Cross Cultural Diversity in Engineering Students in America and Europe

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INTRODUCTION
In this global world, today's engineer is likely to have to work in global international

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teams with colleagues from other nationalities. The challenge for many engineering curricula is how to include, in a realistic way, this global dimension and increase the student's awareness of the cultural issues that are encountered. In the Purdue University engineering technology program, an international industry sponsored, multidisciplinary capstone project was created to change attitudes and increase awareness of the challenges engineers will face in global projects. In the international project, half of the team members are students from a non-US university. The full team works on a project proposed by companies with a global footprint in both the U.S. and in proximity to the foreign institution. This global project is carried out using normal internet tools such as email, skype, and blogs. In addition two exchange trips are made with team members traveling to their opposite foreign location. Ideally the first trip occurs near the initiation of the project for planning, organizing and conceptualization. Two projects are underway presently in Germany and Poland with expansion of the program to include France, Finland and Russia in coming years.

In order to assess whether this approach can increase awareness in global cultures, a study was done to determine the existing differences in attitudes among the students of the participating countries. The Millville-Guzman Universality Diversity Scale (MGUDS-S) survey was used to measure what the initial differences might be [1]. This data is used then to develop pedagogical strategies to expand global awareness and ease the execution of multidisciplinary projects. Data using the MGUDS-S survey was collected from several populations:

- the senior engineering technology capstone class (109) at Purdue University
- the third year electrical engineering class (42) at Leibniz University of Hannover
- the third year mechanical engineering class (117) at Gdansk University of Technology
- final year engineering students in Tambov State Technical University, Russia,

When viewed as a whole population, it appears that this generation of students are generally not interested in engaging in cross cultural behavior such festivals, dance, and music. In addition this generation does not appear to appreciate the benefits that can be derived from engaging with other cultures. Despite this lack of interest and appreciation, this generation of students is emotionally comfortable with different cultures with the American being the most comfortable according to this survey and the Russian student being the least. This observation is surprising in view of the large cross cultural demographics of Russia. There are other surprising differences between American, German, Polish, Finnish and Russian students discussed in the paper.

While the impact of this study is still being evaluated, pedagogical approaches have been created that address these issues and prepare new engineers to perform well in global teams.

1   BACKGROUND

1.1   The Global Engineer

In this global world, today's engineer is likely to have to work in global international teams with colleagues from other nationalities and cultures. Considerable effort has been made to define the attributes and competencies of a global engineer [4,5] and the paper will not attempt to review this body of research. Many of these attributes are well recognized prior to the concept of a global engineer. However several attributes stand out with more emphasis and significance in the global world of the practicing engineer. Parkinson conducted a survey of the 2008 NSF Summit on

Globalization during which the top five competencies were identified. Among these were an appreciation of other cultures, an ability to communicate across cultures and in other languages, an ability to work in cross cultural teams and deal with ethnic and cultural diversity and having an international work/educational experience.[6] In addition the global engineer must have a higher standard of competency in the broad range of electronic communication tools over the internet and over a broad range of ethical and professional standards which includes a sensitivity to norms other than one's own country. These attributes among others take on new dimensions when put in the global context. At the root of these attributes is the heightened awareness of global cultures and a sensitivity to the cross cultural nature of an engineer's profession. The challenge for many engineering curricula is how to include this global dimension in a realistic way.

1.2　International Senior Capstone Projects

In the School of Engineering Technology capstone projects are one of the most effective avenues to synthesize an engineer's education and therefore present themselves as an opportunity to insert global awareness. In the School of Engineering Technology, a very successful program of industry funded, senior capstone team projects exists as a requirement for graduation. In 2014-2015 teams of mechanical engineering technology and electrical and computer engineering technology students are addressing 33 projects on a broad range of topics. Some representative and typical projects that can be accomplished are listed in]2]. All the projects are real world projects sponsored by industry working on open ended problems resulting in a design, build and test experience. Both academic and industry mentors are provided with weekly interactions with a series of reviews based on a modified stage/gate development process.

