AC 2008-752: GLOBALIZATION OF ENGINEERING EDUCATION: ARE WE PREPARING STUDENTS TO SUCCEED IN THE GLOBAL ECONOMY?

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Globalization of Engineering Education: Are we preparing U.S. students to succeed in the Global Economy?

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Abstract

To succeed in the competitive global environment, it is essential to incorporate appropriate courses in the engineering curriculum. The current U.S. curriculum does not adequately prepare engineering students to work, manage and communicate effectively with engineers and other professionals around the globe. A study was conducted to evaluate the current status of engineering education around the globe and the need for updating the curriculum that will prepare U.S. engineering graduates for global work environment. The study included U.S. engineering students, international students currently studying in the USA, engineering students from outside U.S and engineering faculty for their viewpoints. It appeared that the non-US students have better preparation than US students to work in a global business environment. A number of areas were identified and presented that can improve the current US engineering and engineering technology education is presented in the paper

Introduction

We are witnessing a rapid evolution and call for globalization that affects every aspects of our life. A shrinking global village, the upcoming new economies, and globalization of the economy itself have triggered the need for globalization of education. In this study our focus revolves around globalization of engineering education, because we believe, to succeed in the competitive global business environment, it is essential to incorporate appropriate courses in the engineering curriculum. When compared with the evolution of education, globalization of engineering education is at its infancy stage. Researchers, academic institutions, and industry have employed multifarious projects to understand and model globalization of engineering education

We strongly emphasize that optimum work needs to be done to prepare upcoming U.S. students who will be competent in an increasingly demanding global work environment. In order to establish new models, we made an attempt to understand and analyze perspectives of current (U.S. and non-U.S.) students, academic faculty, and engineering professionals currently working in industry. One of the goals of this study was to test the hypothesis that the current U.S. curriculum do not adequately prepare engineering students to work, manage and communicate effectively with engineers and other professionals around the globe. Our survey data and statistical observations strongly favors towards acceptance of the above hypothesis.

This paper is divided into four parts – first, brief analysis of related previous work in this area, and the motivations behind this study; second, survey methodology, questionnaire and sample data; third, statistical analysis of survey data; and fourth, author's conclusions and recommendations.

Background

Globalization of engineering education is being considered as one of the priority areas by emerging economies of the world. Several reasons can be cited to support this pattern. Need for Socio-Economic competency that makes it a forefront issue. Significant researches have been reported in this area, broadly in globalization of education.

There have been many attempts to explore globalization of engineering education at grass root level. Northern Arizona University researchers have described a novel auricular paradigm called the Global Engineering College[1]. The GEC concept is based on the idea of seamlessly combining the curricula and educational opportunities of several internationally-distributed engineering institutions to create a virtual engineering college spanning multiple countries and cultures.

Iowa State University researchers have structured a Global Academic Industrial Network (GAIN) as an attempt to create multi-organizational, international partnerships of academic and industrial organizations that emphasize collaborative educational programs and research that meets the global needs of faculty, students, and industry[2].

Oregon State University's International degree Program allows students to earn a concurrent bachelor's in International Studies associated with an engineering degree[3]. Foreign language proficiency, overseas experience, and courses with a cross-cultural focus are key features of this program.

Union College in New York presented a union college model for preparing engineering students to work in a global environment[8]. Adding international component to the engineering curriculum. The different programs which include other important attributes to a well-rounded engineering education including engineering design, multicultural/ multidisciplinary teaming and exposure to the liberal arts, were also presented.

City University of New York researchers studied various aspects of international exchange program. International exchange programs are perhaps the most tried and tested programs when it comes to programs associated with globalization of education. Case study on international exchange programs[5] have shown that participating students observed a difference in their personal developments after living in a different country. Another study in North Carolina A&T State University and University of Science in Ghana[6] showed how knowledge transfer is utilized in international and intercultural education exchange programs.

