
AC 2011-1329: ACADEMIC PREPARATION FOR THE GLOBAL ENGINEER

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Academic Preparation for the Global Engineer

Introduction

A variety of sources have suggested that engineering curricula must change in order to prepare engineering students to compete and excel in a global economy.^{1,2} In preparing for these changes, engineering academic programs have begun to examine potential new directions for educating engineering students to work in a global environment. Many have surveyed student and faculty attitudes to see what attributes are most important to the students.³ Others have looked at administrators' attitudes about incorporating more humanities courses into established curricula.⁴ Others have tried to measure their students' current skill sets.^{5,6} Several ideas seem to be accepted methods for improving student abilities in a global setting, such as increased study abroad programs, dual degree programs, enhanced humanities requirements, etc.^{7,8,9}

There is little doubt that study abroad programs, foreign language study, and a greater emphasis on humanities can be beneficial to young engineers; however, these programs can be both expensive and time consuming. The curriculum at our university is already packed with traditional engineering courses and our own communication initiative, so where does one make room for additional humanities courses or language studies? Furthermore, while study abroad programs exist at our university, they are available for only a limited number of students, and expanding beyond the current number would be expensive in a time when our budgets are severely constrained.

While some schools have developed innovative ways to pay for overseas study,^{10,11} we are more intrigued by programs that have found ways to prepare global engineers through on-campus options.^{12,13,14} In order to better inform ourselves about what attributes would most improve the job prospects of graduating engineers, we surveyed a variety of engineering alumni to see which skills they most value. We report the findings of this limited survey and use those findings to help us evaluate our current curricula and identify ways in which to leverage our robust communications program to meet the goals for a more global educational perspective.

Engineer Survey

We initially informally polled our Engineering Communication Advisory Council members to seek their opinions on this topic. This advisory body consists of senior engineers and was described in more detail in a previous paper.¹⁵ Responses from these engineers prompted us to widen our survey to a larger group of engineers using a more formal email survey method. Our sample size was not intended to be statistically significant, but rather a manageable number to yield enough feedback for us to initiate an in-house review program. For this paper, we elected to limit the survey to a total of 10 questions: three questions to define the respondent demographic, six questions on the topic at hand, and a tenth question allowing individual feedback via open comment. Our Advisory Council was a valuable resource for helping us choose this survey method and the specific questions asked.

Our email survey was sent to 60 engineers, consisting of a variety of engineering alumni and fewer than 10 senior faculty members who had engineering experience on a global basis. We

received 38 responses, or a response rate of 63%, which was well above the expected average response rate cited by previous researchers.¹⁶ Of the 38 respondents, 18 chose also to comment on their response. It is important to emphasize that this was an exploratory effort to help better focus our evolving program initiative.

Tables 1-3 show summaries of the demographic characteristics of the 38 respondents. Although we purposely attempted to skew experience to favor more senior engineers, our responses were even more skewed than anticipated, leading us to believe that younger engineers are either disinterested or perhaps didn't feel adequately attuned to the topic to formulate opinions. Another possibility we considered is that senior engineers are simply more passionate about the topic of globalization. The diversity of academic backgrounds was not a surprise to us, nor was the spread of employers.

Table 1 – Years Experience

How many years of engineering experience do you currently have?		
Answer Options	Response Percent	Response Count
0-5	15.8%	6
5-10	7.9%	3
10-20	26.3%	10
20+	50.0%	19

Table 2 – Academic Background

What is your academic background?		
Answer Options	Response Percent	Response Count
B.S.	44.7%	17
M.S.	21.1%	8
Ph.D.	34.2%	13
Engineering degree plus MBA	5.3%	2

Table 3 – Characterization of Employer

How would you characterize your employer?		
Answer Options	Response Percent	Response Count
Multi-national corporation with headquarters outside the U.S.	10.5%	4
U.S. corporation with international locations and/or significant dependence on international markets	42.1%	16
Domestic company with only domestic markets	13.2%	5
Governmental agency or educational institution	36.8%	14

These data for observations/opinions are shown in Figures 1-6. In each case the number of respondents is 38.