Into this well developed and stable senior capstone project process, an international capstone project has been created and introduced in 2014-2015. This international capstone project builds on the existing, industry sponsored, multi-disciplinary capstone team project that is required of all students. In the international project, half of the team members are students from a non-US university. The full team works on a project proposed by companies with a global footprint in both the U.S. and in proximity to the foreign institution. Course materials include standard project management and systems engineering tools and are augmented with cultural and business practice research and reporting. Most of the global project is carried out using the full range of electronic communication tools such as email, skype, and blogs. In a variation from many of the other non-traditional activities, two exchange trips are made with team members traveling to their opposite foreign location. Ideally the first trip occurs near the initiation of the project for planning, organizing and conceptualization. This early face to face meeting has been found to facilitate the formation of personal relationships that endure during the project execution and enhance both the outcome of the project and the cultural experience. To further enhance the experience, during each visit, the visiting students are lodged with the host students for a total emersion into the culture of the country. The framework of this international capstone project addresses key variables identified as necessary for maximum impact: customers and co-workers in both countries, project definition by the customer and the requirement for demonstration/presentation to the customer [11].

Despite the challenges of schedule and culture and the intuitive sense that this type of experience would increase global awareness, it is desirable to measure the impact and efficacy of the program. This study surveys attitudes of students from the

participating countries including the U.S students setting a baseline for cross cultural attitudes and exploring potential areas of course content that would address cultural differences and ease the execution of international projects.

2   ASSESSING CROSS CULTURAL DIVERSITY

2.1   Miville-Guzman Universality-DiversityScale

There exist already several survey tools to evaluate various aspects of cultural attitudes. The Miville-Guzman Universality-DiversityScale (M-GUDS)-S in its trimmed version was selected for this broad survey [3,7] because this tool focuses on areas that would be relevant to measure a change in attitude as a result of curriculum changes . Additionally this tool was used in studies with similar goals and found to be useful.[8.9] While this study focused on attitude change, future consideration will be given to tools that focus on assessing acquired skill and the ability to act in appropriate manner consistent with the improved attitude.   The original Miville-Guzman Universality-DiversityScale (M-GUDS) was a 45-item instrument designed to measure an individual's Universal-Diverse Orientation (UDO), defined as "an attitude of awareness and acceptance of both similarities and differences that exist among people". This 45 item tool has been modified and trimmed to 15 items which requires less time and has been shown to be as effective[3]. In the original tool, as in the compressed tool, groups of questions are used to create three subscales to assess behavioral, cognitive and emotional dimensions of UDO. The subscales and the questions used to form the subscales are shown as follows:

1) Diversity of Contact – the students' broad interest in participating in diverse social and cultural activities such as music, dance, celebrations and organization which focus on behavior.
   1. I would like to join an organization that emphasizes getting to know people from different countries.
   2. I would like to go to dances that feature music from other countries.
   3. I often listen to music from other cultures.
   4. I am interested in learning about the many cultures that have existed in this world.
   5. I attend events where I might get to know people from different cultural backgrounds.

2) Relative Appreciation – the extent that diversity could have on self-understanding and personal growth which is a cognitive element
   1. Persons with disabilities can teach me things I could not learn elsewhere.
   2. I can best understand someone after I get to know how he/she is both similar to and different from me.
   3. Knowing how a person differs from me greatly enhances our friendship.
   4. In getting to know someone, I like knowing both how he/she differs from me and is similar to me.
   5. Knowing about the different experiences of other people helps me understand my own problems better.

3) Comfort With Differences – the degree of emotional comfort with individuals of a different culture (Note that these items are reverse scored)
   1. Getting to know someone of another culture is generally an uncomfortable experience for me.
   2. I am only at ease with people of my culture.

3. It's really hard for me to feel close to a person of another culture.
4. It is very important that a friend agrees with me on most issues.
5. I often feel irritated with persons of a different culture.

The MGDUS-s survey uses a six-point Likert scale ranging from strongly disagree to strongly agree and was initially found to be a good fit with our study. As a result of using this survey, some of the wording in the survey questions has been found to create cross cultural issues, the principal one being questions that specifically ask about racial attitudes. Since this study was focused on cultural differences, the word "race was removed and replaced with "culture". With this slight modification and with the extensive development that supports this survey, the MGFUDS-S was adopted for this study.

