Purdue Engineer of 2020 Seed Grant Final Report

Michael Harris, ARMS

1. Project Information

Contact Name: Brent K. Jesiek
Project Title: Assessing Engineer of 2020 Attributes through Transformative Global Experiences
Award Amount: $40,000

Abstract:

The overarching research question for this project is: How do we measure the ways in which global educational experiences prepare future engineers to be "effective in global context"? To address this question, we propose that global engineering education is best viewed in terms of its potential to provide students with transformative learning experiences can increase their global competency. Our study is organized in three parts. First, a survey based on select Engineer of 2020 target attributes was developed to elicit the views of students, faculty, and industry partners about desirable attributes for global engineering practice, as well as typical and/or desirable pathways for attaining such attributes. Second, a series of scenario-based instruments designed to assess global competency were developed and piloted with various groups of students, faculty, and industry partners. Third, the project supported transcription of more than fifty interviews with students, with the goal of better understanding how participation in global engineering programs can promote transformative learning experiences and increase global competency.

2. Project Goals

Briefly state your project goals:

1) Elicit views of Purdue University students, faculty, and industry partners about what Engineer of 2020 target attributes (from the "Abilities" and "Qualities" categories) are most important for global engineering practice, as well as desirable pathways for attaining such attributes.
2) Develop scenario-based assessment instruments that can be used to assess one or more attributes identified by stakeholder populations (students, faculty, and industry partners) as most important and/or relevant for global engineers.
3) Conduct interviews with students to better understand how participation in global engineering programs can promote transformative learning experiences and encourage attainment of attributes needed for effective practice as global engineering professionals.

Please list the project's key results to date:

1) A six-part survey instrument (see Appendix A) was developed and used to collect data from Purdue students (n=231 respondents), faculty (n=35), and industry partners (n=50). Regarding the most important attributes needed for global engineering practice, the study found relatively consistent results across the three target populations (see Appendix B). The study results also revealed that student ranked their own abilities relatively low for many attributes viewed as most important for global engineering practice (Appendix C, Figure 3). However, students reporting prior participation in a global educational experience reported higher levels of competency in many of these same areas (see Appendix C, Table 5).
2) Three new scenario-based assessment instruments (see Appendix D) were developed and piloted with hundreds of individuals in six stakeholder populations, including students, faculty, and industry partners. One of the scenarios is general in character (not limited to geographic region or target attribute), a second scenario is context-specific (focused on China), and a third

is context- and attribute-specific (focused on China, and the attributes communicate effectively, work effectively in diverse and multicultural environments, and work effectively on a team.

3) A baseline analysis of Intercultural Development Inventory (IDI) results was performed for approximately five hundred sophomore mechanical engineering students at Purdue University (Appendix E). Our results were similar to other studies of comparable student populations, including evidence of higher levels of development among female students, and relatively large gaps throughout the population between perceived and actual levels of intercultural sensitivity.
4) Interviews with more than 50 participants in a global engineering program are currently being transcribed in preparation for further data coding and analysis.

3. Project Dissemination (check any that apply)

☒ The PE2020 seed grant has resulted in new collaborations with:

Our work related to scenario-based assessment instruments is leading to new collaborations between the PI (Brent Jesiek) and Monica Cardella (Engineering Education), William Oakes (EPICS and Engineering Education), and Carla Zoltowski (EPICS).

☒ Programs created with the PE2020 seed grant have been exported to the following groups:

Scenario-based assessment instruments have been piloted in the following programs at Purdue: China Maymester (Fall 2010), GEARE Junior Year (2010-2011), and Engineering Term Abroad – SJTU (Spring 2011). The instruments have also been used in the IREE 2010 China program.

☐ Other:

4. External Dissemination

Please check any of the following that apply and provide appropriate details below.

☐ Published Papers (complete reference)

☐ Submitted Papers

☒ Conferences or Seminars

Name: 2010 International Mechanical Engineering Education Conference
Presentation Title:
Global Engineering Education from "At-Home" to Online: Maximizing Impacts via Engineering Cultures, Cybercommunities, and Effective Orientation Sessions
Date: March 27, 2010
Location: Newport Beach, CA

Name: ASEE 2010 Annual Conference and Exposition
Presentation Title:
Assessing Intercultural Competence Among Sophomore Mechanical Engineering Students: Baseline Data and Analysis
(Appendix E)
Date: June 21, 2010
Location: Louisville, KY

Name: ASEE 2010 Annual Conference and Exposition
Presentation Title:
Global Engineering Attributes and Attainment Pathways: A Study of Student Perceptions
(Appendix C)
Date: June 21, 2010
Location: Louisville, KY

☐ Website address: _____

☒ Other (explain below)

Project posters presented at Educating the Engineer of 2020 workshops in 2009 and 2010.

5. External Funding

☒ Yes, we have applied for external funding

Funding agency: National Science Foundation

Status: ☒ Awarded (x1) ☒ Pending (x2) ☐ Denied

If "Denied" do you plan to resubmit or submit elsewhere?

☐ Yes. Agency name:_____

☐ No. Reason for not resubmitting:

NOTE: Aspects of this project informed our successful proposal titled "IREE: Developing Globally Competent Engineering Researchers," NSF award #0965733. This project has also informed a follow-up proposal to NSF for an IREE 2011 program (currently under review), and a Type 2 TUES proposal (submission planned for January of 2011).

☐ No, we did not apply for external funding.

If 'No', please list reasons:

6. Assessments

Please describe any assessment you have done on your project.

None to report.

7. Future Plans

What are your future plans for your project?

1) We are now developing a journal article that will report complete results from our survey of students, faculty, and industry partners, as well as select results from one of our scenario-based assessment instruments.
2) Transcription of interview data is currently underway and will soon be followed by data coding and analysis. Findings related to transformative learning experiences will appear in future conference papers and journal articles.
3) Results from our creation and pilot of three scenario-based assessment instruments will inform a number of future conference papers and journal articles, as well as our NSF TUES proposal.

8. Lessons Learned

What recommendations would you give to others interested in your project?

1) Our survey about desirable attributes for global engineering practice may provide others with ideas and strategies for developing survey questions focused on Engineer of 2020 target attributes in the “Abilities” and “Qualities” categories (see Appendix A).
2) We have successfully identified a cluster of attributes viewed as most desirable and important for global engineering practice (Appendix B). We recommend that individuals involved with developing global experiences for engineering students should place more explicit emphasis on enhancing and measuring such attributes as they develop and refine their program offerings.
3) We have compiled tentative evidence for how global educational experiences can support student attainment of specific attributes important for global practice, e.g. work effectively in diverse and multicultural environments; synthesize engineering with business, societal, and environmental perspectives; and work effectively in the global engineering profession (see Appendix C, Table 5).
4) Our development and pilot of scenario-based assessment instruments (Appendix D) represents important steps toward new tools that can be used to systematically evaluate the global competency of engineering students, including in the context of global engineering programs.

Global Engineer of 2020 Survey

Gloabl Engineer of 2020 Survey

Information Sheet

Purpose of Research
This survey is designed to elicit student, faculty, and industry perceptions of desirable competencies for global engineers and possible pathways for attaining such competencies. This research is part of a larger project to study how global educational experiences can support attainment of select attributes specified in Purdue's Engineer of 2020 initiative.

Specific Procedures
All participants must be 18 years of age or older. During your participation in the study you will complete an online survey.

Duration of Participation
We expect you will be able to complete the survey in approximately 10-15 minutes. The survey will be available from November to December of 2009.

Benefits to the individual
You understand that there is no direct benefit to yourself for participating in this study. However, you understand that findings from this study have the potential of improving advising practices, classroom content and practices, and overall services related to supporting engineering students in making meaningful, long lasting and effective academic and career decisions.

Risks to the individual
You understand that the risks associated with participating in this study are no more than what you would encounter in your everyday life.

Compensation
You understand that all student participants will be entered into an opportunity drawing for a $25 gift certificate for a local shop or restaurant (Von's, Greyhouse, University Bookstore, etc.). The probability of winning a gift card is 1/33. If you are a winner in the drawing, you will be contacted via e-mail to collect your gift card.

Confidentiality
You understand that if you complete a survey you will automatically be assigned a unique identification number (ID#) which will be stored along with your survey data. This ID# is randomly generated and can not be used to identify you. E-mail addresses will only be collected and used for the opportunity drawing and to contact those who have indicated a willingness to participate in possible follow-up studies. Every Friday, from the date when the study begins to December 31, 2009, the survey data will be downloaded from the server and stored in password protected files on a personal computer, only accessible by the research team.The project's research records may be inspected by the Purdue University Institutional Review Board or its designees and by Purdue University to ensure that participants' rights are being protected.

Voluntary nature of participation
You understand that you do not have to participate in this research project. If you agree to participate, you can skip any question you are uncomfortable with, and you can withdraw your participation without penalty. However, once you submit the survey there is no way for your information to be removed from the data set since the research team will not be able to identify the information you provided.

Human subject statement
If you have any questions about this research project, contact Professor Brent Jesiek at (765) 496-1531. If you have concerns about the treatment of research participants, you may contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is (765) 494-5942. The email address is irb@purdue.edu

If you agree with the terms of the study and wish to complete the survey, enter your e-mail addresses in the space below.

(Again, your e-mail address will not be used to identify you, it will only be used for the opportunity drawing and follow-up communications for those who opt-in.) Otherwise, please close this page.

