AC 2008-2313: CULTURAL COMPETENCY ASSESSMENT

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Cultural Competency Assessment

Abstract

Cultural competency is defined as the ability to effectively interact with people from diverse cultures and recognize the importance of cultural differences. These skills will be increasingly important for environmental engineers who work on teams with professionals from diverse backgrounds and design solutions to global problems. For example, these skills are particularly important when engaging in projects for Engineers Without Borders (EWB) and similar organizations. In order to evaluate if curriculum help develop these skills in students, an assessment instrument is needed. A wide variety of such surveys have been developed and validated, although generally for settings outside engineering academia. In this research, the Miville-Guzman Universality-Diversity Scale short form (MGUDS-S) was used. It is a written 15 question survey with responses on a 6-point Likert scale. It evaluates universal-diverse orientation (UDO) and has been most widely used in medical school settings. The overall UDO score is composed of three subscales: diversity of contact, relativistic appreciation, and discomfort with differences. The author also added four of the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS) questions and eight self-created questions to the survey, in addition to five demographic questions. The self-created questions were specific to engineering. This survey was administered in three freshmen courses (environmental, civil, and undeclared engineering) and two senior design courses (environmental and civil engineering) in fall 2006. Four of the eight self-created questions were modified and two additional demographic questions were added prior to administering the survey in two freshmen courses (environmental and civil engineering) and an Engineering for the Developing World course for seniors and graduate students in fall 2007. The results from the survey and evaluation of its usefulness are presented.

Background

Cultural competency (CC) has many potential definitions.[14,15,17,20,22] In this work CC is defined as the ability to effectively interact with people from diverse cultures and recognize the importance of cultural differences. This is closely related to concepts such as intercultural competence[13], intercultural sensitivity [1,2,13], (cross)-cultural sensitivity [2,14,23], and cultural humility [14,22]. In general, CC requires self-awareness, awareness of differences in cultures, and reflection on the implications of these differences.

Cultural competency is important for engineers so that they can be effective in working on teams with engineers, scientists, and others from diverse races and cultural backgrounds. CC is also critical to enable engineers to understand the needs of global clients who will use the engineered product, process, or project. Without an understanding of cultural issues, it is impossible for engineers to create appropriate technology solutions to the problems they are asked to solve. Cultural competency is also important in a number of other disciplines including medicine[15] and business[23]. This skill has become increasing important as the world "flattens". In a survey of higher education institutions, Deardorff[8] found that 54% of the 24 participating institutions (33% survey response rate; 54% private, 67% teaching) said they were encouraging cross-cultural development, but did not assess the cross-cultural competence of students in their programs.

Downey et al.[10] proposed a new engineering learning criterion be incorporated into how ABET accredits engineering programs: "Students will have the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do." Implicit in this criterion is the recognition that cultural differences effect how people view problems that require engineered solutions. To be most effective, engineers need to recognize these differences.

Although cultural differences may be subtle, vast cultural differences are generally present in international settings. In particular, as engineers work with developing communities around the globe, cultural differences are critical. A number of failures of development projects related to water and sanitation projects can be directly attributed to the engineers' lack of understanding of the culture of the people that the projects were serving. Engineering education traditionally focused on technical issues, so the lack of attention to critical non-technical aspects related to culture is not surprising. The University of Colorado at Boulder has created an Engineering for Developing Communities (EDC) program. We are critically aware that to be successful in this endeavor, our students need to be culturally competent. Measuring CC is a key step in the process to determine if our program is effective in meeting this goal.

This research was designed to measure the cultural competency of engineering students. This is a first step to determine if different elements in the curriculum develop these skills. Freshmen and senior/graduate students were given a CC assessment survey, and results from these surveys are presented below.

Measuring Cultural Competency

A variety of assessment tools have been developed to measure cultural competency in various settings.[6] Some of the most widely used instruments will be briefly described below.