2.2 Populations of the Study

In the present international senior capstone projects, half of the team members are students from a non-U.S. university. The full team works on one integrated project proposed and sponsored by companies with a global footprint in both the U.S. and in proximity to the foreign institution. The first two international teams are as follows: 1)Purdue University with the Leibniz University of Hannover sponsored by Lenze

	American	Polish	German	Russian	Total
Male	88.30%	64.96%	78.57%	46.00%	71.29%
Undergraduate	98.94%	99.15%	64.29%	100.00%	94.52%
International Students	7.45%	0.00%	26.19%	6.00%	6.77%
More than one Language	60.64%	95.73%	92.86%	88.00%	82.90%
Study Abroad	31.91%	17.09%	45.24%	12.00%	25.16%
Sample Size	94	117	42	50	309

Table 1 Demographics of the four sampling groups

Corporation and 2) Purdue University with Gdansk University of Technology sponsored by Eaton Corporation. As a result of these projects, data using the MGUDS-S survey was collected from these universities as well as a university in Russia:

- the full senior engineering technology capstone class at Purdue of 109 students,
- the third year class of 42 electrical engineering students at Leibniz University of Hannover,
- the third year class of 117 mechanical engineering students at Gdansk University of Technology and finally
- .the third year class from Tambov State Technological University, Tambov, Russia.

The comparison between nationalities further supports specific areas where diversity could be troublesome and where course structure could be altered to address the functional effect in these areas. In addition to the survey questions, anonymous demographic information was collected. A summary of the demographics of the four main populations is shown in Table 1.

2.3 Results of the Surveys

The analysis of the survey data began with examining the entire population relative to key demographic information. Of immediate interest is whether cross cultural diversity is impacted by study abroad experience. In Table 2, the responses to each question is shown for the query of study abroad or not: the average value of the sample and its sigma and the difference between the two samples. In the difference column, the numerical value of the difference is given along with a bar indicator. If the bar indicates extends to the right, the first data shows a reduced cross cultural awareness while, if the bar extends to the left, the second data shows a reduced awareness. Remarkably, on all questions averaged over the entire student population, more cross cultural sensitivity was seen in the students that have studied abroad. However the effect is not as uniform across all the students sampled. The data on all national cultures is divided into the three major subscales 1)diversity of contact--the behavior dimension, 2) relative appreciation—the cognitive dimension and 3) comfort with differences—the emotional dimension. As is shown in figure 1,

	Study Abroad		No Study Abroad			
Sample Size	78		232			
Question Specific	Average	Sigma	Average	Sigma	Difference	Sigma Diff
1. I would like to join an organization that emphasizes getting to know people from different countries	4.67	1.01	4.12	1.20	0.55	8.45
2. Persons with disabilities can teach me things I could not learn elsewhere	4.69	0.92	4.36	1.10	0.33	5.41
3. Getting to know someone of another culture is generally an uncomfortable experience to me	1.74	0.84	1.98	1.06	0.25	4.26
4. I would like to go to dances that feature music from other countries	3.87	1.29	3.67	1.52	0.20	2.37
5. I can best understand someone after I get to know how he/she is both similar to and different from me	4.51	1.05	4.37	0.98	0.14	2.48
6. I am only at ease with people of my culture.	2.15	1.02	2.33	1.22	0.18	2.76
7. I often listen to music of other cultures	4.03	1.44	3.97	1.45	0.07	0.81
8. Knowing how a person differs from me greatly enhances our friendship	4.20	1.09	3.83	1.21	0.37	5.44
9. It's really hard for me to feel close to a person from another culture.	2.05	1.17	2.28	1.20	0.23	3.43
10. I am interested in learning about the many cultures that have existed in this world	4.78	0.90	4.44	1.17	0.33	5.27
11. In getting to know someone, I like knowing both how he/she differs from me and is similar to me	4.58	0.99	4.33	1.05	0.25	4.25
12. It is very important that a friend agrees with me on most issues	3.43	1.30	3.36	1.35	-0.07	0.88
13. I attend events where I might get to know people from different cultural backgrounds	4.21	1.33	3.52	1.47	0.70	8.52
14. Knowing about the different experiences of other people helps me understand my own problems better	4.62	1.01	4.22	1.30	0.41	5.77
15. I often feel irritated by persons of a different culture.	2.13	1.08	2.18	1.25	0.04	0.64