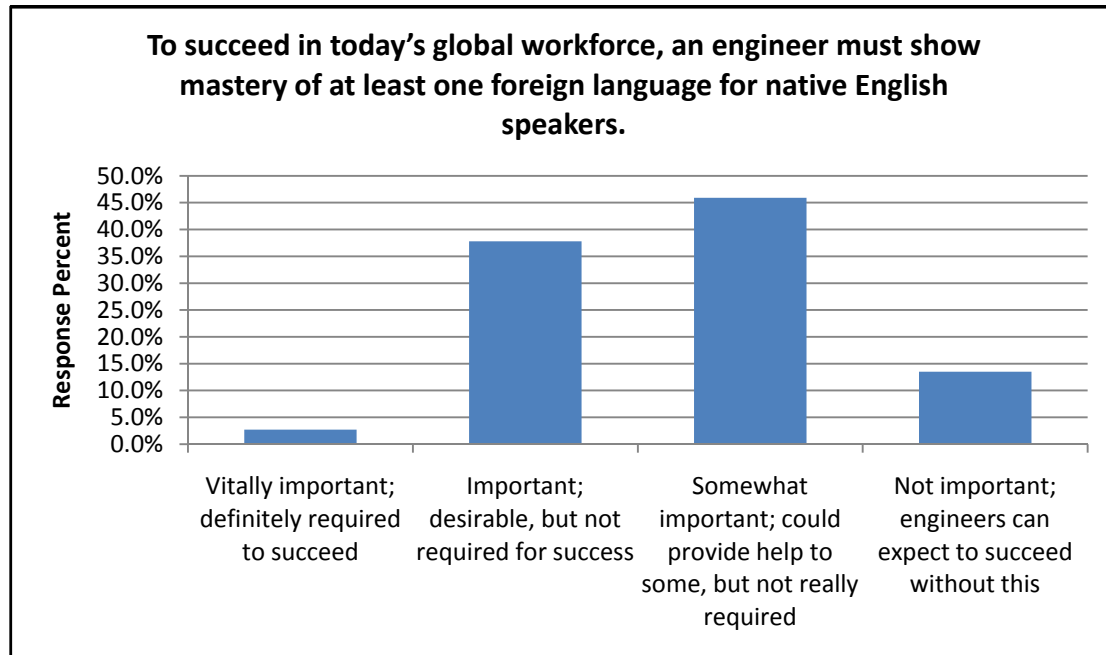


Figure 1 – Mastery of a Foreign Language

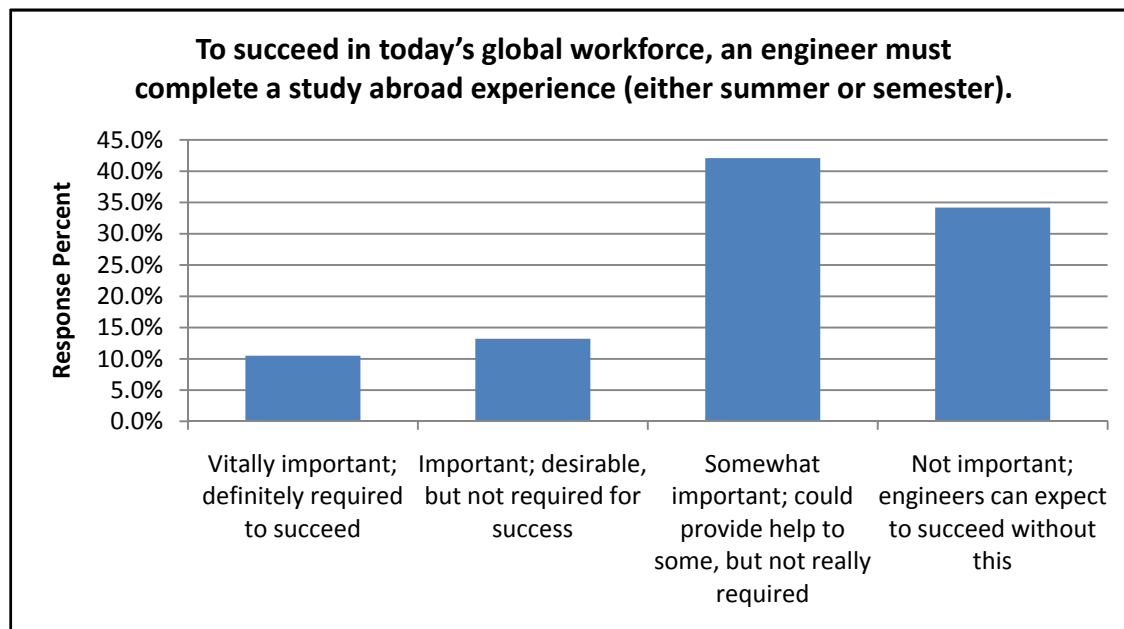


Figure 2 – Study Abroad Experience

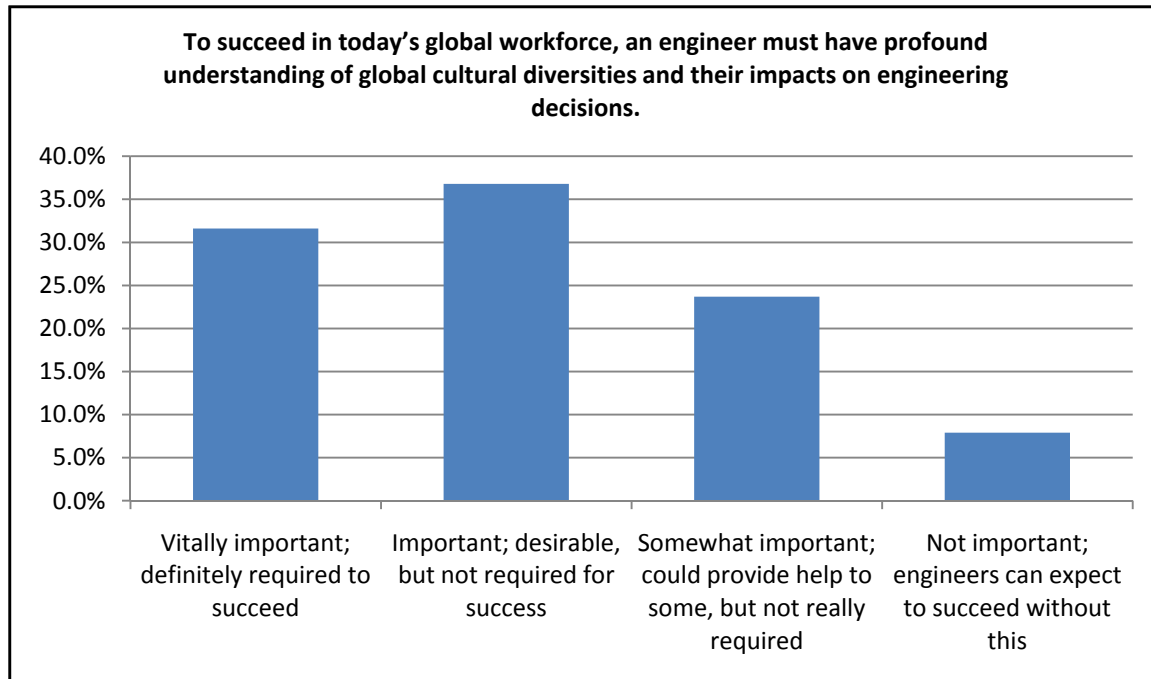


Figure 3 – Understanding of Cultural Diversities

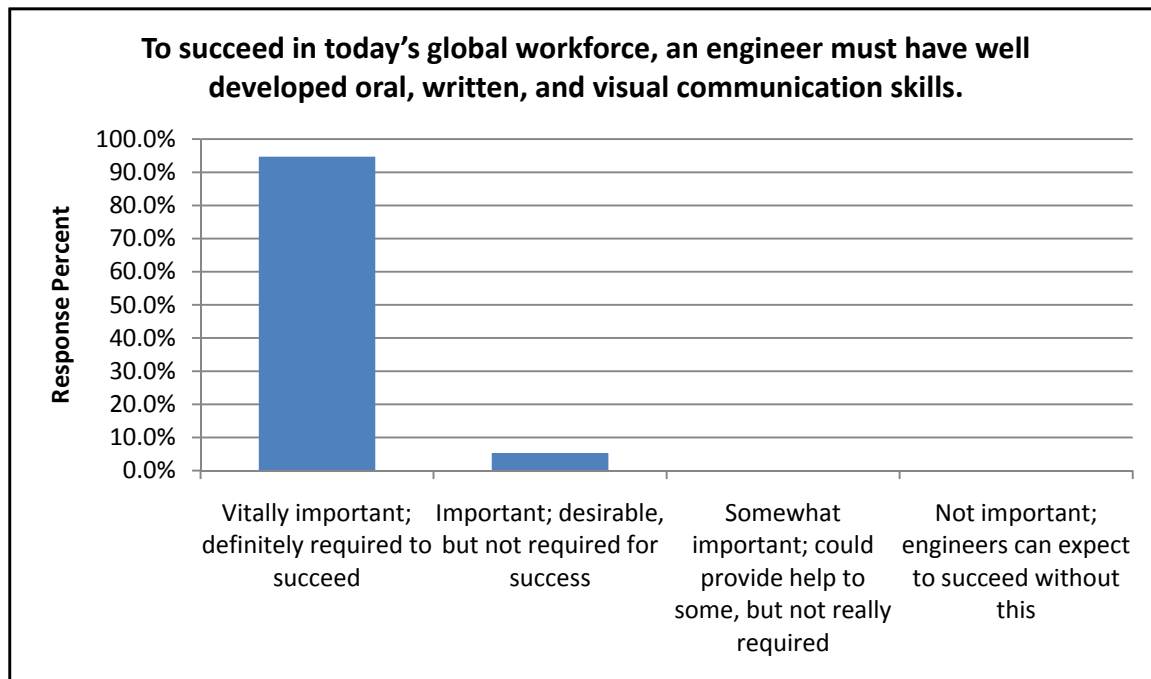


Figure 4 – Communication Skills

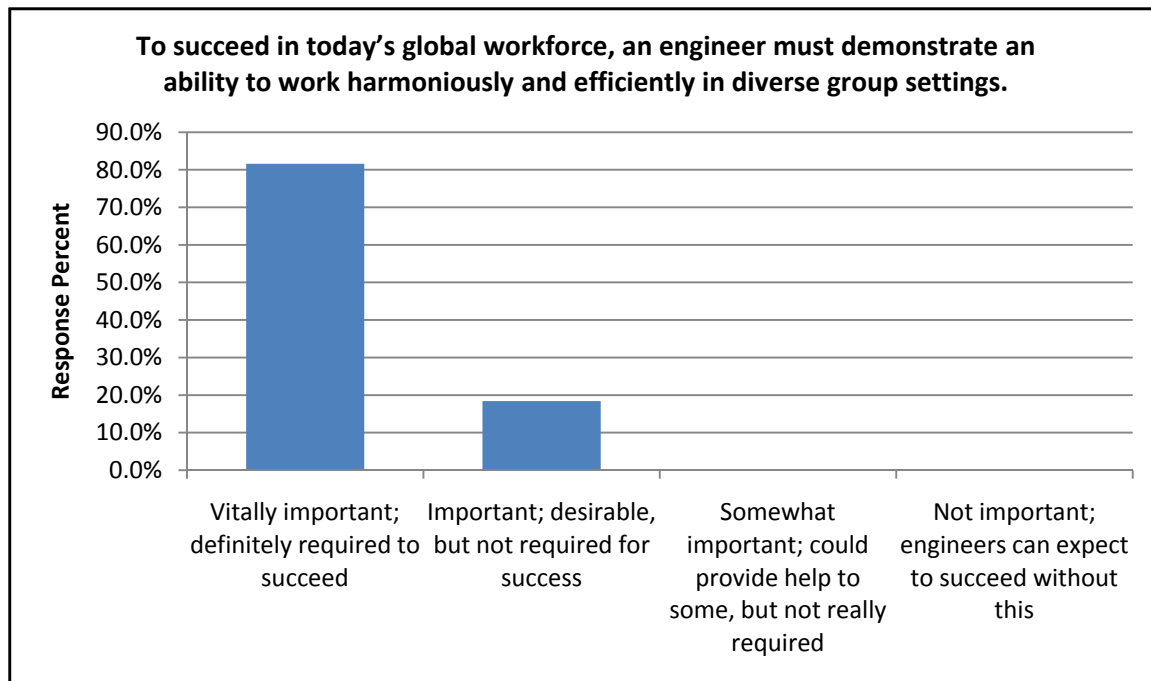


Figure 5 – Working in a Diverse Team

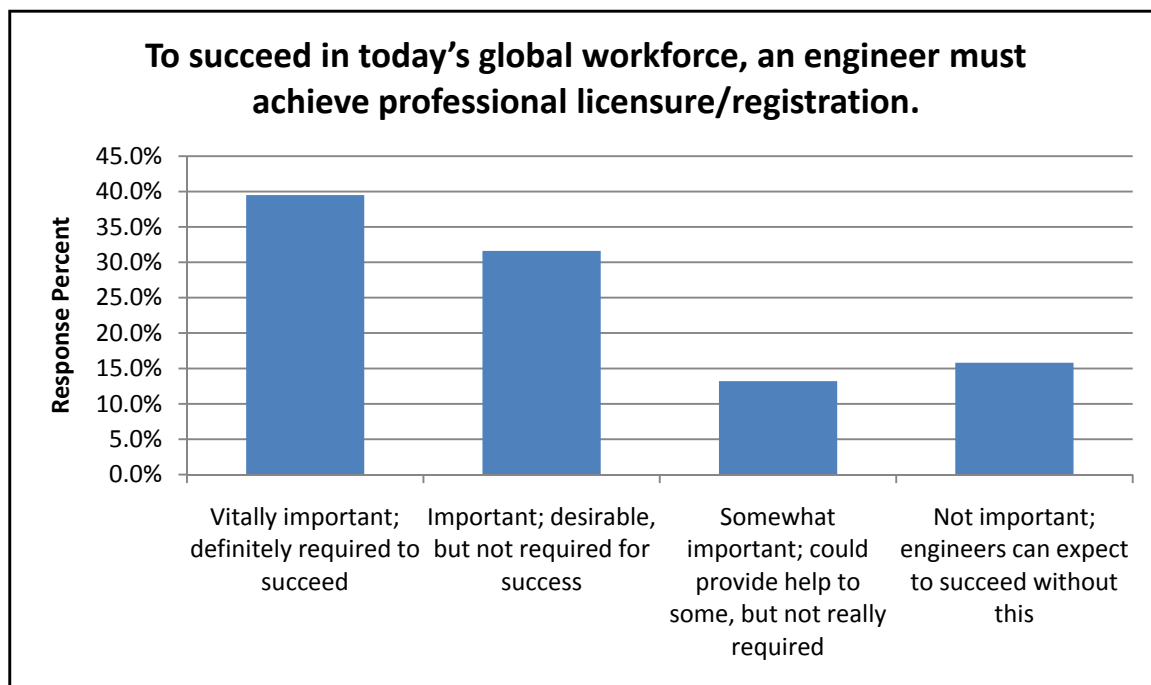


Figure 6 – Professional Licensure/Registration

Perceptions for Skills Required

Mastery of a Foreign Language. Looking first at mastery of a foreign language for native English speakers (Figure 1), 15 respondents thought mastery was important (37.8%) or vitally