Please enter your e-mail address and click the arrow to continue:

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Imagine you are an engineer working for a multinational corporation that is expanding operations in both South America and Southeast Asia. You are involved in evaluating the feasibility of the expansion, including finding suitable locations and planning operations. From the following list, pick the top five (5) competencies you would most need to complete this assignment:

- [ ] apply principles of effective leadership
- [ ] engage in continuous and life-long learning
- [ ] understand and apply ethical responsibility
- [ ] communicate effectively
- [ ] work effectively in the global engineering profession
- [ ] evaluate situations to make informed decisions
- [ ] synthesize engineering with business, societal, and environmental perspectives
- [ ] work effectively in diverse and multicultural environments
- [ ] recognize and manage change in one's work context
- [ ] be creative and innovative
- [ ] work effectively on a team
- [ ] realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)
- [ ] be personally adaptable in a changing environment
- [ ] work hard and commit fully to a task
- [ ] apply concepts and principles of sustainability (environmental, economic, social)
- [ ] Other:

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By clicking and dragging, rank order the competencies you selected on the previous page from most important (1) to least important (5):

» apply principles of effective leadership

- engage in continuous and life-long learning
- understand and apply ethical responsibility
- communicate effectively
- work effectively in the global engineering profession
- evaluate situations to make informed decisions
- synthesize engineering with business, societal, and environmental perspectives
- work effectively in diverse and multicultural environments
- recognize and manage change in one's work context
- be creative and innovative
- work effectively on a team
- realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)
- be personally adaptable in a changing environment
- work hard and commit fully to a task
- apply concepts and principles of sustainability (environmental, economic, social)
- Other:

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Please rate your own ability to do each of the following:

	No Ability		Adequate Ability		High Ability
apply principles of effective leadership	○	○	○	○	○
engage in continuous and life-long learning	○	○	○	○	○
understand and apply ethical responsibility	○	○	○	○	○
communicate effectively	○	○	○	○	○
work effectively in the global engineering profession	○	○	○	○	○
evaluate situations to make informed decisions	○	○	○	○	○

	No Ability		Adequate Ability		High Ability
» synthesize engineering with business, societal, and environmental perspectives	○	○	○	○	○
» work effectively in diverse and multicultural environments	○	○	○	○	○
» recognize and manage change in one's work context	○	○	○	○	○
» be creative and innovative	○	○	○	○	○
» work effectively on a team	○	○	○	○	○
» realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)	○	○	○	○	○
» be personally adaptable in a changing environment	○	○	○	○	○
» work hard and commit fully to a task	○	○	○	○	○
» apply concepts and principles of sustainability (environmental, economic, social)	○	○	○	○	○
» Other:	○	○	○	○	○

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For each question below, please be as specific as possible and/or give examples.

How have you developed, or how would you expect to develop, your ability to **apply principles of effective leadership**?

How have you developed, or how would you expect to develop, your ability to **engage in continuous and life-long learning**?

How have you developed, or how would you expect to develop, your ability to **understand and apply ethical responsibility**?

How have you developed, or how would you expect to develop, your ability to **communicate effectively**?

How have you developed, or how would you expect to develop, your ability to **work effectively in a global engineering profession**?

How have you developed, or how would you expect to develop, your ability to **evaluate situations to make informed decisions**?

How have you developed, or how would you expect to develop, your ability to **synthesize engineering with business, societal, and environmental perspectives**?

How have you developed, or how would you expect to develop, your ability to **work effectively in diverse and multicultural environments?**

How have you developed, or how would you expect to develop, your ability to **be creative and innovative?**

How have you developed, or how would you expect to develop, your ability to **realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)**?

How have you developed, or how would you expect to develop, your ability to **work effectively on a team?**

How have you developed, or how would you expect to develop, your ability to **recognize and manage change in one's work context?**

How have you developed, or how would you expect to develop, your ability to **be personally adaptable in a changing environment**?

How have you developed, or how would you expect to develop, your ability to **work hard and commit fully to a task?**

How have you developed, or how would you expect to develop, your ability to **apply concepts and principles of sustainability (environmental, economic, social)?**

How have you developed, or how would you expect to develop, the **"Other"** competency you specified in Section 1?

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Reflecting on the learning experiences you identified in the previous section, describe the experience that would have the most significant impact on your behavior, lifestyle, beliefs,

values, and/or understanding of your self.

Demographics

Please select your status

- First Year
- Sophomore
- Junior
- Senior
- Graduate Student
- Other, Please specify:

Gender

- Male
- Female
- Prefer not to say

Are you a native English speaker?

- Yes
- No

How do you describe your ethnicity? (Pick all that apply)

- International Student
- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Multiracial
- Other:

Prefer not to say

Which of the following applies to you? (Choose all that apply)

- [ ] I am proficient in a language other than English
- [ ] I have interned/co-oped abroad (outside the US)
- [ ] I have worked in a multi-national company (in US or outside) and collaborated with co-workers abroad
- [ ] I have traveled abroad for volunteering/mission/relief work (any duration)
- [ ] I have studied abroad (less than eight weeks)
- [ ] I have studied abroad (eight weeks or more)
- [ ] I have traveled extensively on my own as a tourist
- [ ] Other global/international experiences or characteristics:

Total amount of time spent living in another culture:

- ○ Never lived in another culture
- ○ Less than 3 months
- ○ 3-6 months
- ○ 7-11 months
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ Over 10 years

Which of the following best characterizes you?

- ○ My time spent in another culture has been intermittent or of short duration
- ○ I have lived continuously in another culture for an extended period of time

Thank you for completing the Survey!

Raffle prize notifications will be sent out on or before December 31, 2009.

Would you also consider participating in a follow-up focus group and/or interview to discuss this survey? (You would receive compensation for your time.)

- ○ Yes
- ○ No

Any other comments?

Rank	Students (n=231)	Industry (n=50)	Faculty (n=35)
1	communicate effectively (185)	work effectively in diverse and multicultural environments (44)	work effectively in diverse and multicultural environment (26)
2	work effectively in diverse and multicultural environments (127)	communicate effectively (39)	communicate effectively (23)
3	evaluate situations to make informed decisions (97)	synthesize engineering with business, societal, and environmental perspectives (30)	synthesize engineering with business, societal, and environmental perspectives (20)
4	work effectively on a team (95)	evaluate situations to make informed decisions (27)	work effectively in the global engineering profession (19)
5	synthesize engineering with business, societal, and environmental perspectives (89)	work effectively on a team (27)	evaluate situations to make informed decisions (19)
6	apply principles of effective leadership (81)	be personally adaptable in a changing environment (18)	work effectively on a team (19)

This research was supported by an Engineer of 2020 grant from Purdue University's College of Engineering.

Appendix B

AC 2010-2010: GLOBAL ENGINEERING ATTRIBUTES AND ATTAINMENT PATHWAYS: A STUDY OF STUDENT PERCEPTIONS

Brent Jesiek, Purdue University

Deepika Sangam, Purdue University, West Lafayette

Juila Thompson, Purdue University

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Global Engineering Attributes and Attainment Pathways: A Study of Student Perceptions

Keywords: attainment pathways, attributes, competencies, engineer of 2020, global engineering, global engineering education, student perceptions, survey

Abstract

Many engineering schools are proactively responding to the challenges of globalization, including by enhancing their international profiles and developing global educational programs and initiatives. Some schools are placing particular emphasis on preparing engineers for practice in dynamic, global workplaces. Yet what abilities and qualities define the globally competent engineer, and what types of experiences help support attainment of such attributes? This paper reports on the results of a survey of undergraduate and graduate students at Purdue University (n=231) that was designed to elicit: a) perceptions of desirable qualities and abilities for global engineers, b) self-evaluation of abilities in each of the identified areas, and c) awareness of possible pathways for enhancing one's own competence in each of the identified areas. The survey instrument is unique in that it presents students with a realistic global engineering scenario, and then prompts them to pick the specific abilities and qualities they think would be most essential for completing the described assignment. The list of 15 attributes presented to respondents is focused on the professional and global dimensions of engineering practice, and is based on relevant attributes from Purdue University's Engineer of 2020 initiative. In addition to presenting aggregate results from the survey, we use demographic data to discuss some similarities and differences across different sub-populations. We conclude with a discussion of ongoing and future work, including similar surveys planned for faculty and industry populations.

Introduction

Many universities are encouraging global awareness, education, and citizenship among students and staff, including through cross-national research collaborations, partnerships with foreign institutions, study abroad programs, recruitment of international students and teaching staff, distance education initiatives, and international conferences and workshops.[1,2] In addition, many influential stakeholders have been urging universities to cultivate a new generation of "global engineers" who are prepared to practice effectively in an increasingly diverse, interconnected, and rapidly changing world.[3,4,5,6] ABET's EC2000 accreditation criteria, established in 1997, lends further support to this movement by requiring that graduates "understand the impact of engineering solutions in a global and societal context."[7]

Schools like Purdue University are now embracing this global agenda. For example, specific objectives noted in the university's latest strategic plan include: "expand[ing] pathways to global education," "developing successful global citizens and leaders," "prepar[ing] graduates for a dynamic global workplace," and "graduating students with global credentials."[8] The plan also calls for increasing student participation in "transformational learning opportunities," including those with global dimensions. Purdue's College of Engineering has similarly indicated that producing "graduates [who are] effective in global context" is one of its three strategic goals for

2009-2013.[9] And as discussed in more detail below, the College's Engineer of 2020 initiative features a number of target graduate attributes with an explicit global dimension.

Many kinds of strategies and programs have emerged to help prepare engineering students for global professional trajectories.[6,10-11] At Purdue, for example, the Global Engineering Program (GEP) and Global Engineering Alliance for Research and Education (GEARE) give students opportunities to study, work, volunteer, and intern abroad, and participate in multi-national design projects.[12,13] Many students receive other kinds of global education through coursework, interactions with faculty and peers, team projects, student organizations, and independent travel.

Yet even as such programs and experiences gain traction against the backdrop of ambitious global visions, challenges remain. To begin, there is the problem of scaling up. Even generous estimates suggest that only about 5% of American engineering students have a substantial global experience during their undergraduate years, while others assert that only 10-15% of U.S. engineering schools are taking global education seriously.[11,14] Persistent barriers to expanding global engineering education – ranging from financial considerations and inflexible curricula to a lack of institutional support and language issues – are well documented.[6] But even as these kinds of issues are addressed, there remain important unanswered questions about how students perceive global engineering and global engineering education, including appropriate pathways for attaining the kinds of competencies they will need to practice as global professionals.