The Beliefs, Events, and Values Inventory (BEVI) was created by Craig Shealy.[21] It has been used "in a wide range of national and international studies and applications"[21], although results from these studies do not seem to appear in peer-reviewed literature that is readily available. BEVI was designed to assess relevant processes and constructs including basic openness; receptivity to different cultures, religions, and social practices; the tendency to stereotype in particular ways; self and emotional awareness; and strategies for understanding why people from specific cultures behave in particular ways. The survey includes 10 demographic questions followed by 494 evaluative questions that allow responses on a 4-point Likert scale. The questions can be grouped to evaluate 3 validity scales and 10 process scales. This results in an evaluation of such aspects as negative life events, naïve determinism, authoritarian introjects, religious traditionalism, the need for control, emotional attunement, self-access, separation-individuation, sociocultural closure, and gender stereotypes.

The Intercultural Development Inventory (IDI) measures progression of worldview orientations toward cultural differences.[13] The basic model is shown in Figure 1. The five main dimensions are: (1) denial/defense; (2) reversal; (3) minimization; (4) acceptance/adaptation, and (5) encapsulated marginality. Intercultural competency is evaluated using a written survey comprised of 10 demographic questions and 50 statements to which participants respond on a 7-

point Likert scale. The IDI has been used in a diversity of studies.[11,13]

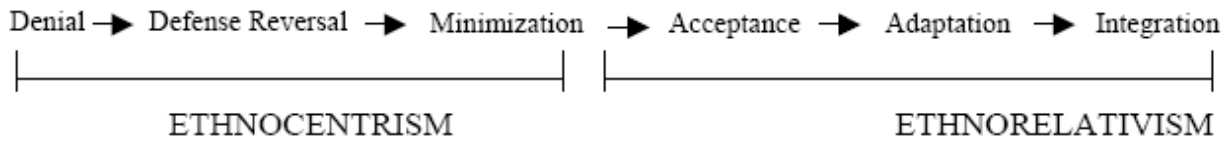

Figure 1. Sequential phases of cultural competency[13]

The Cultural Diversity Attitudes Scale[9] is a written survey with three parts. In part 1 there are 25 questions that participants respond to on a 5-point Likert scale. These questions are related to attitudes about different cultures, with statements on diversity education and diversity in medical practice. Part 2 of the survey describes a scenario and allows an open ended response. In part 3 there are nine statements based on the Bogardus Social Distance Scale, respondents are asked to define terms, and there are questions relating to students' understanding of culture and ethnicity.

The Cross-Cultural Adaptability Instrument (CCAI)[7,16] assesses peoples readiness to interact with members of another culture or adapt to life in another culture by determining an individual's effectiveness in cross-cultural interaction and communication. The survey has been used to measure the effectiveness of cultural training. It measures four specific dimensions: flexibility/openness; emotional resilience; perceptual acuity; and personal autonomy. The written survey includes 50 items that are answered on a 6-point Likert scale. The survey is reported to take 20 to 30 minutes to complete. Recent factor analysis indicates "the model is misspecified". [7]

Few cultural competency assessment tools have been used in engineering educational settings. Downey et al.[10] developed an evaluation instrument specific to their Engineering Cultures course. It includes a set of multiple choice questions on the content covered in the course and essay questions that are scored with a rubric. The survey is given at the beginning and end of the course. Students also complete a final self assessment by responding to questions on a 4-point Likert scale.

The evaluation instrument used in this work is the Miville-Guzman Universality-Diversity Scale (MGUDS-S).[12,18] The instrument was developed to evaluate universal-diverse orientation (UDO). UDO is "an attitude toward all other persons which is inclusive yet differentiating in that similarities and differences are both recognized and accepted."[12] Subscales of the instrument assess cognitive, behavioral, and affective components: relativistic appreciation of self and others, seeking diversity of contact with others, and a sense of connection with larger society or humanity, respectively. An original written survey was validated that contained 45 questions. From this, a short form of only 15 questions was derived. Participants respond to various statements on a 6-point Likert scale. The assessment instrument was developed and used in nursing and medical school settings.