A student exchange program between Siemens-Westinghouse and the University of Central Florida found out that students benefited from an understanding of the systems, standards, and cultures involved[7]. The globalization of the market place is a driving force that demands the establishment of study abroad programs. Study abroad may lessen the culture gap and bring people of different nations closer together as discussed in a joint case study conducted by Kasetsart University and the University of Florida[9].

The dramatic change in the globalization of economy, society, industry, and education has compelled the Universities and Fachhochschulen in Europe to adopt the bachelor-masters-doctoral (BMD) system as the de facto international standard for engineering education[10]. Globalization has created a need for European multinational companies to hire engineers with a more practical education, and for European engineering programs to better compete for graduate students from other countries and institutions.

Researchers at the American University and Universidad de Buenos Aires presented an international and interdisciplinary look at how research on learning styles can be utilized in science and engineering classrooms[11]. They put specific emphasis on the Dunn and Dunn Learning Style Model. The Dunn model is used at American University and at the University of Buenos Aires to improve the quality of teaching and learning in science and engineering classes. Their strategy that has been particularly successful at both institutions is the use of writing as an assessment and learning tool. The writing strategies used at both institutions were summarized and information regarding assessment of student learning and learning styles were shared. Their idea was to analyze how writing strategies can be used to accommodate a diversity of student learning styles.

The implementation of the Bologna protocol[12] in the European Union has set new goals for the entire higher education system such as quality assessment of university courses, a framework for students and academics exchange, and opportunities for changing the teaching/learning methodologies. University of Minho's Mechanical Engineering curricula have been comprehensively formulated to meet these standards.

ICT model used to prepare foreign students planning for engineering studies in France. Few highlights of this model include methods to train students to understand scientific presentations through intensive listening comprehension. This model was achieved as a result of close collaboration between experts in the fields of science, linguistics, intercultural relations and educational ICT[13].

The Global Engineering Education Exchange Program[14], initiated nearly five years ago, focuses on providing undergraduate engineering students international academic experiences and industrial internships. Over the years, the program developed to national stature with over 200 exchanges annually and involving over 80 major engineering schools throughout the world.

Japanese organizations have proposed the establishment of an Integrated System to support Professional Development of Engineers (PDE). This system will cover engineering education, training and practice, professional certification and Continuing Professional Development (CPD). One of the targets is to have a national and an international recognition of the professional competences of Japanese engineers. Another target is to promote CPD to maintain engineers' professional qualification and/or to give them the opportunity of career development by adding competences in different fields[15].

We are highlighting the lack of preparedness among American engineering students when it comes to global engineering community. There is a need for radical augmentation in engineering education curriculum.

Survey Methodology and Questionnaire

Our survey methodology can be best described as succinct. We limited our questionnaire to nine objective questions where respondents were requested to select one out of many available options. Few questions required respondents to select options based on facts and in some questions; they had to select options based on their perspective and opinion.

Table 1. Distribution of Survey Questionnaire

No.	Question	Classifier
1	My academic/employment status:	Objective
2	I have graduated from a high school or undergraduate institution which is located:	Objective
3	The undergraduate curriculum provides knowledge necessary for working in a global environment:	Objective
4	Course materials emphasize SI units (metric units) to solve problems:	Objective
5	I can communicate effectively in writing with at least one foreign language:	Objective
6	To be competitive in a global environment, it is necessary to include at least one foreign language in the curriculum:	Objective
7	I am willing to accept a job in a country where the native language than mine:	Objective
8	I believe that in the future, I will need to work in an environment where the communication with individuals with different background, knowledge and/or language will be necessary:	Objective
9	Engineering programs outside the U.S. place more emphasize more on global education:	Objective
10	Please provide comments and specific suggestions on how to globalize engineering education.	Subjective

Question number 1 and 2 were presented to extract respondents' professional status such as student, faculty and engineers working in the industry, and educational background. We define these two questions as respondent demography extraction. Questionnaire included some fact-based objective questions (refer to question numbers 3, 4 and 5 in table 1) such as respondent's proficiency in at least one written foreign language, and understanding the emphasis of global standards such as SI units in course materials for problem solving. Many questions were asked to understand respondent's perspectives and suggestions towards the issue of globalization of engineering education and global work platform.