This paper is part of a larger study designed to examine how global educational experiences can provide students with opportunities for transformative learning, thereby supporting attainment of desirable graduate attributes. Here we more specifically report on student perceptions of global engineering attributes and related educational pathways. Our primary research questions include:

- What global and professional attributes do engineering students perceive as desirable for practicing as global engineers?
- How do students evaluate their own ability for each of these attributes?
- How do students improve, or expect to improve, their ability for each of these attributes?

As further grounding for our analysis, we begin by reviewing existing literature on identifying and assessing desirable learning outcomes for global engineering education.

Literature Review

Many studies have focused on identifying competencies required for professional engineering practice, including to support the development of specific criteria and strategies for evaluating the effectiveness of various educational experiences, including degree programs. Yet few researchers have more specifically examined student perceptions of desirable graduate outcomes. Exceptions include Nguyen's examination of essential engineering skills and attributes as perceived by students (n=47) and relevant academic and industry stakeholders.[15]

There has also been a lack of systematic research to establish what specific competencies are required for global engineering practice, although numerous definitions and lists have been proposed. Patil and Codner, for instance, advocate these "essential global competencies":

- Awareness of global political and societal issues;
- Understanding of cross and multicultural issues;
- Understanding of the globalised nature of engineering education;
- Knowledge of the international labor market and workplace imperatives;
- Understanding of the international business, economy and world market;
- Competency in applying engineering solutions/applications in a global context.[16]

The authors have used surveys to identify gaps between employer perceptions of the importance of attributes as compared to their satisfaction with the actual performance of recent graduates.

In the more specific context of global engineering education, Lohmann et al. have noted a continued dearth of research on student learning, career impacts, and intercultural proficiency: "Largely absent are rigorous methods for assessing foreign language ability or competencies specifically related to professional practice within the academic discipline."[17] In response, they are working to develop a comprehensive assessment strategy for Georgia Tech's International Plan, based on four measurable facets of global competence: foreign language proficiency, comparative global knowledge, intercultural assimilation, and disciplinary practice in a global context. Their assessment instruments and strategies are still being developed, and some baseline data from their work has been reported.[18]

Ongoing efforts to study Purdue's GEARE program have similarly emphasized global competency, in part evaluated through student questionnaires, individual interviews, and focus groups.[19-20] This work has largely been based on a "three dimensional" definition for global engineering that consists of a wide array of technical, professional, and global competencies. This list of competencies was in part inspired by the NAE's Engineer of 2020 report, and later informed the list of graduate attributes developed by Purdue's Engineer of 2020 Committee.

Downey et al., on the other hand, have developed a unique scenario-based instrument to evaluate the global competency of students, which they define as the ability to work with others who define and solve problems differently, including across national, cultural, and/or disciplinary boundaries.[10] To date, however, this definition and instrument have not been embraced outside of the undergraduate elective courses developed and taught by the authors at their home institutions.

As this overview suggests, a lack of shared expectations for global educational experiences has begotten a lack of common assessment instruments and strategies. However, there are notable exceptions. For example, administrators at Purdue and many other institutions are using the Intercultural Development Inventory (IDI).[18,21,22,23] The IDI is standardized, validated, and has a long history of use, making it easy to administer and suitable for comparative research. But while IDI may allow measurement of cross-cultural sensitivity in general, this proprietary instrument is costly, not readily modifiable, and not specifically tailored to global practice in technical fields.

Hahn et al. have used multiple assessment methods, including self-reflection writing, oral presentation, and interviews, to assess learning outcomes of a project abroad program.[24] Content analysis of student self-reflection papers revealed that student comments could be mapped onto

many of the graduate attributes from Purdue's Engineer of 2020 initiative.[25] We follow Hahn et al. in avoiding *a priori* definitions of desirable outcomes for global engineering education.

We also do not make any assumptions about what educational pathways might best support attainment of such outcomes. Instead, we hope our research will help us better understand how relevant groups of stakeholders (students, faculty, and industry partners) perceive desirable graduate attributes and associated attainment pathways. The findings can then be compared and contrasted with other definitions. We will also be developing new assessment instruments and strategies that are focused on the specific attributes and outcomes identified through our research, and we hope these will be usable across multiple programs and even institutions.

Methods

Survey Instrument

This paper presents results from a mixed-methods survey instrument. The instrument was iteratively developed and refined by the five authors from June to November of 2009. Before the final version of the survey was released, it was piloted with at least one representative from each target group (undergraduate and graduate students, industry partners, faculty). The results of the pilots were used to improve the final instrument. This paper presents results only from the student version of the survey, which differs slightly from the industry and faculty versions.

Purdue's Engineer of 2020 target attributes helped drive survey development.[24] As indicated in Table 1, competency statements were generated for the indicated attributes. Some attributes were used verbatim, while others were refined to make their meanings more transparent. Because our study is specifically concerned with "global" and "professional" attributes and outcomes, we did not include any of the more technical "Knowledge Areas" in our list of competencies. However, we did include an "Other" option so respondents could add their own competencies to the list.

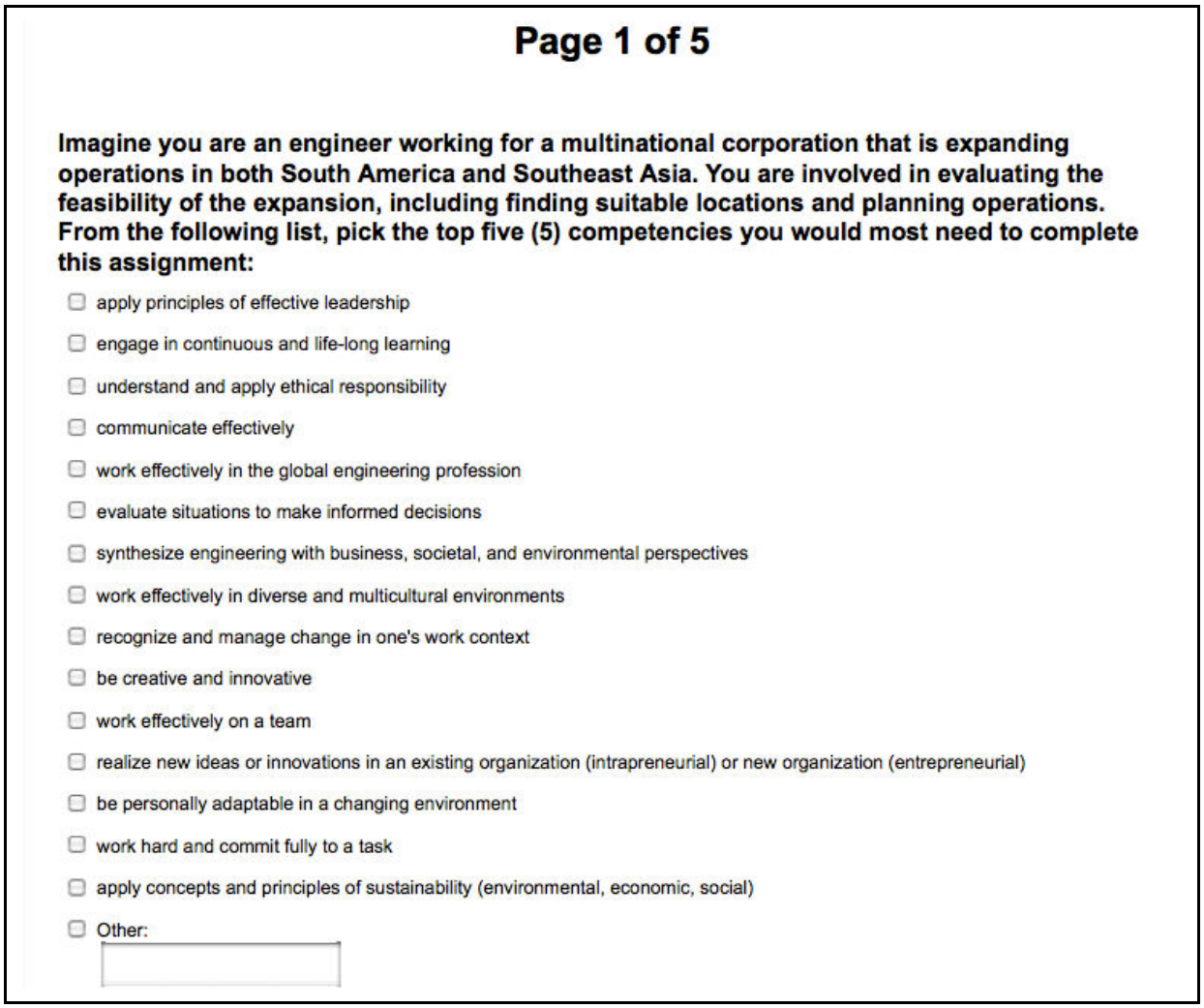
The final survey consists of six sections, and was administered online using the Qualtrics application. As indicated in Figure 1, the first section combines the statements listed above with a scenario-based question inspired by the work of Downey et al.[10] The scenario was specifically intended as a realistic engineering work situation that is generalizable across both engineering disciplines and regions.

Table 1. Purdue Engineer of 2020 Attributes and Equivalent Survey Statements

Purdue Engineer of 2020 Attribute[24]	**Equivalent Survey Statement**
Abilities	
Leadership	apply principles of effective leadership
Teamwork	work effectively on a team
Communication	communicate effectively
Decision-making	evaluate situations to make informed decisions
Recognize and manage change	recognize and manage change in one's work context
Work effectively in diverse and multicultural environments	work effectively in diverse and multicultural environments
Work effectively in the global engineering profession	work effectively in the global engineering profession
Synthesize engineering, business, and societal perspectives	synthesize engineering with business, societal, and environmental perspectives
Knowledge Areas	
Science & math	N/A
Engineering fundamentals	N/A
Analytical skills	N/A
Open-ended design and problem solving skills	N/A
Multidisciplinarity within and beyond engineering	N/A
Integration of analytical, problem solving, and design skills	N/A
Qualities	
Innovative	be creative and innovative
Strong work ethic	work hard and commit fully to a task
Ethically responsible in a global, social, intellectual, and technological context	understand and apply ethical responsibility
Adaptable in a changing environment	be personally adaptable in a changing environment
Entrepreneurial and intrapreneurial	realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)
Curious and persistent learners	engage in continuous and lifelong learning
Other (not featured in original list of Engineer of 2020 attributes)	
N/A	Apply concepts and principles of sustainability (environmental, economic, social)*
N/A	Other

* Sustainability was not among the original list of attributes developed by Purdue's Engineer of 2020 committee. However, it has been featured prominently in a number of related events and publications.