Given the available surveys to measure various aspects of cultural competency, the shortest was selected and piloted for engineering students at the University of Colorado at Boulder. Initial results from the 2006 pilot study, which were combined with results from students at Oklahoma State University, have been previously presented.[4]

Assessment Method

The method used to assess cultural competency relevant for engineering students in this study was developed by combining a variety of aspects. First, five demographic questions were used to determine gender, race, if the participant was primarily raised in the U.S., the number of students in their high school class, and years of college completed. These various demographics could contribute to differences in cultural competency. Freshman college students might have been exposed to a wider variety of cultures if they attended a large versus small high school. The college experience itself generally includes people from a range of cultural backgrounds. If the student were raised primarily outside the U.S., they have likely experienced different cultures in their lifetimes. Next, the survey defined terms used in the evaluative questions. In particular, for freshmen new to engineering, some of the concepts may be unfamiliar. The terms defined were: engineering problem, stakeholders, technical constraints, culture, race, ethnicity, country, occupation, and profession. The survey then contained statements intended to evaluate attitudes toward engineering and cultural competency. This included 4 questions from the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS)[3], 15 questions from MGUDS-S[12], and 8 questions about engineering problem definition and solution that were developed by the author (questions 1 to 8 shown in Table 4 in the results section).

In 2006, the written assessment survey was administered on the second day of class in fall freshmen 1-credit introductory courses for environmental (EVEN), civil (CVEN), and undeclared (GEEN) engineering majors. One particular activity in the EVEN course was designed to expose students to the idea that culture is important in engineering problem solving. The students spent three weeks participating in a case study that described selecting the best method to treat wastewater from a Native American community.[5] Another activity that included some aspects of cultural differences was the ethics assignment in the EVEN and CVEN courses. In this assignment students could read about Fred Cuny's activities in refugee camps and serving displaced populations.[19] In the CVEN course, students studied the Three Gorges Dam in China and its implications. The response rates of the students to the survey are given in Table 1. Despite the culture-related activities in the first year EVEN course, previous comparison of first and last day responses using a paired t-test indicated significant changes in only two questions.[4] On a per student basis comparing responses on all of the questions with a paired t-test, only 5 of the 25 students had significant changes in their attitude.[4] Thus, the single semester had minimal impact on cultural competency and attitudes toward engineering.

The attitudes of senior engineering students were evaluated. The attitudes survey was given at the end of the semester in an Environmental Engineering Design course (EVEN design) for seniors and graduate students in fall 2006. Eighty-one percent of the students enrolled in the course returned the survey. Teams of students completed an alternatives assessment and preliminary design for 1 of 3 service learning projects. Two of the projects served clients within the state, while the third was a project for a rural, poor community in Mexico. Of the 12 students working on the project for Mexico, 8 traveled to the community over 4 days in October. The students also wrote essays on their community service experience and non-technical aspects of their projects. This qualitative information is useful to compare to the survey data. Students in a senior Civil Engineering design course (CVEN design) were also given the survey at the end of the fall 2006 semester. All of the students in the course worked on a building design project for

the University of Colorado at Boulder campus. The project focused on technical aspects.

Based on analysis of the 2006 results, four of the self-written questions (questions 1 to 4 in Table 4) were retained due to statistically significant differences based on gender and whether the students were raised outside the U.S. Two of the retained questions also had an average student response outside the neutral range of 3 to 4. The other four self-written questions on the survey (questions 5 to 8) were modified; revised questions are shown in Table 4 in the results section (questions 9 to 12). Two additional demographic questions were also added to the survey: (1) have you lived in/traveled to three or more countries; and (2) have you participated in Engineers Without Borders or other service-activities outside the U.S. This modified survey was administered early in fall 2007 to the EVEN and CVEN freshmen introductory courses; responses rates were 93% and 74%, respectively. The survey was also given at the end of fall semester to seniors and graduate students enrolled in an Engineering for the Developing World (EDW) course (http://www.edc-cu.org/cven4838.htm). In the EDW course, teams of 2 to 6 students worked on a service learning project for a developing community. Three projects were in the U.S. and two were abroad in Rwanda and Bolivia. One of the stated objectives of the course was to help students develop cultural and social awareness. The attitude survey was emailed to students in the second to the last week of class. Students printed out the survey and returned it to ensure anonymity. The lowest response rate was received from this group – 50% of the 6 undergraduates and 61% of the 14 graduate students enrolled in the course returned the survey.