Questions number 6, 7, 8 and 9 were centered on global work platform with five different possible answer choices: strongly agree (SA), agree (A), no comment (NO), disagree (D) and strongly disagree (SD). Question number 7 attempts to evaluate respondent's desire to work in a country where the native language is different. Question number 8 tries to understand the awareness and preparedness of the respondents.

The concluding question no.10 of the survey was a subjective question where respondents were requested to give feedback and suggestions on how to globalize engineering education. This question is particularly important in understanding explicit views of the respondents. Nearly 32% respondents left some remarks and suggestions, which we believe shows the awareness and importance of this subject among various sects of engineering community.

Respondent Data Analysis

Our survey on globalization of engineering education received 785 responses, which was conducted through the popular online surveying tool Zoomerang. Out of 785 respondents, 525 (67%) accounted for student responses, 194 (25%) respondents were faculty members and the remaining 61 (8%) responses were made by engineers working in the industry. Table 2 illustrates distribution of respondents' academic or employment status.

Table 2. Respondents' Academic/Employment Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Faculty	194	24.7	24.9	24.9
	Engineers Working in the Industry	61	7.8	7.8	32.7
	Student	525	66.9	67.3	100.0
	Total	780	99.4	100.0	
Missing	1	5	.6		
Total		785	100.0		

Our approximate student to faculty ratio of 3 to 1 is justified with typical student to faculty ratios in U.S. universities, which hovers around 15 to 1. A lower 8% working engineers respondents can be attributed to the fact that globalization of engineering education and the global work platform are current issue, and significant part of existing workforce are unaffected by it. From a futuristic perspective, the upcoming generation of students will be affected by rapidly evolving global engineering work platform. As such, 67% student respondents are justified. Table 3 illustrates the distribution of respondents' academic background.

Table 3. Respondents' Academic Background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In the United States.	641	81.7	82.0	82.0
	Outside the United States.	141	18.0	18.0	100.0
	Total	782	99.6	100.0	
Missing	1	3	.4		
Total		785	100.0		

Educational backgrounds of respondents were essential component of our survey. Here the term background refers to respondents' high school or undergraduate education in an U.S. institution or an institution outside the United States. Analyzing educational background will help us in understanding the perspectives and preparedness of students with various backgrounds. Out of 785 respondents, 641 (82%) respondents have graduated from a high school or undergraduate institution which is located in the United States. Remaining 141 (18%) respondents graduated from a high school or undergraduate institution which is located outside the United States. Approximately 5 to 1 ratio should provide us with considerable support to justify our survey findings.

Statistical Analysis of Survey Data

A series of Chi-Square tests were performed using statistical analysis software SPSS to assess the bivariate associations of responses. The first chi square test examined the association between the academic/employment status of the survey respondents (Q1) and respondents' academic background (Q2). Table 4.1 and 4.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 4.1: Cross tabulation of Respondent Status (Q1) and Academic Background (Q2)

			Q2		
			In the United States.	Outside the United States.	Total
Q1	Faculty	Count	144	48	192
		% within Q1	75.0%	25.0%	100.0%
		% within Q2	22.6%	34.3%	24.7%
	Other (please specify your title if employed)	Count	48	13	61
		% within Q1	78.7%	21.3%	100.0%
		% within Q2	7.5%	9.3%	7.8%
	Student	Count	446	79	525
		% within Q1	85.0%	15.0%	100.0%
		% within Q2	69.9%	56.4%	67.5%
Total		Count	638	140	778
		% within Q1	82.0%	18.0%	100.0%
		% within Q2	100.0%	100.0%	100.0%

Table 4.2: Chi-Square Test 1

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.930[a]	2	.007
Likelihood Ratio	9.517	2	.009
Linear-by-Linear Association	9.855	1	.002
N of Valid Cases	778		

a. 0 cells (.0%) have expected count less than 5.
The minimum expected count is 10.98.