Figure 1. Survey Section 1 – Global Engineering Scenario and Competencies



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Imagine you are an engineer working for a multinational corporation that is expanding operations in both South America and Southeast Asia. You are involved in evaluating the feasibility of the expansion, including finding suitable locations and planning operations. From the following list, pick the top five (5) competencies you would most need to complete this assignment:

- ☐ apply principles of effective leadership
- ☐ engage in continuous and life-long learning
- ☐ understand and apply ethical responsibility
- ☐ communicate effectively
- ☐ work effectively in the global engineering profession
- ☐ evaluate situations to make informed decisions
- ☐ synthesize engineering with business, societal, and environmental perspectives
- ☐ work effectively in diverse and multicultural environments
- ☐ recognize and manage change in one's work context
- ☐ be creative and innovative
- ☐ work effectively on a team
- ☐ realize new ideas or innovations in an existing organization (intrapreneurial) or new organization (entrepreneurial)
- ☐ be personally adaptable in a changing environment
- ☐ work hard and commit fully to a task
- ☐ apply concepts and principles of sustainability (environmental, economic, social)
- ☐ Other:

Table 2 provides sample questions for the other major survey sections. In Section 2, respondents were asked to rank order the relative importance of the five competencies selected in Section 1. In Section 3, respondents ranked their own ability for each of the selected competencies, and in Section 4 they were asked to describe how they had developed, or would expect to develop, each of the five selected competencies. Section 5 was designed to elicit respondent understandings of transformative learning experiences. A final section of the survey collected relevant demographic information (e.g. educational level, age, ethnicity, global characteristics and experiences, etc.). A question related to amount of time spent living in another culture was adapted from the IDI instrument. This paper mainly reports results from Sections 1-4 of the survey.

Table 2. Overview of Survey Instrument Sections 2-5

Section 2 – *Rank order all five (5) of the selected competencies*

By clicking and dragging, rank order the competencies you selected on the previous page from most important (1) to least important (5):

Section 3 – *Self-assess own ability for each selected competency*

Please rate your own ability to do each of the following:

	No Ability		Adequate Ability		High Ability
» apply principles of effective leadership	○	○	○	○	○

Section 4 – *Describe possible attainment pathways for each selected competency*

How have you developed, or how would you expect to develop, your ability to **apply principles of effective leadership**?

Section 5 – *Reflect on transformative learning experiences*

Reflecting on the learning experiences you identified in the previous section, describe the experience that would have the most significant impact on your behavior, lifestyle, beliefs, values, and/or understanding of your self.

Participant Characteristics

Our target population for this survey was students enrolled at all levels (first year through graduate) in Purdue University's College of Engineering. To obtain data from students with a wide range of global experience (from minimal to extensive), the survey was promoted heavily among students affiliated with various global programs (e.g. study abroad, GEARE, GEP, etc.). The study received appropriate human subjects clearance (Purdue IRB approval #0911008658).

Table 3. General Demographic Characteristics of Study Survey Respondents, n=231

Level		Gender		English Language		Ethnicity/Culture*	
23	First year	160	Male	179	Native Speaker	33	International Student
72	Sophomore	68	Female	50	Non-Native Speaker		
41	Junior	3	Not Specified	2	Not Specified	1	Native American
69	Senior					42	Asian
23	Graduate					3	African American
1	Postdoc					8	Hispanic/Latino
2	Not Specified					158	White/Caucasian
						2	Multiracial
						9	Not Specified

* Ethnicity/Culture does not total 231 because respondents could pick multiple categories.

From December 2-23, 2009 we received 278 survey responses, with 231 usable in whole or part (e.g. mostly complete, but some questions with partial or missing responses). General participant characteristics are summarized in Table 3. A reasonably diverse demographic was obtained, including in terms of student level, gender, native language, and ethnicity/culture. The top three departments represented in our respondent pool were Mechanical Engineering (94 responses), Electrical and Computer Engineering (50 responses), and First-Year Engineering (32 responses). The high response rates in these units were likely due to our targeted promotional efforts.

Table 4. Global/International Characteristics of Survey Respondents, n=231

Global/international characteristic (select all that apply)		Total amount of time spent living in another culture	
103	I am proficient in a language other than English	89	Never
24	I have interned/co-oped abroad (outside the US)	53	Less than 3 months
54	I have worked in a multi-national company (in US or outside) and collaborated with co-workers abroad	15	3-6 months
		11	7-11 months
36	I have traveled abroad for volunteering/mission/relief work (any duration)	12	1-2 years
		21	3-5 years
42	I have studied abroad (less than eight weeks)	7	6-10 years
46	I have studied abroad (eight weeks or more)	21	Over 10 years
79	I have traveled extensively on my own as a tourist	2	Not Specified
26	Other global/international experiences or characteristic		

Table 4 summarizes the global/international characteristics reported by survey respondents. Again, this information indicates a reasonably diverse sample, with significant numbers of respondents having anywhere from very minimal to very extensive experience living and

working across countries and cultures. In future analysis we intend to group respondents into a smaller number of discrete clusters or levels of global/international experience.

Data Analysis

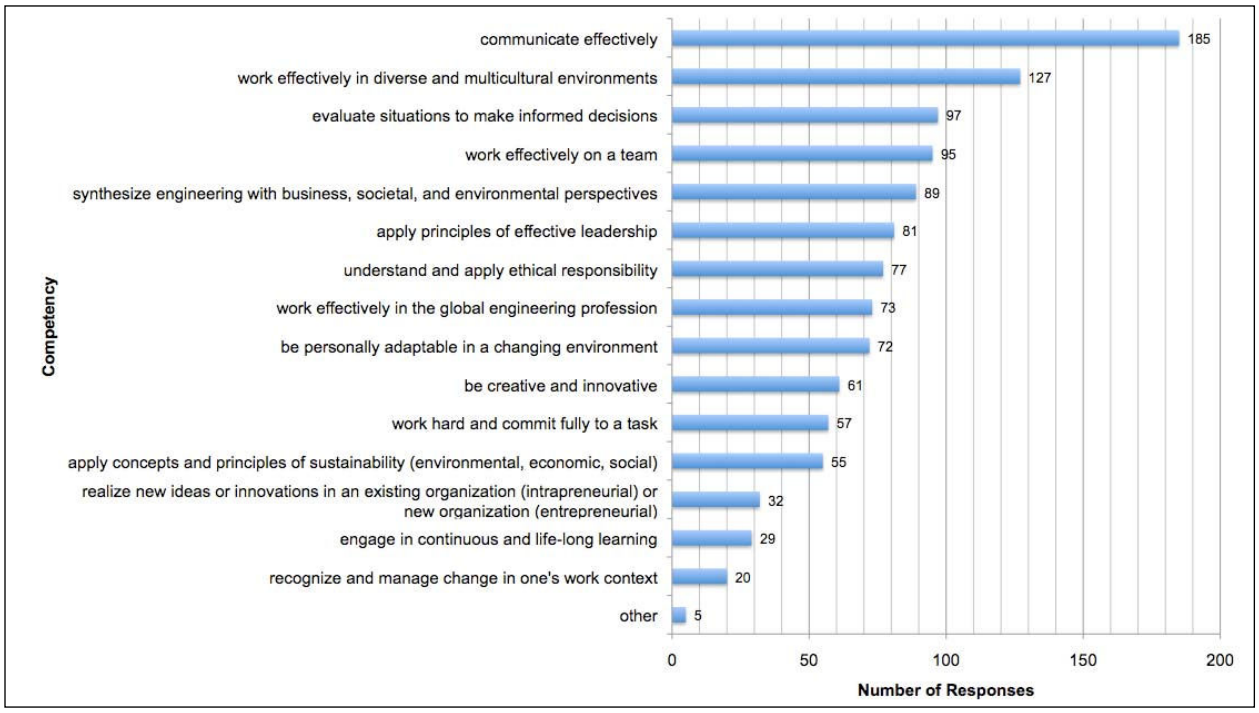
All data was exported from the Qualtrics survey application in CSV format, then imported into Microsoft Excel for preliminary analysis. Some simple results verification was performed by comparing tabulations of data in Qualtrics and Excel. The lead author used an open coding procedure to perform preliminary analysis of qualitative responses from survey Section 4.[26]

Findings

Global Engineering Competencies

As noted above, the first survey section asked respondents to select the five competencies most needed for the hypothetical global engineering scenario. As indicated in Figure 2, by far the most common competencies selected by respondents were *communicate effectively* (selected by 185 of 231 or 80% of respondents) and *work effectively in diverse and multicultural environments* (selected by 127 of 231 or 55% of respondents). *Decision-making*, *teamwork*, and *synthesis of engineering with business, societal and environmental perspectives* were respectively ranked third, fourth, and fifth. Leadership and ethics were respectively ranked sixth and seventh.