important (2.7%). When we correlated these responses to the respondents' employers, it was interesting that very few of these respondents were employed by multi-national corporations or U.S. companies with significant international dependence (only 2 of 15). We are left wondering whether this is a perception problem for those who are not directly affected. Another possibility that we pondered was whether this might somewhat be related to question 6 in which we ask about importance of understanding of cultural diversity. Some clue to this relationship was offered in the comments by a respondent with 20+ years of experience and employed by a multi-national corporation:

“Language skill is a tremendous plus for any career but as long as the US market is one of the largest then success can be achieved without it. However, the globe is a much more exciting and lucrative opportunity and language along with appreciation for cultural diversity is tremendously important. Cultural appreciation is even more so. This appreciation can be achieved in many ways including but not limited to study abroad. These things only enhance potential...”

Another senior engineer respondent commented:

“It would be an amazing coincidence if the foreign language an engineer knew happened to be relevant to any assignment offered.”

During our research into the topic of the role of the English language in engineering, we found that some researchers believe that English has become the *lingua franca* of engineering, especially in the academic environment.¹⁷ It has also been stated that for engineering graduates in non-native English speaking countries, employability is inextricably linked to the graduates' command of the English language.¹⁸ We must also note that two of our authors have extensive experience in international engineering projects, and both have observed that all engineering design documentation was in English. One of these authors managed all of his company's Central and South American operations and found that subtle differences in the Spanish in each region was incompatible with the demands of engineering exactness; therefore, English was always the language of both engineering designs and construction specifications.