The groups have significantly different distributions ($p = 0.007$) in terms of origin, with faculty being the most likely to be from outside the U.S. (25%). Students make up the majority of respondents who are outside the U.S., which is not surprising given how many students responded.

The second chi square test examined the association between the necessity to include at least one foreign language in the curriculum (Q6) and respondents' academic background (Q2). Table 5.1 and 5.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 5.1 Cross tabulation of Academic Background (Q2) and Foreign Language (Q6)

			Q6					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	102	229	123	148	39	641
		% within Q2	15.9%	35.7%	19.2%	23.1%	6.1%	100.0%
		% within Q6	63.8%	82.4%	88.5%	90.2%	95.1%	82.0%
	Outside the United States.	Count	58	49	16	16	2	141
		% within Q2	41.1%	34.8%	11.3%	11.3%	1.4%	100.0%
		% within Q6	36.3%	17.6%	11.5%	9.8%	4.9%	18.0%
Total		Count	160	278	139	164	41	782
		% within Q2	20.5%	35.5%	17.8%	21.0%	5.2%	100.0%
		% within Q6	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.2 Chi-Square Test 2

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	52.360 [a]	4	.000
Likelihood Ratio	49.418	4	.000
Linear-by-Linear Association	41.303	1	.000
N of Valid Cases	782		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.39.

The group of respondents outside the U.S. is significantly ($p < 0.001$) more likely to agree that foreign language should be a part of the curriculum. Only about 52% of the U.S. respondents agreed to this question, compared to 76% of foreign respondents.

The third chi square test examined the association between the respondents' willingness to accept a job in a country where the native language is different that respondent's native language (Q7) and respondents' academic background (Q2). Table 6.1 and 6.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 6.1 Cross tabulation of Academic Background (Q2) and Willingness to Work Overseas (Q7)

			Q7					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	110	279	82	107	59	637
		% within Q2	17.3%	43.8%	12.9%	16.8%	9.3%	100.0%
		% within Q7	63.6%	81.8%	89.1%	94.7%	100.0%	81.9%
	Outside the United States.	Count	63	62	10	6	0	141
		% within Q2	44.7%	44.0%	7.1%	4.3%	.0%	100.0%
		% within Q7	36.4%	18.2%	10.9%	5.3%	.0%	18.1%
Total		Count	173	341	92	113	59	778
		% within Q2	22.2%	43.8%	11.8%	14.5%	7.6%	100.0%
		% within Q7	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.2 Chi-Square Test 3

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	67.839 [a]	4	.000
Likelihood Ratio	75.972	4	.000
Linear-by-Linear Association	59.604	1	.000
N of Valid Cases	778		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.69.

About 89% of respondents outside the U.S. agree to this question in some form, agreeing to work outside their home country, as opposed to about 61% of U.S. respondents. There is a strongly significant difference between the groups in this regard ($p < 0.001$).

The fourth chi square test examined the association between the working environment where communication with individuals and different background, knowledge and/or language will be necessary (Q8) with respondents' academic background (Q2). Table 7.1 and 7.2 illustrates the cross tabulations and chi-Square test results respectively

Table 7.1 Cross tabulation Academic Background (Q2) and Recognition of Multicultural Work Environment (Q8)

			Q8					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	321	262	24	29	2	638
		% within Q2	50.3%	41.1%	3.8%	4.5%	.3%	100.0%
		% within Q8	78.3%	85.1%	85.7%	96.7%	100.0%	82.0%
	Outside the United States.	Count	89	46	4	1	0	140
		% within Q2	63.6%	32.9%	2.9%	.7%	.0%	100.0%
		% within Q8	21.7%	14.9%	14.3%	3.3%	.0%	18.0%
Total		Count	410	308	28	30	2	778
		% within Q2	52.7%	39.6%	3.6%	3.9%	.3%	100.0%
		% within Q8	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 7.2 Chi-Square Test 4

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.853 [a]	4	.028
Likelihood Ratio	12.931	4	.012
Linear-by-Linear Association	10.328	1	.001
N of Valid Cases	778		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is .36.