Figure 2. Number of Responses by Competency



Interestingly, *work effectively in the global engineering profession* was ranked eighth. Based on observations from our survey pilots, we hypothesize that many respondents favored specific statements over broader or more ambiguous alternatives. It is also notable that only five

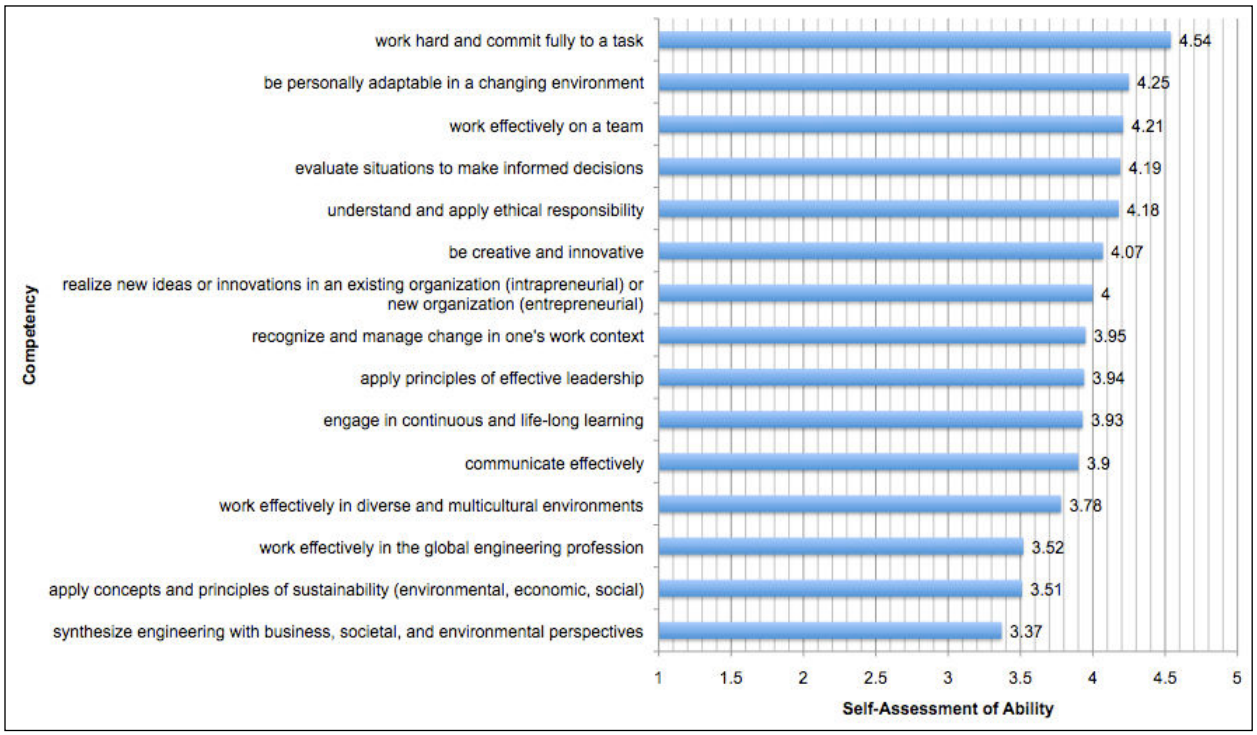
respondents utilized the *Other* option. Responses for those who selected *Other* included "all of the above" and "achieve at least basic foreign language competence." Two additional responses discussed economic or cost analysis. It is notable that no students identified technical knowledge or skills in their responses. While the given competencies implicitly suggested that the survey was focused on global and professional attributes, we hypothesize that many respondents assumed an engineer in this kind of global scenario would have appropriate technical skills.

Student Self Evaluation of Abilities

For each of the five competencies they selected, respondents were asked to rate their own ability on a five-point scale, from no ability (1) to adequate ability (3) to high ability (5). Overall, self-assessment ratings were high, with an average across all competencies of 3.95. In summary, students evaluated their abilities highest in the areas of *work ethic* (4.54 out of 5), *personally adaptive* (4.25), *teamwork* (4.21), *decision-making* (4.19), and *ethical responsibility* (4.18).

Respondents ranked themselves lower in a number of areas that were perceived as important for the practice of global engineering. Most notably, the lowest ranking attributes were *global engineering* (3.52), *sustainability* (3.51), and *synthesize engineering with business, societal, and environmental perspectives* (3.37). Respectively ranked eleventh and twelfth, the competencies *work effectively in diverse and multicultural environments* and *communicate effectively* were also identified as relatively weaker area across the entire survey population.

Figure 3. Self Evaluation of Ability by Competency



It is especially striking that three of the top five competencies that respondents identified as important (*communicate effectively*, *work effectively in diverse and multicultural environments*,

and *synthesize engineering with business, societal, and environmental perspectives*) were among the lowest five competencies in terms of self-evaluation of abilities. These findings tentatively suggest gaps between student perceptions of desirable competencies for global engineering as compared to their own levels of confidence and ability in many of these same areas.

Demographic information allows further comparative analysis of results. For instance, we found no significant difference in self-assessment ratings by gender. Across educational levels, ratings were slightly lower than average (3.875) for sophomores, near average for first year, junior year, and graduate students, and slightly above average for seniors (4.04). Ratings were also slightly higher for students who had spent some amount of time living in another culture.

Table 5. Self-evaluation of Competency With and Without Intern/Study Abroad

	No Intern and/or Study Abroad		**Intern and/or Study Abroad**	
Competency (overall rank)	**n**	**Average Self-Evaluation**	**n**	**Average Self-Evaluation**
communicate effectively (1)	143	3.89	42	3.95
work effectively in diverse and multicultural environments (2)	92	3.61	34	4.28 ($p < 0.001$)
evaluate situations to make informed decisions (3)	77	4.13	20	4.40
work effectively on a team (4)	72	4.22	23	4.17
synthesize engineering with business, societal, environmental perspectives (5)	68	3.25	21	3.76 ($p < 0.05$)
work effectively in the global engineering profession (8)	57	3.37	16	4.07 ($p < 0.05$)

Perhaps most suggestive, respondents who studied abroad (eight weeks or more) and/or interned abroad evaluated their own abilities higher for many of the competencies frequently associated with global engineering. Statistically significant differences are indicated as shaded rows in Table 5. These results suggest that intern and/or study abroad experiences improve student confidence in many areas of ability frequently associated with global engineering practice. However, there were no statistically significant differences between the two groups in the competency areas of *communication skills*, *decision-making*, and *teamwork*. As we note below, one possible explanation for this trend is that most students do not readily identify intern or study abroad experiences as necessary pathways for attainment of these two competencies. "Domestic" coursework and work experiences may adequately support development of these abilities, resulting in similar self-evaluations for both of these groups.

Competency Definitions and Attainment Pathways: Communicate Effectively

Qualitative responses from Section 4 of the survey help show how respondents understand: a) the scope and definition of each competency, including related skills they view as important, and b)

possible pathways for developing each competency. For this preliminary analysis we focus on *communicate effectively* since respondents selected it most often as an important attribute.

As summarized in Table 6, presentation skills and public speaking were frequently mentioned by respondents when asked how they had improved, or would expect to improve, their ability to *communicate effectively*. Diversity/multicultural skills and language skills were also noted often, sometimes with direct reference to the global engineering scenario presented in the first part of the survey. Various aspects of writing – including technical communication, memo and e-mail writing, etc. – were mentioned 16 times. Six respondents referenced listening skills and just one explained that reading skills were important. These results help reveal the perceived breadth of this particular competency area. In fact, many responses mentioned multiple skills.

Table 6. Definitions and Attainment Pathways for *Communicate Effectively*

Definitions	*Attainment Pathways*
34 Presentations, Public Speaking	56 Coursework
18 Diversity/Multicultural Skills	42 Teamwork
16 Writing	40 Experience/Practice
13 Language Skills	35 Work
6 Listening	16 Projects
1 Reading	8 Extracurricular
	4 Informal Social Interactions
	3 Teaching/Tutoring
	3 Interviewing for Jobs
	2 Leadership Roles
	1 Study Abroad

A total of 40 individuals indicated that practice and/or experience (in general) had improved or could improve competency in this area, e.g. “I have developed my communication skills through practice and real world experiences.” While such statements may seem obvious and perhaps even circular, they nonetheless reveal a widespread perception that communication skills are not innate, and can be enhanced through practice and experience.

Among those who identified specific pathways for improving this competency, 56 discussed coursework. Of these, 19 referred to coursework in general, while 27 discussed classes outside of engineering (in communication, English, foreign languages, etc.) and 10 referenced engineering courses. Many individuals identified teamwork (42 responses) and project-related activities (16 responses) as providing opportunities to improve communication skills. Of those who discussed work-related contexts, 26 respondents discussed work in general while 9 referred specifically to co-ops or internships. Surprisingly, only one respondent mentioned study abroad as a possible pathway for improving communication skills. Again, this may suggest that students perceive “domestic” educational and work settings as suitable contexts for improving communication skills. As noted above, participation in study or internship abroad had little impact on how respondents evaluated their own communication skills.

Discussion and Conclusions

Our findings show that many engineering students perceive "generic" or "transferable" competencies like *communication*, *teamwork*, and *decision-making* as most important for global practice. They also frequently identified as important some more specialized competencies, such as *work effectively in diverse and multicultural environments* and *synthesize engineering with business, societal, and environmental perspectives*. Our results reinforce the idea that "global competency" might best be defined as a cluster of global and professional skills, some of which might shift in importance depending on the particular context or scenario of practice.

We also observe that many students rated their own abilities relatively low in some of the areas most often associated with global competence, which suggests they are not especially well-prepared for global practice. However, intern and study abroad experiences appear to have an overall positive impact on student self perceptions of confidence in a number of important competency areas, including *work effectively in diverse and multicultural environments*, *synthesize engineering with business, societal, and environmental perspectives*, and *work effectively in the global engineering profession*.

It is notable that respondents were not especially confident in their ability to *communicate effectively,* despite this being a top-ranked attribute. Further, few students saw study abroad as a pathway for improving this competency, and participation in intern or study abroad was not correlated with higher confidence in one's communication skills. Large numbers of respondents identified courses and work experiences as typical pathways to improved communication skills.

Teamwork is another area worth highlighting, especially since it was both ranked highly as a global engineering attribute and evaluated highly in terms of student ability. We propose that the pervasiveness of teamwork within and beyond engineering education has both reinforced the importance of this concept and enhanced the ability of students to work on teams. Interestingly, our results also show an interdependence of communication and teamwork skills, with large numbers of respondents identifying group interactions or projects as providing opportunities for enhancing communication skills. Many respondents also linked communication to diversity.