Study Abroad Experience. Study abroad opportunities did not seem to be a priority with our respondents (Figure 2). Twenty-nine respondents thought study abroad was somewhat important but not really required (42.1%) or not important (34.2%). Only 9 respondents thought study abroad was important (13.2%) or vitally important (10.5%).

We are aware that newly hired engineers are often sent to locations all over the world as part of their training, and we also know that sometimes internships provide opportunities for overseas travel for students. As educators, we would prefer to provide opportunities for overseas study, rather than pass this task off to companies. It is our belief that a study-abroad experience would be beneficial to any aspiring engineer; whether it is merely somewhat important or vitally important, study abroad is almost sure to be helpful to some degree. However, due to our institution's limitations, we must prioritize. In the College of Engineering, our existing opportunities for overseas study can only accommodate a handful of students each summer;

however, we do recognize the value this experience brings for those who are able to take advantage of it, and we would like to expand it to a greater proportion of our students

Unfortunately, we struggle to find ways to fit these classes into the curricula. Our university employs a lockstep sequence to engineering curricula, and classes that do not fit into the lockstep can cause students to delay the completion of their degrees. Building a course (or suite of courses) for overseas study that fulfills curriculum requirements for more than one department has proven to be a challenge on a variety of levels. With the budget woes that currently seem to affect every department, and the difficulty of finding a place for study abroad that serves students from more than one department, it is unlikely that our university would be able to significantly expand the opportunities for students to travel overseas.

Understanding Cultural Diversity. The respondents held a variety of opinions about the importance of understanding cultural diversity (Figure 3). Most respondents found it important (36.8%) or vitally important (31.6%). Only 3 respondents (7.9%) thought engineers could expect to succeed without it. At our university, both the student population and the faculty represent a variety of cultures. The groups working on projects in our capstone courses often include students from diverse cultural backgrounds. Working in small groups with group members from a variety of cultural backgrounds allows students to identify and confront issues that arise when cultural norms differ.

While many aspects of globalism can be addressed by this model, many cannot. Temporal or spatial issues, such as communicating across time zones, are an example of an issue that group work in an academic setting rarely confronts. However, working in diverse student groups at least should allow students to begin considering differences based on cultural norms, even if some more time-based difficulties must be neglected. While far from perfect, perhaps this model presents the most cost-effective way to help engineering students understand global cultural diversities and their impacts on engineering decisions.

Communication and Teamwork Skills. According to our respondents, communication skills were clearly the most important attribute of a global engineer (Figure 4). Nearly all of the respondents (94.7%) called communication skills vitally important, with the remaining respondents (5.3%) saying communication skills are important. None of our respondents doubted the importance of communication skills. In fact, one of our respondents said, “To succeed, engineers must have tremendous communications skills.”

At our university, our communication initiatives already take globalism somewhat into account. In our Communication-Intensive (C-I) courses, we emphasize 4 modes of communication: written, spoken, visual, and technological. Of these, only 2 are language specific. However, even when working in language-specific modes, rhetorical strategies that consider audience needs are taught so that language can be supplemented with graphical information, calculations, or other non-linguistic elements. The visual and technological modes are not taught merely as alternatives to writing and speaking but also as a means to transcend the limitations of spoken and written language.

Figure 5 shows responses received regarding the statement, “To succeed in today’s global workforce, an engineer must demonstrate an ability to work harmoniously and efficiently in diverse group settings.” We were somewhat surprised to see the overwhelmingly positive responses with all respondents feeling that teamwork skills were important or vitally important for success. Looking at our university emphasis on collaborative work, per an ABET requirement, we believe our graduates are indeed receiving this academic preparation.

Professional Licensure/Registration. The final item in our survey asked respondents to evaluate the statement, “To succeed in today’s global workforce, an engineer must achieve professional licensure/registration.” We included this topic not so much to better prepare graduates for Professional Engineer examination requirements but more to better advise them on the importance of pursuing the P.E. after graduation. The results, shown in Figure 6, revealed a strong perceived relationship between attainment of registration and success in the global workforce. Comments offered by three respondents were:

“PE registration is required to obtain easily international recognition.”

“The PE license demonstrates competence to an international audience.”

“Within the environmental engineering career field, post-licensure certification by the American Academy of Environmental Engineers is highly desirable within the consulting industry.”