Comparisons of the data were made by conducting t-tests in Excel. These were two-tailed and heteroscedastic. The data sets were considered significantly different when the calculated probability (p) was 0.05 or less. Probable differences were inferred when p was <0.10 (and >0.05). In some cases, the small number of students fitting the sorting characteristics prevents making rigorous conclusions from the data.

Results

The demographics of the students who responded to the survey are summarized in Table 1. Note that these are the self-reported characteristics of the respondents, and they do not always agree with official University designations of year in college, major, or race.

Table 1. Demographics of survey respondents*

Course	Term	% Response	# Responses	% Female	% Minority	Year in college	% Non-engrg majors	Predominant Student Major
EVEN Intro	F06 F07	90 93	26 42	50 36	19 7	62% fr 71% fr	38 17	50% EVEN 64% EVEN
CVEN Intro	F06 F07	96 74	49 42	12 24	22 12	64% fr 81% fr	26 7	59% CVEN 74% CVEN
GEEN Intro	F06	97	116	16	14	95% fr	16	84% engrg
EVEN Design	F06	81	17	29	29	76% sr 18% grd	0	65% EVEN 35% CVEN

CVEN Design	F06	65	15	27	33	100% sr	0	100% CVEN
EDW	F07	55	10	70	30	70% grd	0	50% EVEN

* Abbreviations: fr = freshman, sr = senior, grd = graduate (MS/PhD)

Freshman Students' Cultural Competency

Using the 15 questions from the MGUDS-S portion of the survey, the data from the beginning of the semester in all of the 2006 and 2007 freshman courses was pooled and analyzed for differences. Note that some students did not indicate a race or some of the other demographic data. These students were included in an overall average but not within specific sorts of the data. Average scores for different groups of the students are summarized in Table 2. Women had significantly higher cultural competency in all three areas (since discomfort with differences questions are reverse scored) and overall UDO. When white students were compared to students of all other races combined, the minorities had a higher diversity of contact score. When students majoring in EVEN were compared to students with non-engineering majors (including open students without a declared major), the EVEN students had higher diversity of contact, relativistic appreciation, and overall UDO scores. Not surprisingly, the male students raised primarily outside the U.S. (n=10) had higher diversity of contact scores than all male students (n=215); other differences were not statistically significant, probably due to the small number of students in the data set. Surprisingly, there were not significant differences when students who had traveled to 3 or more countries (n=51) were compared to those who had not (n=31); the more widely traveled students had a somewhat higher comfort with differences (p=0.08).

Table 2. Average CC scores for students enrolled in first-year engineering courses

	Male	Female	Non white	Major = EVEN	Major = Non Engrg	Raised Outside US
n	215	63	40	40	47	15
Diversity of Contact	3.97	4.46*	4.35*	4.55	3.95*	4.63*
Relativistic Appreciation	4.53	4.83*	4.69	4.79	4.49*	4.72
Discomfort with Differences	2.08	1.80*	1.98	1.89	2.06	2.15
Overall UDO	12.42	13.40*	12.88	13.58	12.12*	13.04

* = significantly different than comparison population (male vs. female; non white vs. white; EVEN majors vs. non-engineering majors; raised outside U.S. vs. inside U.S.)

Comparison of Student Cultural Competency

It was of interest to determine if the cultural competency of senior students was higher than freshmen. Therefore, all of the students in the first-year course majoring in engineering (n=229) were compared to all of the students in the senior/graduate design/project courses (n=41; 2 students with incomplete responses to MGUDS-S questions were removed from the data set). Results are summarized in Figure 2. Although the scores appear similar, the senior/graduate

students had higher diversity of contact (DC) and overall UDO scores (p = 0.01 and 0.03, respectively). This was the expected result since more senior college students are likely to have a wider range of experiences and acquaintances. In particular, the senior and graduate students would have engaged in numerous team activities in their engineering coursework. The courses in which the surveys were administered contain an intensive semester-long group project, and in the EVEN design and EDW courses some of the projects specifically exposed the students to different cultures through the communities being served.