We acknowledge the limitations of our results, including some skewed demographics in our respondent pool and a potential lack of reliability in having participants rate their own abilities in select areas. We are also aware that our efforts are to some extent limited by the specific statements presented in this survey, including competency statements that are very broad and/or open to wide interpretation (e.g. *work effectively in the global engineering profession*).

Nonetheless, we feel our results are suggestive of aggregate trends and can be used to make a number of broad comparisons (e.g. contrasting lowest and highest ranking competencies). In future work we intend to analyze and report findings on attainment pathways for more of the competency areas, which will help us better understand how respondents are understanding and interpreting their scope and definition. We are also now using a similar survey to collect data from faculty members and industry partners, which will allow comparisons across all three stakeholder populations.

Acknowledgements

The authors gratefully acknowledge support for this research through an Engineer of 2020 seed grant from Purdue University's College of Engineering. We also extend thanks to all survey respondents, as well as those students who piloted early versions of the survey.

References

[1] Knight, J. An Internationalization Model: Responding to New Realities and Challenges. In de Wit, H., Jaramillo, C., Gacel-Ávila, J., and Knight, J. (Eds.). Higher Education in Latin America, 1-38. Washington, DC: The World Bank. 2005.

[2] Stromquist, N. P. Internationalization as a Response to Globalization: Radical Shifts in University Environments. Higher Education. 2007. 53(1): 81-105.

[3] Boeing Company, The. 1997. A Manifesto for Global Engineering Education: Summary of the Engineering Futures Conference. Seattle, WA: The Boeing Company.

[4] Wulf, W. 2003 Annual Meeting - President's Remarks. 2003. Available at http://www.nae.edu/News/SpeechesandRemarks/page2003AnnualMeeting-PresidentsRemarks.aspx (Accessed January 8, 2010).

[5] Katehi, L. The Global Engineer. In Educating the Engineer of 2020: Adapting Engineering Education to the New Century (151-155). Washington, DC: The National Academies Press. 2005.

[6] Grandin, J. M., and Hirleman. E. D. Educating Engineers as Global Citizens: A Call for Action / A Report of the National Summit Meeting on the Globalization of Engineering Education. Online Journal of Global Engineering Education. 2009. 4(1): 10-25. Available at http://digitalcommons.uri.edu/ojgee/vol4/iss1/1/ (Accessed November 23, 2009).

[7] Besterfield-Sacre, M.E., Shuman, L. J., Wolfe, H., Atman, C. J., McGourty, J., Miller, R. L., Olds, B. M., and Rogers, G. M. Defining the Outcomes: A Framework for EC 2000. IEEE Transactions on Engineering Education. April 2000. 43(2): 100-110.

[8] Purdue University. New synergies: Purdue University's Strategic Plan. West Lafayette, IN: Purdue University. 2008. Available at http://www.purdue.edu/strategic_plan/documents/StrategicPlanBrochure.pdf (Accessed January 8, 2010).

[9] College of Engineering, Purdue University. Purdue Engineering Strategic Plan: 2009-2014. West Lafayette, IN: Purdue University. 2009. Available at https://engineering.purdue.edu/Engr/AboutUs/StrategicPlan/2009-2014/StratPlan-2009-10-20.pdf (Accessed January 8, 2010).

[10] Downey, G., Lucena, J., Moskal, B., Parkhurst, R., Bigley, T., Hays, C., Jesiek, B., Kelly, L., Miller, J., Ruff, S., Lehr, J. and Nichols-Belo, A. The Globally Competent Engineer: Working Effectively With People Who Define Problems Differently. Journal of Engineering Education. 2006. 95(2): 1-16.

[11] Parkinson, A. Engineering Study Abroad Programs: Formats, Challenges, Best Practices. Global Journal of Engineering Education. 2007. 2(2): 1-15.

[12] Groll, E. and Hirleman, E. D. Undergraduate GEARE Program: Purdue University's School of ME Contribution to Educating Globally Sensitive and Competent Engineers. Paper presented at the 6th ASEE Global Colloquium. October 1-4, 2007. Istanbul, Turkey.

[13] Hirleman, E. D., Groll, E., and Atkinson, D. The Three Axes of Engineering Education. Paper presented at the International Conference on Engineering Education – ICEE 2007. September 3-7, 2007. Coimbra, Portugal.
[14] Bremer, D. Engineering the World. The Online Journal of Global Engineering Education. 2008. 3(2): 13-18.
[15] Nguyen, D. The Essential Skills and Attributes of an Engineer: A Comparative Study of Academics, Industry Personnel and Engineering Students. Global Journal of Engineering Education. 1998. 2(1): 65-75.
[16] Patil, A., Nair, S. N., and Codner, G. Global Accreditation for the Global Engineering Attributes: A Way Forward. Paper presented at the Australasian Association for Engineering Education (AAEE) Annual Conference 2008. December 7-10, 2008. Yeppoon, Australia.
[17] Lohmann, J., H. Rollins, Jr., and Hoey, J. Defining, Developing, and Assessing Global Competence in Engineers. European Journal of Engineering Education. 2006. 31(1): 119-131.
[18] Lohmann, J., Gordon, J., Harwell, K., McLaughlin, S., and Paraska, S. Annual Impact Report of the Quality Enhancement Plan on Student Learning: Strengthening the Global Competence and Research Experiences of Undergraduate Students. Atlanta, Georgia: Georgia Institute of Technology. 2008. Available at http://www.assessment.gatech.edu/legacy/SACS/QEP/QEP%20(SACS)%20Annual%20Impact%20Report%202007-2008%20FINAL%20WEB.pdf (Accessed January 8, 2010).
[19] Allert, B., and Atkinson, D. Work in Progress – Identifying Learning Outcomes of a Multi-Semester International Program in Mechanical Engineering. In Proceedings of the 35th ASEE/IEEE Frontiers in Education Conference, Session S1D. October 19 – 22, 2005, Indianapolis, IN.
[20] Allert, B., Atkinson, D., Groll, E., and Hirleman, E. D. Making the Case for Global Engineering: Building Foreign Language Collaborations for Designing, Implementing, and Assessing Programs. Global Journal of Engineering Education. 2007. 2(2).
[21] Demetry, C. Work in Progress – Development of Intercultural Sensitivity from Study Abroad Programs. In Proceedings of the 37th ASEE/IEEE Frontiers in Education Conference. October 10-13, 2007. Milwaukee, WI.
[22] Mayhew, M., Eljamal, M., Dey, E., and Pang, W. Outcomes Assessment in International Engineering Education: Creating a System to Measure Intercultural Development. In Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition. June 12-15, 2005. Portland, OR.
[23] Widmann, J., and Vanasupa, L. Work in Progress - Attaining and Measuring Global Competency for Engineering Graduates. In Proceedings of the 38 ASEE/IEEE Frontiers in Education Conference. October 22 – 25, 2008. Saratoga Springs, NY.
[24] Hahn, L., and Hansen, A. Learning Outcomes Assessment of a Project-Abroad program in South Africa: Toward "A Better Engineer in the Real World. Paper presented at the ASEE Annual Conference & Exposition. June 14-17, 2009. Austin, TX.
[25] Jones, J., Meckl, P., Harris, M., et al. Purdue's Engineer of 2020: The Journey. Paper presented at the ASEE Annual Conference & Exposition. June 14-17, 2009. Austin, TX.
[26] Strauss, A., and Corbin, J. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory (2nd ed.). Thousand Oaks: SAGE. 1998.

Global Competency Activity

Scenario: Imagine you are an engineer working for a multinational corporation that is expanding operations in both South America and Southeast Asia. You are involved in evaluating the feasibility of the expansion, including finding suitable locations and planning operations. How prepared are you to enter this work situation? What knowledge and capabilities do you have and what do you lack?

Task: List and briefly describe five (5) competencies (knowledge, skills, and/or attitudes) you think would be most needed to complete this work assignment.

1)

2)

3)

4)

5)

Global Competency Evaluation

Last four digits of your cell phone number: _____ (only used for tracking survey data/results)

Scenario 1: As an American engineer, you have been invited to General Electric's China Technology Center in Shanghai to help develop prototypes for a new medical imaging device. Your team includes engineers from GE's Research Centers in Shanghai, Beijing, and New York (USA). How prepared are you to enter this work situation? What knowledge and capabilities do you have and what do you lack?

Global Competency Evaluation

Last four digits of your cell phone number: _____ (only used for tracking survey data/results)

Scenario 2: As an employee in a large multinational corporation, you are temporarily assigned to your company's branch operations in Shanghai, China. Your work team consists of three Chinese engineers, all at about the same rank as you. Your team reports to an engineering manager, who is also Chinese. In a recent team meeting, your manager proposed a solution to a difficult quality control problem. However, you feel you have a much better solution to the problem. How would you deal with this situation?

AC 2010-873: ASSESSING INTERCULTURAL COMPETENCE AMONG SOPHOMORE MECHANICAL ENGINEERING STUDENTS: BASELINE DATA AND ANALYSIS

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Assessing the Intercultural Competence of Sophomore Mechanical Engineering Students: Baseline Data and Analysis

Keywords: IDI, intercultural development, global competency, global engineering education, mechanical engineering, sophomores

Abstract

This paper presents baseline analysis of Intercultural Development Inventory (IDI) results for approximately five hundred sophomore mechanical engineering students at Purdue University. The IDI is a statistically reliable and cross-culturally valid measure of an individual's actual and perceived intercultural development. This instrument is being used by Purdue's School of Mechanical Engineering, particularly to assess students who are involved in global educational programs such as Global Engineering Alliance for Research and Education (GEARE). In this paper we examine IDI results for Purdue sophomore mechanical engineering students, including comparisons based on gender, amount of time spent living abroad, and whether or not they later participated in GEARE. We intend that our results will provide valuable baseline data for sophomore mechanical engineering students, thereby paving the way for cross-institutional comparisons, and enhancing the ability of university staff to design courses and experiences for students that match their current levels of intercultural sensitivity. We conclude with suggestions for further research and analysis, such as collecting and analyzing post-experience IDI data for students who have participated in global educational experiences.