About 97% of people outside the U.S. agree to this question, agreeing that the economy will be more global in the future, as opposed to about 91% of U.S. respondents. Both groups tend to agree, but a large portion of foreign respondents tends to agree, and the difference is still significant ($p = 0.028$).

The fifth chi square test examined the association between the emphasis on usage of SI units for solving problems in respondents' academic curriculum (Q4) and respondents' academic background (Q2). Table 8.1 and 8.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 8.1 Cross tabulation of Academic Background (Q2) and Proficiency with Metric System (Q4)

			Q4					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	232	268	47	78	15	640
		% within Q2	36.3%	41.9%	7.3%	12.2%	2.3%	100.0%
		% within Q4	80.3%	85.9%	78.3%	77.2%	78.9%	81.9%
	Outside the United States.	Count	57	44	13	23	4	141
		% within Q2	40.4%	31.2%	9.2%	16.3%	2.8%	100.0%
		% within Q4	19.7%	14.1%	21.7%	22.8%	21.1%	18.1%
Total		Count	289	312	60	101	19	781
		% within Q2	37.0%	39.9%	7.7%	12.9%	2.4%	100.0%
		% within Q4	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 8.2 Chi-Square Test 5

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.002 [a]	4	.199
Likelihood Ratio	6.081	4	.193
Linear-by-Linear Association	.539	1	.463
N of Valid Cases	781		

a. 1 cell (10.0%) has expected count less than 5. The minimum expected count is 3.43.

There is no evidence of a difference between the groups in terms of responses to this particular question, which suggests that the two groups tend to have the same opinion on willingness to work with the SI metric system. In each group, about 75% are willing to work with the system.

The sixth chi square test examined the association between the respondents' capabilities of communicating effectively in writing with at least one foreign language (Q5) and respondents' academic background (Q2). Table 9.1 and 9.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 9.1 Cross tabulation of Academic Background (Q2) and Communication Skills in Foreign Language (Q5)

			Q5					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	57	100	40	227	216	640
		% within Q2	8.9%	15.6%	6.3%	35.5%	33.8%	100.0%
		% within Q5	39.9%	69.9%	93.0%	97.4%	98.6%	81.9%
	Outside the United States.	Count	86	43	3	6	3	141
		% within Q2	61.0%	30.5%	2.1%	4.3%	2.1%	100.0%
		% within Q5	60.1%	30.1%	7.0%	2.6%	1.4%	18.1%
Total		Count	143	143	43	233	219	781
		% within Q2	18.3%	18.3%	5.5%	29.8%	28.0%	100.0%
		% within Q5	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.2 Chi-Square Test 6

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	267.665[a]	4	.000
Likelihood Ratio	261.176	4	.000
Linear-by-Linear Association	234.886	1	.000
N of Valid Cases	781		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.76.

About 92% of respondents outside the U.S. claim to have the ability to write in a foreign language, while only 25% of respondents inside the U.S. claim to have this ability, and this difference is highly significant ($p < 0.001$). About 70% of U.S. respondents disagree with this item.