Table 2 Full survey result indicates the positive impact of a study abroad experience. Cross cultural diversity improves in almost all categories. *Note that questions for emotional comfort (#3,6,9,12,15 in green) are negative such that disagreement reflexes better cross cultural awareness and agreement reflex poorer awareness.*

the emotional comfort dimension is apparently made worse by studying abroad.
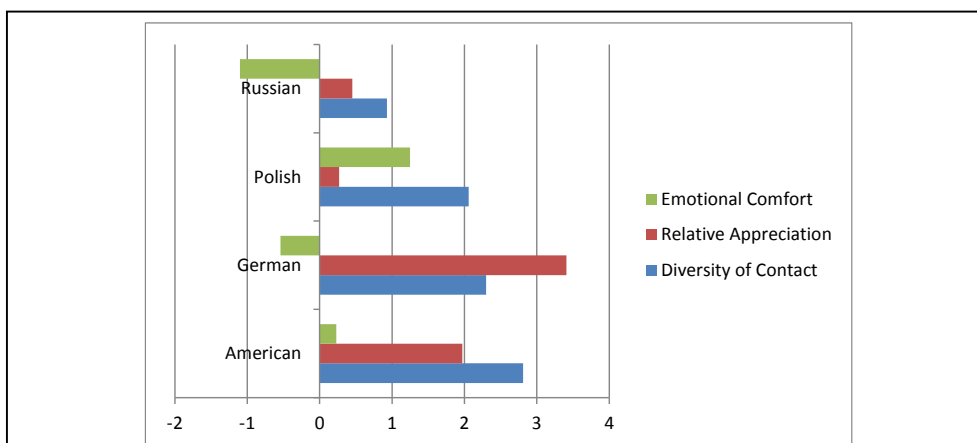
Figure 1 The impact of study abroad on cross cultural attitudes by nationality.

Question Specific	Second Language		No Second Language			
Sample Size	257		53			
	Average	Sigma	Average	Sigma	Difference	Sigma Diff
1. I would like to join an organization that emphasizes getting to know people from different countries	4.29	1.19	4.09	1.11	0.20	2.95
2. Persons with disabilities can teach me things I could not learn elsewhere	4.44	1.07	4.43	1.05	0.01	0.15
3. Getting to know someone of another culture is generally an uncomfortable experience to me	1.94	1.03	1.83	0.96	-0.11	1.89
4. I would like to go to dances that feature music from other countries	3.76	1.46	3.51	1.46	0.25	3.01
5. I can best understand someone after I get to know how he/she is both similar to and different from me	4.38	0.98	4.48	1.11	-0.10	1.68
6. I am only at ease with people of my culture.	2.35	1.20	1.96	1.01	-0.39	5.86
7. I often listen to music of other cultures	4.08	1.40	3.49	1.58	0.59	7.28
8. Knowing how a person differs from me greatly enhances our friendship	3.96	1.16	3.75	1.33	0.21	3.10
9. It's really hard for me to feel close to a person from another culture.	2.32	1.23	1.75	0.85	-0.56	8.39
10. I am interested in learning about the many cultures that have existed in this world	4.55	1.07	4.42	1.34	0.13	2.10
11. In getting to know someone, I like knowing both how he/she differs from me and is similar to me	4.42	1.02	4.29	1.11	0.13	2.20
12. It is very important that a friend agrees with me on most issues	3.47	1.32	2.94	1.35	-0.53	6.96
13. I attend events where I might get to know people from different cultural backgrounds	3.66	1.49	3.83	1.35	-0.16	1.96
14. Knowing about the different experiences of other people helps me understand my own problems better	4.39	1.22	3.98	1.31	0.41	5.79
15. I often feel irritated by persons of a different culture.	2.21	1.21	1.97	1.17	-0.24	3.44

Table 3 The impact of knowing a second language on cross cultural attitude (Query 1 having a second language and Query 2 being without a second language). Notice the consistent reduction in cross cultural issues in the emotional comfort dimension. *Note that questions for emotional comfort (#3,6,9,12,15 in green) are negative such that disagreement reflexes better cross cultural awareness and agreement reflex poorer awareness.*