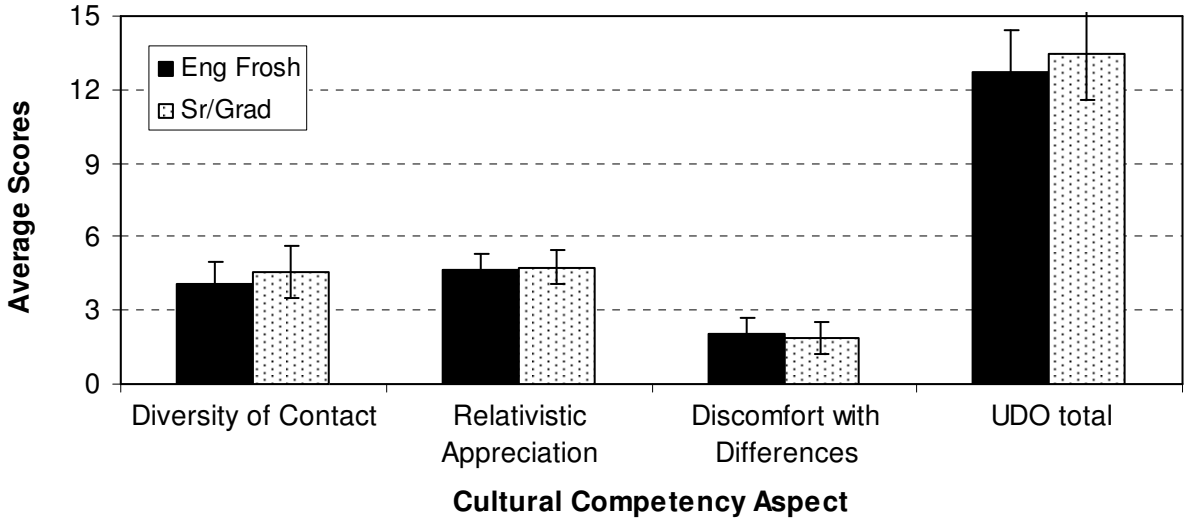

Figure 2. Comparison of lower division and senior/graduate student cultural competency scores on the MGUDS-S assessment. Error bars represent the standard deviation.

In an attempt to elucidate the factors that might differentiate the senior/graduate students, the three different courses were compared. Results are shown in Figure 3. In general, the EDW students (n=11) exhibit the highest cultural competency based on their survey responses (less discomfort with differences is higher CC). The senior students in the CVEN design course (n=14) had the lowest CC. Statistical evaluation of the data sets found no significant differences in the EVEN design course (n=16) versus the EDW course. However, students in both the EVEN and EDW courses had significantly higher diversity of contact and total UDO scores than the CVEN students. Comfort with difference scores were somewhat higher in the EVEN and EDW students than the CVEN students (p = 0.07 and 0.06, respectively). Both the EVEN and CVEN courses are required, although graduate students can electively take the EVEN course. The service learning project in Mexico directly exposed 12 of the 21 students in the EVEN course to the culture of a small, rural community. Most correspondence related to the project was in Spanish. This experience may account for the higher CC of the EVEN students. In the EDW course, all the students were likely exposed to different cultures than they are generally familiar with. The projects in EDW were in Rwanda; Boliva; a Native American community; a low income housing community initially built for immigrant farm workers in the U.S.; and a poor, predominantly Latino neighborhood near a major urban area in the U.S. One of the explicit goals of the EDW course was to make students aware of cultural differences and their importance to engineering projects. However, because the EDW course is an elective, it is possible that the students choosing to participate came into the course with a higher cultural competency than typical engineering seniors and graduate students. This may have caused the

higher CC, rather than the course itself increasing the cultural competence of the students. Pre and post course evaluations would be needed to determine impacts of the course itself on CC.

