematically as an outcome of the senior students graduating from the program. This evaluation would be needed to determine if graduates were meeting the desired BOK2 levels of achievement for globalization. The previous survey of seniors in 2009 noted that globalization was perceived as a weakness by the students, but direct measures of achievement are not currently used in the program.

Summary

Overall, there was evidence of fairly strong interest in global issues pertaining to civil engineering among first year students. The use of global examples in the sustainability module, ethics module, and project research papers seemed popular with students, and provided a strong platform to emphasize non-technical issues such as the societal impacts of civil engineering. International case studies may provide an effective way for students to learn about ethical and sustainability related issues, thereby achieving multiple ABET and BOK2 outcomes. More structured evaluation instruments would be needed to assess the level of achievement that students reached with regards to the desirable BOK2 globalization outcomes. In addition, other courses in the curriculum should build on the foundation established in this course, and

subsequent evaluations need to be conducted for graduates of the program to determine whether the BOK2 globalization outcome is being achieved.

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