The seventh chi square test examined the association between whether the respondents' undergraduate curriculum provides knowledge necessary for working in a global environment and respondents' academic background (Q2). Table 10.1 and 10.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 10.1 Cross tabulation of Academic Background (Q2) and Global Engineering Curriculum (Q3)

			Q3					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	36	268	123	202	11	640
		% within Q2	5.6%	41.9%	19.2%	31.6%	1.7%	100.0%
		% within Q3	58.1%	84.3%	83.7%	85.6%	61.1%	81.9%
	Outside the United States.	Count	26	50	24	34	7	141
		% within Q2	18.4%	35.5%	17.0%	24.1%	5.0%	100.0%
		% within Q3	41.9%	15.7%	16.3%	14.4%	38.9%	18.1%
Total		Count	62	318	147	236	18	781
		% within Q2	7.9%	40.7%	18.8%	30.2%	2.3%	100.0%
		% within Q3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 10.2 Chi-Square Test 7

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	32.769[a]	4	.000
Likelihood Ratio	27.069	4	.000
Linear-by-Linear Association	4.382	1	.036
N of Valid Cases	781		

a. 1 cell (10.0%) has expected count less than 5. The minimum expected count is 3.25.

About 54% of foreign respondent agree to this item, as opposed to 48% of U.S. respondents, and this difference is strongly significant ($p < 0.001$). There is evidence that the undergraduate curriculum outside the U.S. puts more emphasis on global education.

The eighth chi square test examined the association between whether the engineering programs outside the U.S. place more emphasis on global education and respondents' academic background (Q2). Table 11.1 and 11.2 illustrates the cross tabulations and chi-Square test results respectively.

Table 11.1 Cross tabulation of Academic Background (Q2) and Emphasis on Globalization in Curriculum (Q9)

			Q9					Total
			SA	A	NO	D	SD	
Q2	In the United States.	Count	100	176	311	37	12	636
		% within Q2	15.7%	27.7%	48.9%	5.8%	1.9%	100.0%
		% within Q9	79.4%	81.1%	87.9%	55.2%	92.3%	81.9%
	Outside the United States.	Count	26	41	43	30	1	141
		% within Q2	18.4%	29.1%	30.5%	21.3%	.7%	100.0%
		% within Q9	20.6%	18.9%	12.1%	44.8%	7.7%	18.1%
Total		Count	126	217	354	67	13	777
		% within Q2	16.2%	27.9%	45.6%	8.6%	1.7%	100.0%
		% within Q9	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 11.2 Chi-Square Test 8

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	42.129[a]	4	.000
Likelihood Ratio	36.304	4	.000
Linear-by-Linear Association	.534	1	.465
N of Valid Cases	777		

a. 1 cell (10.0%) has expected count less than 5. The minimum expected count is 2.36.

On this question, 49% of U.S. respondents had no opinion, versus only 31% of non-US respondents. More non-US respondents disagree (22%) than U.S. respondents (8%). U.S. respondents may simply not be informed about programs outside of the U.S.

Conclusions and Recommendations

This study has highlighted some interesting observations. Before drawing our conclusions, we would like to provide the following categorization of possible results:

Category 1: U.S. students are aware of globalization of engineering work, and we are preparing them adequately.

Category 2: U.S. students are aware of globalization of engineering work, but we are not prepared, or we are falling short of essential requirements from a global education perspective.

Category 3: U.S. students are not aware about globalization of engineering work, although we are trying to prepare them adequately.

Category 4: U.S. students are not aware about globalization of engineering work, and we have not taken adequate steps to prepare them.

The statistical analysis section of this paper demonstrates that about 97% of non-US respondents and about 91% of U.S. respondents agree that the economy will be more global in the future. We can construe high level of awareness among U.S. students towards globalization of engineering work. As such, we can confidently rule out scenarios described in category 3 and 4.

Our statistical analysis shows that significantly higher percentage of non-U.S. respondents agree to have foreign language as part of their curriculum, a higher percentage of non-U.S. respondents are willing to work in a country where primary language is different from their own, and our analysis also shows that sufficiently higher percentage of non-U.S. respondents have the ability to write in a foreign language than the US respondents. The abovementioned observations show that our students are not fully prepared for a global engineering work environment. Also, it has been observed that undergraduate engineering curriculum outside the United States puts more emphasis on global education such as foreign languages and usage of international metric systems among few concentrations. From these observations we can infer that US students are aware of globalization of engineering work, but not fully prepared. As such, the scenario described in category 2 is a good match with statistical findings.