Introduction

Given dramatically changing technologies and increasingly globalized markets, leading stakeholders have declared that "it is imperative that all engineering students develop the skills and attitudes necessary to interact successfully with people from other cultural and national environment."[1] Universities throughout the world are now establishing curricula and programs to help prepare students for this new reality. One common avenue for this preparation is giving students the opportunity to study and/or work abroad. In the United States, it is now estimated that up to 7.5% of engineering students spend time abroad during their undergraduate studies and many schools have made commitments to increase this number.[2]

Purdue University is no different in this regard. In 2001, Purdue's School of Mechanical Engineering launched Global Engineering Alliance for Research and Education (GEARE).[3] This program involves collaboration between Purdue and the University of Karlsruhe in Germany, Shanghai Jiao Tong University in China, IIT Bombay in India, and Monterrey Tech in Mexico. Participating students study and intern abroad, and work on team projects with students at partner schools. Yet as programs like GEARE develop and mature, questions remain about what specific skills and competencies participating students can and should develop. There is also the issue of finding the most appropriate and effectives assessment mechanisms, to insure students are achieving these outcomes.

One of the more common anticipated outcomes for global engineering education is enhanced intercultural sensitivity and skills. One assessment mechanism often used to examine this

competency is the Intercultural Development Inventory (IDI). To date, however, little data has been published on IDI results from engineering student populations, including engineering students who participate in global programs.

For a number of years, Purdue's School of Mechanical Engineering has been collecting IDI data from sophomore-level mechanical engineering students, as well as post-experiential data from GEARE participants. In this paper we present aggregate IDI results for the sophomore student population. Our hope is that this data can provide a baseline that can be generally compared with results from other schools, and more specifically used to examine how global experiences impact the intercultural development of engineering students.

Literature Review

Many U.S. universities have established a global focus within engineering coursework and use the IDI as a tool to measure intercultural development and sensitivity, including John Brown University and Georgia Tech. John Brown, for example, offers a freshman course that introduces students to global issues. Using IDI, Bland assessed students taking this course to get a general sense of who the students were and where they stood coming into the engineering program.[4] After organizing the results based on different levels of intercultural development, he found there was a large gap between the perceived and actual intercultural sensitivity of students in this population, though the actual numbers of students and detailed results were not published.

Georgia Tech has created a degree designation called the International Plan (IP) that prepares students for a global work environment. The university is collecting large amounts of relevant evaluation data, including to examine the intercultural development of students in the program based on various demographic and other variables. To date, the school has reported IDI data from 3,781 incoming students.[5] In their baseline results, they found that intercultural sensitivity was generally higher among women as compared to men. In addition, intercultural sensitivity was notably higher among men who opted to enter the International Plan, but for women there was less variation between the IP and non-IP subgroups.

The Georgetown Consortium study, on the other hand, looked at 1,300 students in 61 different programs to determine what specific aspects of a student experiences abroad helped develop their intercultural sensitivity, with particular emphasis on examining how students develop culturally when either a program is designed to cultivate cultural integration or students are allowed to create their own experience.[6] This study used two approaches for assessing students, namely IDI and Simulated Oral Proficiency Interview, which is another validated and widely used instrument. There were three main conclusions drawn from the IDI portion of this study. First, women on average had higher cultural sensitivities as compared to their male counterparts. Second, planned study abroad experiences resulted in higher gains, especially when they involved features such as host families and/or cultural mentors. And third, the length of the duration effected sensitivity gains, with the optimal period being 13-18 weeks.

While not used as widely as IDI, others have proposed other strategies and instruments to evaluate the cultural development and intercultural skills of engineering students. For example, Del Vitto proposes assessing the attainment of "cultural intelligence" among participants in

global engineering education using instruments such as the Cross-Cultural Adaptability Inventory (CCAI) or Global Awareness Profile (GAP) test.[7] Bielefeldt, on the other hand, has used the Miville-Guzman Universality-Diversity Scale short form (MGUDS-S) to examine cultural competence in a variety of engineering student populations.[8]

Downey et al., by contrast, have defined global competency as being able to work with others who define and solve problems differently, including across national and culture boundaries.[9] To evaluate attainment of this competency, they developed a scenario-based writing exercise to gauge student awareness of how engineering cultures and identities differ across countries. Their approach is unique because of its emphasis on evaluating intercultural knowledge and skills in the context of global engineering practice. They also reported statistically significant increases in student performance on this exercise when it was administered before and after Engineering Cultures, an undergraduate elective course designed to enhance students' global competency.

Methods

Participants

For the present study, the IDI was given to sophomore mechanical engineering students enrolled in a technical writing course, Mechanical Engineering 290 (ME290). A small number of juniors and seniors were also in the course due to timing constraints in their sophomore year. In total, 527 tests were given to students, but 27 were not complete, leaving n=500 total valid responses. Complete demographic information was collected for n=138 respondents. The semesters that were included were Spring 2007 (n=80), Fall 2007 (n=138), Fall 2008 (n=140), GEARE Spring 2008 (n=13), and Spring 2009 (n=129). Thirteen valid respondents were identified as students who later participated in the GEARE program. All data was collected under Purdue IRB #0503001816.

Instrument

The IDI consists of 50 questions that assess an individual's intercultural sensitivity. The measured level of sensitivity is based on Bennett's Development Model of Intercultural Sensitivity (DMIS), where an individual is presumed to go through six world views while establishing cultural sensitivity, namely: denial, defense/reversal, minimization, acceptance, adaption, and integration.[10] The instrument measures perceived intercultural sensitivity, as well as "actual" intercultural sensitivity. The tool has been rigorously tested and proven valid.[11]

Figure 1. Stages of Intercultural Sensitivity and Associated Survey Scales

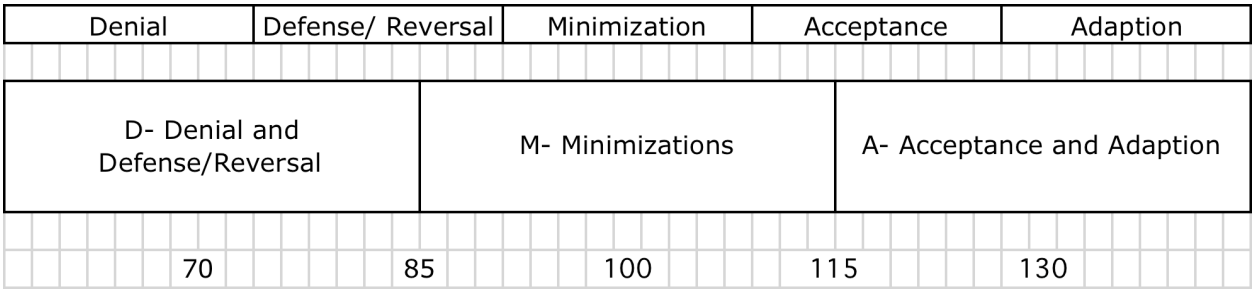


Figure 1 shows the five different levels (excluding integration, the penultimate level) of cultural sensitivity, along with the three corresponding subcategories of the IDI instrument. The fist category, Denial and Defense/reversal (D), includes all of the scores showing that respondents are either in denial or defense/reversal. A common thought process of an individual in this level is that that one culture is better than another, whether it be an individual's own culture or another culture. The second category, Minimization (M), encompasses a fraction of defense/reversal, all of minimization, and part of the acceptance scale. A common outlook of individuals in this category is to feel that people are pretty much the same everywhere. The third category, Acceptance and Adaptation (A), comprises the majority of the acceptance level and all of the adaption level. Individuals falling in this category understand cultural differences and are more likely to adapt their behaviors accordingly in various cultural environments.

Data Analysis

To find the IDI scores for each respondent, the IDI software, Version 2, was used. This Microsoft Access add-on takes raw survey data and uses it to generate reports detailing individual and/or group results. All results were then exported to Microsoft Excel 2007, which was used to examine different populations of students, such as by cohort, gender, etc.

Findings and Interpretations

Figures 2 and 3 show average perceived and average actual cultural sensitivity values for all subpopulations and populations. Gender was not specified for 28 respondents. Certain trends appeared within the data set that are worth examining in greater detail. First, average perceived and average actual sensitivities within the largest collection groups have remained very consistent and stable for each class, which suggests the results are generally precise and repeatable within this particular population.

Another trend to note is that students who later participate in GEARE have been coming into the program with higher levels of sensitivity (average perceived of 120.7 and average actual of 91.5 as compared to 117.5 and 85.1 for the non-GEARE population). Yet due to the small size of this subgroup, the results are not statistically significant. Nonetheless, this finding generally agrees with Georgia Tech's data, which showed similar correlations, especially among male students. These findings suggest higher levels of cultural sensitivity as a possible self-selection factor among GEARE participations. However, additional research is needed, especially with larger populations, to verify this hypothesis. We also observe that female respondents have statistically

significant higher sensitivity scores ($p < 0.005$) as compared to their male counterparts (average actual sensitivity of 89.7 for females as compared to 84.4 for men). These findings are similar to Georgia Tech's findings and are in agreement to other previous research conducted.[5,10]