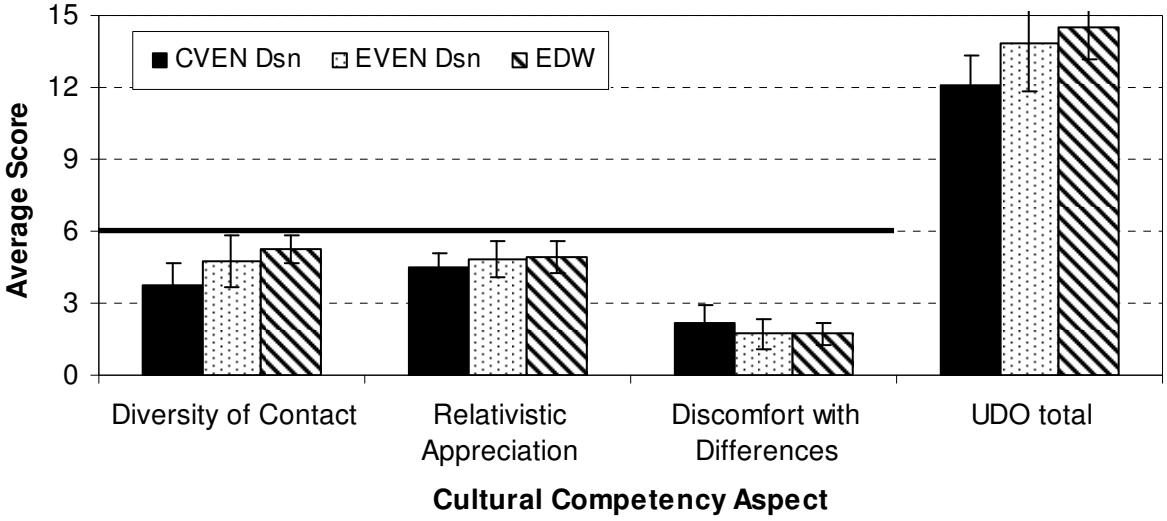

Figure 3. Comparison of the three senior/graduate level design/project courses. The 3 aspects of CC are averages on the 6-point Likert scale. Error bars represent the standard deviation.

Attitudes Toward Societal Contributions of Engineers

Students' attitudes about how engineering contributes to making the world a better place were evaluated via four questions from the PFEAS.[3] The average responses of the students are compared in Table 3. There was minimal variation in the average student responses, with somewhat agreement that engineers contribute to improving the welfare of society. Overall, senior civil engineering students agreed most strongly with this idea and the senior/graduate students in the EDW course the least with this idea. It is possible that because the EDW students were working on projects in under-developed countries or in poorer U.S. communities that they were more aware of the lack of critical engineering services to these populations. The only other statistically significant difference among the different demographic aspects explored was that male students in the first year engineering courses more strongly believed that engineers improve the welfare of society than female students.

Table 3. Summary of students' belief that engineers contribute to improving the welfare of society. Responses on a 6-point Likert scale (4 = agree a little bit, 5 = agree, 6 = strongly agree)

Student Characteristics	n	Average response	Statistical difference?
All engineering majors in first year courses	229	4.60	
Non engineering majors in first year courses	47	4.48	
Male students in first year engineering courses	215	4.66	Male vs. Female
Female students in first year engineering courses	63	4.29	
All students in senior/graduate courses	43	4.57	
Students in EDW course	11	4.16	vs. CVEN Dsn
Students in EVEN design course	17	4.60	
Students in CVEN design course	15	4.83	

Engineers Recognition of the Importance of Cultural Differences

The remaining 8 questions on the survey asked students to respond to specific statements related to engineering problem definition and design solutions. Table 4 lists the self-created questions in the 2006 and 2007 versions of the survey with average student responses.