Knowing a second language is another dimension to being cross culturally adept. In Table 3, the cross cultural awareness for the entire student population was determined relative to knowing a second language. Interestingly from this survey,

		Male		Female			
Sample Size		221		85			
Question Specific		**Average**	**Sigma**	**Average**	**Sigma**	**Difference**	**Sigma Diff**
1. I would like to join an organization that emphasizes getting to know people from different countries		4.13	1.13	4.60	1.19	-0.47	7.12
2. Persons with disabilities can teach me things I could not learn elsewhere		4.38	1.09	4.59	1.00	-0.21	3.47
3. Getting to know someone of another culture is generally an uncomfortable experience to me		1.97	1.00	1.74	1.04	-0.23	3.97
4. I would like to go to dances that feature music from other countries		3.49	1.44	4.29	1.37	-0.81	9.87
5. I can best understand someone after I get to know how he/she is both similar to and different from me		4.33	1.02	4.59	0.95	-0.26	4.57
6. I am only at ease with people of my culture.		2.20	1.11	2.46	1.31	0.25	3.79
7. I often listen to music of other cultures		3.83	1.41	4.34	1.48	-0.52	6.29
8. Knowing how a person differs from me greatly enhances our friendship		3.85	1.16	4.12	1.26	-0.26	3.89
9. It's really hard for me to feel close to a person from another culture.		2.11	1.04	2.45	1.48	0.34	4.96
10. I am interested in learning about the many cultures that have existed in this world		4.40	1.11	4.83	1.11	-0.43	6.82
11. In getting to know someone, I like knowing both how he/she differs from me and is similar to me		4.38	1.04	4.48	1.00	-0.11	1.82
12. It is very important that a friend agrees with me on most issues		3.28	1.32	3.58	1.37	0.29	3.84
13. I attend events where I might get to know people from different cultural backgrounds		3.65	1.38	3.74	1.66	-0.09	1.06
14. Knowing about the different experiences of other people helps me understand my own problems better		4.21	1.22	4.58	1.25	-0.38	5.34
15. I often feel irritated by persons of a different culture.		2.19	1.17	2.05	1.29	-0.15	2.14

Table 4 Cross cultural attitudes for women show a strong willingness to engage emotionally with other cultures involving music, dance, and closeness. *Note that questions for emotional comfort (#3,6,9,12,15 in green) are negative such that disagreement reflexes better cross cultural awareness and agreement reflex poorer awareness.*

having a second language improves cultural awareness behaviorally and cognitively but significantly lowers the student's emotional comfort with other cultures. This effect may be due to self-consciousness about the quality and proficiency in the foreign language and may not be indicative of a decreased attitude toward cultural awareness. Based on gender, women are more comfortable with cultural diversity particularly in the arts such as music and dance as well as a comfort in being close to people of another culture as shown in Table 4.

2.4 Comparison between National Cultures

In this portion of the paper the analysis turns to differences between national cultures: American, Polish, German and Russian. In table 5 the data for each nationality are presented for each question of the survey. In this section, the discussion centers on responses that are significantly different than the other responses.

1) Americans in general seems to be more at ease with other cultures.
2) Music seems to be particularly important to both the Polish and Russian cultures.

	American	Polish	German	Russian
1. I would like to join an organization that emphasizes getting to know people from different countries	4.46	4.09	4.12	4.34
2. Persons with disabilities can teach me things I could not learn elsewhere	4.63	4.47	4.17	4.14
3. Getting to know someone of another culture is generally an uncomfortable experience to me	1.75	1.97	2.02	2.04
4. I would like to go to dances that feature music from other countries	3.50	3.74	3.29	4.46
5. I can best understand someone after I get to know how he/she is both similar to and different from me	4.60	4.32	4.35	4.28
6. I am only at ease with people of my culture.	1.63	2.34	2.85	3.04
7. I often listen to music of other cultures	3.45	4.15	3.76	4.82
8. Knowing how a person differs from me greatly enhances our friendship	4.04	4.1	3.8	3.38
9. It's really hard for me to feel close to a person from another culture.	1.63	2.25	2.43	3.12
10. I am interested in learning about the many cultures that have existed in this world	4.48	4.41	4.31	5.06
11. In getting to know someone, I like knowing both how he/she differs from me and is similar to me	4.56	4.37	4.07	4.42
12. It is very important that a friend agrees with me on most issues	2.73	3.62	3.55	4.02
13. I attend events where I might get to know people from different cultural backgrounds	3.88	3.72	3.9	3
14. Knowing about the different experiences of other people helps me understand my own problems better	4.27	4.46	4.1	4.22
15. I often feel irritated by persons of a different culture.	1.89	2.35	2.57	1.98