Figure 2. Average perceived sensitivity levels by sub-group and overall

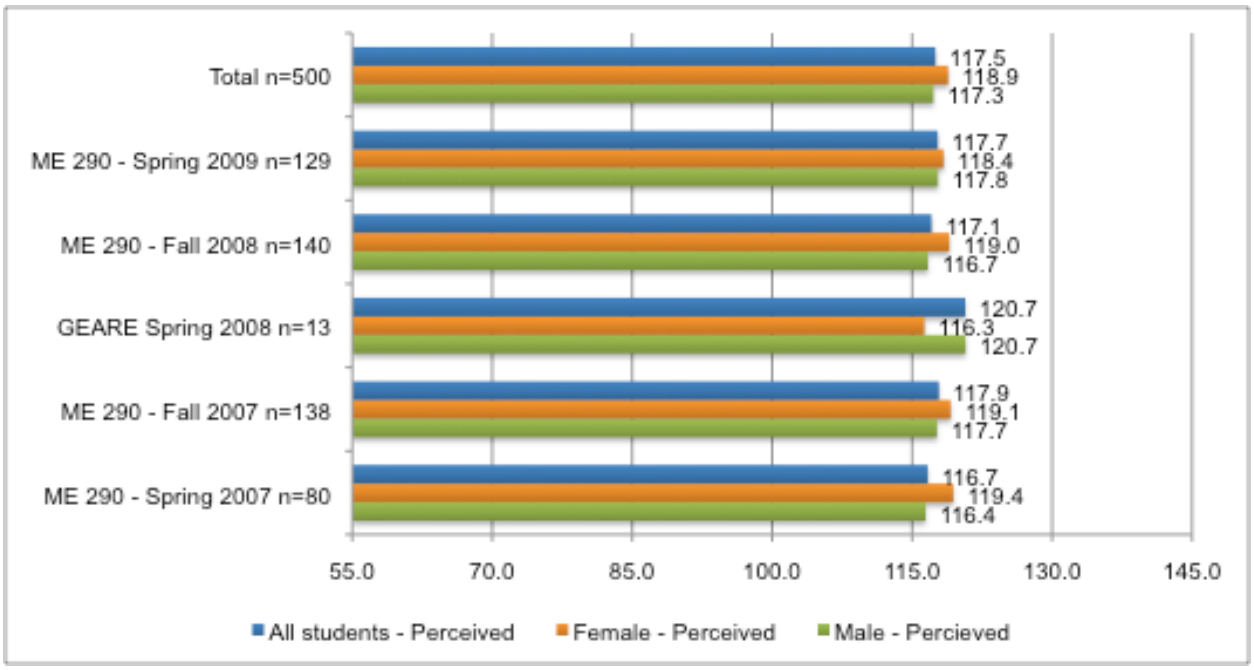
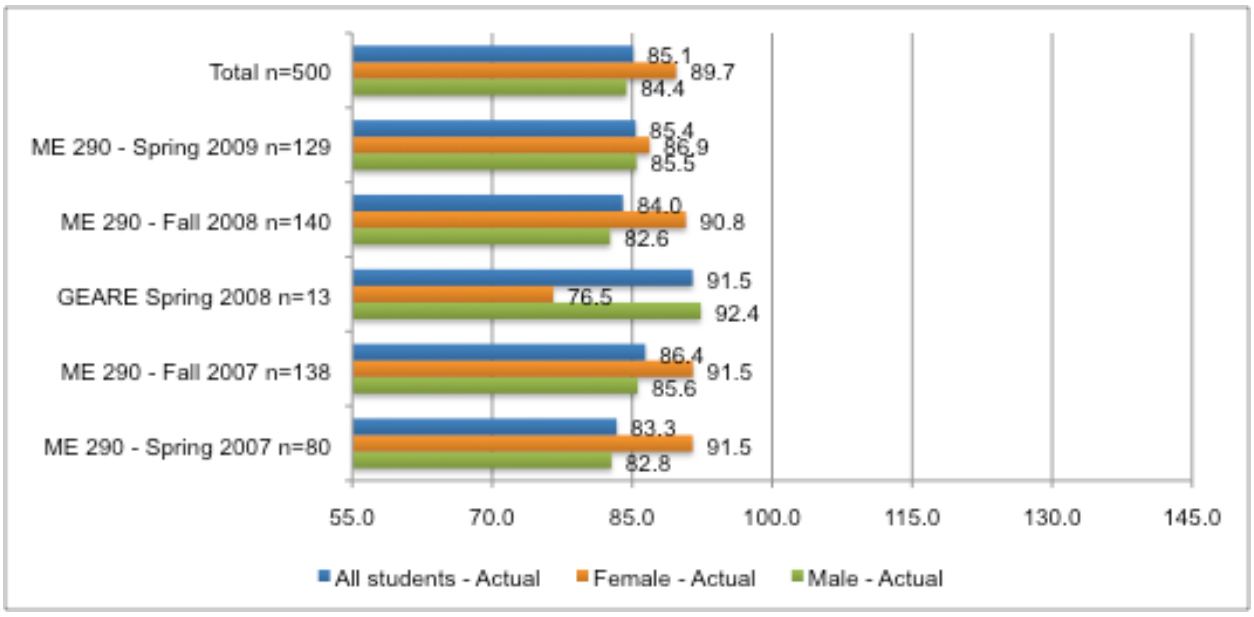


Figure 3. Average actual sensitivity levels by sub-group and overall



Finally, we note that our data shows relatively large gaps between perceived and actual levels of intercultural sensitivity. Compared to other populations, e.g. political science study abroad populations, the gap in our data larger.[12] Additional research is needed to determine whether these results can be explained by particular factors or characteristics that are unique to engineering student populations. However, these findings suggest that global engineering programs may need to be tailored for a population of students that generally overestimates its intercultural savvy.

Table 1. Intercultural development level by percent of subgroup

Subgroup	n	Intercultural Development Level		
		Denial and Defense	Minimizations	Acceptance and Adaption
GEARE	13	30.8%	61.5%	7.7%
Non-GEARE	486	53.4%	44.6%	2.1%
Male	405	56.3%	41.2%	2.5%
Female	67	31.3%	67.2%	1.5%
Less than one year abroad	107	53.3%	43.0%	3.7%
More than one year abroad	22	59.1%	40.9%	0.0%
Total	500	52.8%	45.0%	2.2%

Table 1 indicates the percent of students in each of three major levels if intercultural development as measured by the IDI instrument, including for specific subgroups and for the population overall. Here again, we observe that students who later elect to participate in the GEARE program tend to test at higher levels of intercultural development as compared to the non-GEARE group. One also finds female students typically testing at higher levels of development. For example, 56.3% of all male students were ranked in the Denial and Defense level based on their actual intercultural sensitivity, while 41.2% were at the Minimization level. By contrast, less than a third (31.3%) of female students were in the Denial and Defense range, while more than two thirds (67.2%) were measured in the Minimization level. Finally, we note that students who report having lived abroad for a year or more have levels of intercultural development that are comparable to those who lived abroad less than a year or not at all. But again, we acknowledge that relatively small sample sizes limit the strength of this finding.

Conclusions

As U.S. colleges and universities continue to develop their global focus, including through global engineering education, developing and examining assessment and evaluation tools becomes more urgent and important. However, we have only begun to understand how various kinds of programs and experiences are linked to specific learning outcomes. Documenting baseline IDI results among incoming student populations may represent a first step toward evaluating how various kinds of global experiences support the intercultural development of our undergraduate

engineering students. In fact, our findings generally follow patterns observed in data collected by Georgia Tech, which suggests some commonality across engineering schools. In future phases of this research we will be analyzing pre/post-experiential IDI results for GEARE participants, including to determine if any gains in intercultural sensitivity are detected. We will also be examining other strategies for assessing global competence that are specifically tailored to engineering student populations.

References

[1] Grandin, J. M., and Hirleman. E. D. Educating Engineers as Global Citizens: A Call for Action / A Report of the National Summit Meeting on the Globalization of Engineering Education. Online Journal of Global Engineering Education. 2009. 4(1): 10-25.

[2] Parkinson, A. Engineering Study Abroad Programs: Formats, Challenges, Best Practices. Online Global Journal of Engineering Education. 2007. 2(2): 1-15.

[3] Groll, E. and Hirleman, E. D. Undergraduate GEARE Program: Purdue University's School of ME Contribution to Educating Globally Sensitive and Competent Engineers. Paper presented at the 6th ASEE Global Colloquium. October 1-4, 2007. Istanbul, Turkey.

[4] Bland, L. Incorporating Global Issues into Freshman Engineering Course. Paper presented at the ASEE Annual Conference and Exposition, June 24-27, 2007, Honolulu, HI.

[5] Lohmann, J., Gordon, J., Harwell, K., McLaughlin, S., and Paraska, S. Annual Impact Report of the Quality Enhancement Plan on Student Learning: Strengthening the Global Competence and Research Experiences of Undergraduate Students. Atlanta, Georgia: Georgia Institute of Technology. Available at http://www.assessment.gatech.edu/legacy/SACS/QEP/QEP%20(SACS)%20Annual%20Impact%20Report%202007-2008%20FINAL%20WEB.pdf (Accessed January 8, 2010).

[6] Vande Berg, M. Intervening in in Student Learning Abroad: A Research-Based Inquiry. Available at https://en.afs60.de/webcontent/files/MbM_Vande_Berg.pdf (Accessed January 8, 2010).

[7] Del Vitto, C. Cross-Cultural 'Soft Skills' and the Global Engineer: Corporate Best Practices and Trainer Methodologies. Global Journal of Engineering Education, 2008. 3(1): 1-9.

[8] Bielefeldt, A. Cultural Competency Assessment. Paper presented at the ASEE Annual Conference and Exposition, June 22-25, 2008, Pittsburgh, PA.

[9] Downey, G., Lucena, J., Moskal, B., Parkhurst, R., Bigley, T., Hays, C., Jesiek, B., Kelly, L., Miller, J., Ruff, S., Lehr, J. and Nichols-Belo, A. The Globally Competent Engineer: Working Effectively With People Who Define Problems Differently. Journal of Engineering Education. 2006. 95(2): 1-16.

[10] Hammer, M., Bennett, M., and Wiseman, R. Measuring Intercultural Sensitivity: The Intercultural Development Inventory. International Journal of Intercultural Relations, 2003. 27(4): 421-443.

[11] Intercultural Development Inventory. Validity and Reliability of the Intercultural Development Inventory. N.d. Available at http://www.idiinventory.com/pdf/idi_validity.pdf (Accessed January 8, 2010).

[12] Patterson, P. Effect of Study Abroad on Intercultural Sensitivity. Doctoral Dissertation. 2006. Columbia, MO: University of Missouri. Available at http://edt.missouri.edu/Fall2006/Dissertation/PattersonP-120806-D5552/research.pdf (Accessed January 8, 2010).