Table 4. Average student responses to engineering-related statements on a 6-point Likert scale

Survey Question	Engrs in 1st year courses	Non Engrs in 1st year courses	Sr/grad CVEN+ EVEN students	EDW students
n for questions 1 to 4 n for questions: 5 to 8 in 2006/9 to 12 in 2007	229 76/153	47 38/9	22 22/0	11 0/11
1 The technology that is used in the U.S. is likely the best technology to use to solve similar technical problems in other countries	3.66	3.55	3.44	**1.73**
2 There is a single best solution to an engineering problem	1.92	1.81	1.59	1.82
3 It is important for engineers to consider the broader potential impacts of technical solutions to problems on minority racial and ethnic groups in the effected population	4.66	4.60	5.06	5.27
4 Technical constraints and criteria are the most important element determining the success of an engineered solution	3.93	3.70	4.09	**2.64**
5 Most people in the U.S. would define an engineering problem similarly	4.12	3.39	3.22	n/a
6 People in the US and India would define an engineering problem similarly.	3.31	2.92	2.91	n/a
7 If two teams of engineers design different solutions to an engineering problem, stakeholders are likely to disagree on which solution is better	5.23	4.47	4.38	n/a
8 The technology that is used in the U.S. is not likely the best technology to use to solve similar technical problems in other countries such as China.	4.37	3.53	3.86	n/a
9 Engineers are able to design good solutions to engineering problems if given sufficient technical data, even without visiting the community or talking with stakeholders.	3.22	3.33	n/a	2.55
10 I would be equally comfortable teaming with an engineer from the US as one in India or China for a project	4.33	4.33	n/a	3.95
11 Given a range of engineering designs to solve a particular problem, different stakeholder groups are likely to agree on which design is best.	3.54	3.11	n/a	3.18
12 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.	3.38	4.00	n/a	2.36

n/a = not available since the questions were not on the version of the survey administered to these students; answers in bold are significantly different than the senior/graduate CVEN and EVEN design courses

The widest variation in responses was noted among the EDW students, with responses ranging from 1 to 6 on three of the eight questions. In general, the EDW students exhibited the greatest recognition that culture and non-technical issues are important factors in engineering solutions. There were not statistically significant differences in the responses of the EVEN design versus CVEN design students to any of the eight questions; question 1 in Table 4 had a somewhat higher agreement by the CVEN (3.4) versus EVEN (3.1) students ($p = 0.08$). Other statistically significant differences in the responses are summarized in Table 5. No significant differences were found within the freshmen courses for engineering versus non-engineering majors.

Table 5. Questions from Table 4 that had significantly different student responses

	Male vs. Female in Freshman Courses	Minority vs. White in Freshman Courses	Freshman Courses vs. Sr/Grad Courses	EVEN design + CVEN design vs. EDW
Significant Difference	**1**, 3, 10, **12**	none	1, 2, 3, 12	1
Probable Difference	**2**	4	none	4

Question numbers are listed in **BOLD** if the first group had the higher average

Summary and Conclusions

This research represents an initial attempt to measure the cultural competency of engineering students in a variety of courses. The MGUDS-S survey seems to generally gauge engineers comfort level with various cultures. A higher UDO score may indicate that the engineers are better able to function on multidisciplinary teams and are comfortable interacting with clients from diverse backgrounds. It was disappointing that the senior and graduate students did not evidence a significantly higher CC than the freshmen students. Tracking the 2006 and 2007 freshmen students as they progress through the redesigned curriculum may find a greater growth in CC. The new questions developed for this survey are more specific gauges of whether students recognize the importance of cultural differences in the definitions of and solutions to engineering problems. The EDW course contained some content aimed specifically at this goal, and some impacts appeared evident based upon the responses of the students. However, the small data set prohibits conclusive results. Discussion of the survey questions with the students after the survey, perhaps with some specific examples or case studies, may be useful to teach students why it is important to recognize cultural differences. Future studies will expand on this work by surveying more students and try to combine the quantitative responses to these surveys with qualitative information that reflects cultural competency.

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