Table 5 Survey data for all survey questions by nationality. *Note that questions for emotional comfort (#3,6,9,12,15 in green) are negative such that disagreement reflexes better cross cultural awareness and agreement reflex poorer awareness.*

3) Dance is of great interest to Russians
4) Americans and Russians are at two extremes very far apart regarding closeness to people of another culture. This result is surprising from the authors personal experience when in their experience the opposite it more the case.
5) Americans according to this survey seems to tolerate disagreement among friends more than the other three nationalities.
6) Americans and Russians seem to be less irritated by other cultures than the Polish and the Germans.

If the data is combined into the three subscales, the conclusions are similar:

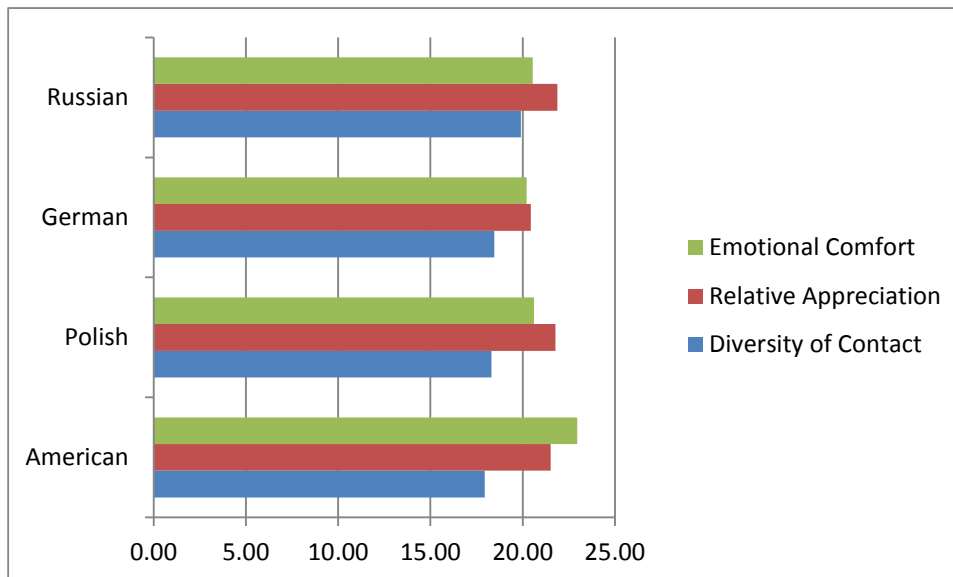1) Americans are significantly more at ease with different cultures than any of the other nationalities.

Figure 2 A comparison of American undergraduate student attitudes to attitudes from a group of global professionals.

2) Russians have the strongest behavioral openness and interest to/in other cultures with music and dance being the strongest areas while the Americans have the least interest in pursuing the aspects of other cultures.

3   CONCLUSIONS AND SUGGESTED APPROACHES

The results of this study has revealed some interesting dimensions that could be included in the cross cultural training aspects of an international capstone project.

Realizing that American students do not naturally pursue cultural aspects of different cultures, deliberate attention should be made to introduce the students to music, dance, historical events and celebrations of the particular nationality to which they are jointed in a team and vice versa. Knowledge of and an appreciation of these aspects of their mutual team members can be a means of building empathy for each other.

Since other nationalities are not as comfortable with different cultures, American can exercise a sensitivity to this issue and demonstrating patience in developing relationships.

4   ACKNOWLEDGEMENTS

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