These results indicate that we should find opportunities to advise students to prepare themselves to pursue a P.E. or another appropriate credential if they hope to succeed in more global engineering employment.

Opportunities to Leverage Current Initiatives

When the campus-wide communications initiative, Communication across the Curriculum (CxC), became a priority in the College of Engineering, the first classes sought for certification as Communication-Intensive (C-I) were the capstone courses (also known locally as Senior Design) in each engineering department. For us, these classes were obvious choices because by the time the students were seniors, they had already been introduced to fundamental engineering concepts. Senior design required students to apply these fundamental concepts to real projects, including the difficulties of managing budgets, time, and people. In other words, students had to be able to communicate effectively in multiple venues, modes, and genres to be successful in these courses.

Because we have certified capstone courses in each department as C-I courses, faculty have had multiple opportunities to teach most of those courses. We find that the faculty’s comfort level with teaching communications has improved to the point that many faculty are able to incorporate communications into their courses smoothly, without depending on supplemental instruction from CxC staff. In a previous paper, we reported on the results of a survey of faculty members teaching C-I courses.¹⁹ We found that faculty members believed that students learned the technical content in more detail when the course was taught in a C-I format. Rather than merely teaching rhetorical concepts as important tools for the students’ futures, we are able to

use communications to further students' critical thinking regarding topics that are vital to prospective engineers, like ethics, teamwork, and lifelong learning.

We believe that there is an opportunity to develop communications assignments for topics that also help prepare future engineers for a global environment, like cultural awareness and cultural sensitivity. We find ourselves in a position to focus on these topics, not by adding more communication assignments to an already-crowded curriculum, but by varying the focus of the communication assignments. Students will not treat global issues as mere topics of communication assignments but will have to consider cultural differences in order to complete the communications. In future C-I capstone courses, cultural awareness will not only be a product of communication assignments; rather, issues confronting globalism, like cultural awareness, will be a step in the communication processes that is necessary to complete those assignments.

The approach that we envision is similar to the Integrated Class Experience described in a 2006 paper.²¹ The authors of this paper describe this classroom exercise as frequently prefatory or collateral to other initiatives that require international travel. The fundamental theme throughout this well-documented effort is that different cultures define problems differently; hence, an international engineering project may be doomed in its conceptual stages. We believe that this problem is actually a function of a complex set of variables that hinder cross-cultural communication. An example of this type of barrier is evident in a quote found at a Purdue-sponsored resource for advancing global engineering.²² An engineer on an overseas assignment writes:

“I have noticed that my Chinese counterparts are generally unwilling to ask questions and acknowledge that they do not understand me. I have been introducing them to some testing methods that are unfamiliar to them. During our interactions, they have never asked a question – even if they do not understand. I have stressed the importance of asking questions, and that it is perfectly acceptable in American culture to ask questions whenever clarification is needed. I think that in Chinese academics, students are not encouraged to ask questions in the classroom and this behavior continues into their professional relationships.”

Our university has a diverse international engineering student body, especially at the graduate level. We propose to capitalize upon this diversity by building team-oriented Capstone assignments that require students to seek opinions and guidance from these graduate students regarding completing projects in their home countries. Teams will then report their learned experiences to the class in a communication method already well established in our Capstone courses. Of course, development of the assignments and the logistics of involving international graduate students must be well planned to succeed.

As mentioned previously, our alumni survey was intended to help guide our efforts in its preliminary stages; however, as we undertake the development of assignments, we will also conduct a more detailed alumni survey. The design of this survey is underway at this time and will be undertaken to include a wider sample of our alumni population.

Summary and Conclusions

It is apparent that the academic preparation of engineering students should be reviewed to determine whether this preparation includes components vital to success in an increasingly global engineering environment. Learning from a survey of a small segment of our engineering graduates, we were able to focus on the most critical need that we were not already addressing; one that could be applied across several engineering disciplines with manageable resource demands. This is the need for a better understanding of global cultural diversity and its impact upon engineering decisions. To meet this need, we propose to leverage the communication initiatives currently used in capstone courses as well as our international student community by developing communication assignments that require students to consider the cultural diversities they will confront upon graduation. These changes will be timed to take advantage of a more detailed engineering alumni survey. Our current thought is to pilot this program in the Petroleum Engineering Department because of its graduates' expectations of overseas assignments and the presence of a multi-cultural student population in this discipline.

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