The author recommends several areas of curriculum update that may help prepare US students for a global engineering environment. The first one is to incorporate a foreign language in engineering curriculum with carefully considering a foreign language from one of the leading emerging economies such as India and China. The second recommendation is to require a global experience component such as study abroad trip to those emerging economies for both U.S. engineering faculty and students. The third recommendation is to work on a senior design projects requiring collaboration with engineering students from overseas institutions. Realizing the challenges associated with incorporating all these three recommendations, the authors strongly recommends at least one of these global components to be added to the engineering curriculum.

References

1. Doerry, E., B.N. Bero and K. Doerry. The Global Engineering College: Exploring a new model for engineering education in a global economy. In proceedings of the 2003 American Society for Engineering Education (ASEE) Annual Meeting, Nashville, TN, June 2003.
2. Melsa, J.L., Holger, D., Zachary, L. Achieving a global academic industrial network for students and faculty. In proceedings of the 2003 American Society for Engineering Education (ASEE) Annual Conference Proceedings, Nashville, TN, June 2003.

3. Herling. D., Herling. A., Peterson. J. Integrating Engineering and Global Competencies: A case study of Oregon State University's International Degree Program. In proceedings of the 31st ASEE/IEEE Frontiers in Education Conferences, Reno, NV, October 2001.
4. Torres, J.L. What's in it for me? The whys and wherefores of international exchange programs. In proceedings of the 2002 ASEE Annual Conference Proceedings, Montréal, Quebec, June 2002.
5. Hipel. K.W. The Internationalization of Engineering Education: A Tale of Two Countries. IEEE Transactions on Systems, Man and Cybernetics 2003, Vol. 33, No. 1.
6. Owusu-Ofori. S., Klett. D., Pai. D., Roberts. K., Obeng. D., Agbeko. E. Global Engineering Education Project at North Carolina A&T State University. In proceedings of the 31st ASEE/IEEE Frontiers in Education Conferences, Reno, NV, 2001, S1D-10.
7. Walbaum, F., Rogers, H.K. The impact of globalization on student preparation in Germany and the United States. In proceedings of the 2002 ASEE Annual Conference Proceedings, Montréal, Quebec, June 2002.
8. Wilk, R.D., Bucinell, R.B., Andersen, A.M., Thomas, W.W. Preparing engineering students to work in a global environment: The union college model. In proceedings of the 2001 ASEE Annual Conference Albuquerque, New Mexico, June 2001.
9. Pathomvanich, S., Najafi, F.T. International partnership in engineering education. In proceedings of the 2001 ASEE Annual Conference Albuquerque, New Mexico, June 2001.
10. Yeargan, J., Hernaut, K. The Globalization of European engineering education: An American observer's perspective. In proceedings of the 31st Annual Frontiers in Education Conference, 2001.
11. Larkin, T.L., Feldgen, M., Clúd, O. A global approach to learning styles. In proceedings of the 32nd Annual Frontiers in Education Conference, 2002.
12. Teixeira, J., Ferreira, J., Flores, P. Development of mechanical engineering curricula at the University of Minho. European Journal of Engineering Education, 2007, Vol. 32, Issue. 5.
13. Meunier, F., Dutto, E., Guillet, S., Michau, F. Preparing foreign students for engineering studies in France. European Journal of Engineering Education, 2007, Vol. 32, Issue. 1.
14. In Proceedings of the 31st Annual Frontiers in Education Conference - Impact on Engineering and Science Education. In proceedings of the 31st ASEE/IEEE Frontiers in Education Conferences, Reno, NV, October 2001.
15. Angelino, H. Engineering Education and Professional Development in Germany, France and United Kingdom - Examples of establishing Continuing Professional Development of Engineers in Japan. National Institute of Informatics Journal, March 2003.