Developing Global Engineering Competency Skills Through Participation in the Undergraduate GEARE Program

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- Why Global Engineering?
- Defining the Global Engineer
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- Summary
Personal Experience

1988: one-year master student exchange from Ruhr-University of Bochum to Texas A&M University

- Received scholarship from DAAD (German Academic Exchange Service)

Deciding factor to pursue Ph.D. studies
Personal Experience

- 1991 - 1994: Ph.D. student exchange from University of Hannover to University of Maryland
  - Conducted part of my Ph.D. research studies
  - Stayed on as a Post-Doc

Deciding factor to pursue academic career
Personal Experience

- **2003**: seven-month sabbatical from Purdue University to University of Karlsruhe
  - Received guest professorship from DAAD (German Academic Exchange Service)

http://www.hanksville.org/sand/contacts/tribal/US.html
Why Global Engineering?

Examples of Cultural Differences
(from Gary Downey at Virginia Tech)
Why Global Engineering?

● Cultural Differences #1:

» During the summer of 1940, British freighters were sinking, victims of Nazi U-boats. Doubting its survival, the U.K. sent a purchasing commission to U.S. shipyards. A deal was quickly reached, but then all progress came to a stop. To the commissioners’ dismay, their ship plans proved meaningless to American engineers, workers, and managers. The entire set of drawings had to be redrafted and hundreds of additional drawings were needed before work could begin on building the ships that would help save the war for Britain.

» Explain why?
Why Global Engineering?

• Cultural Differences #1:
  » British engineers
    – Focus on design
    – Design did not include dimensions
    – Other workers add dimensions, based on experience and craft knowledge
    – Long tradition of apprenticeship; engineers are higher labor
  » U.S. engineers
    – Developed blueprint in late 19th century to exert control over unskilled labor
    – Sharp distinction between design & manufacturing
Why Global Engineering?

● Cultural Differences #2:
  » An American engineer working in the avionics group at Honeywell reported a confusing experience with a French colleague. At a 50-minute engineering group meeting one day to decide the type of circuit they needed for a particular avionics system, the French engineer suddenly ran to the whiteboard and began deriving equations. This happened again on other occasions, even under severe time pressure.
  » What was happening here?
Why Global Engineering?

- Cultural Differences #2:
  - French engineers
    - Place highest value on mathematical knowledge
    - Elite French engineers speak for the nation as a whole
    - You start from basics and derive the problem
    - French engineer at Honeywell solved problem according to what counts as engineering knowledge in France
Why Global Engineering?

• Cultural Differences #3:
  » An American engineer working as a consultant for the U.S. Department of Defense was assigned to a project working jointly with German government engineers. She was confused by the fact they “wouldn’t do anything without checking with industry.” That is, every time they faced a difficult issue, the government engineers left the room to telephone the industry engineers.
  » What was going on here?
Why Global Engineering?

Cultural Differences #3:

- German engineers
  - Production of high-precision *technik* became a key indicator of Germany national progress
  - Longtime resistance to patents
  - Engineering knowledge: applied science to industrial problems (TU); high-precision *technik* for industry (FH)
  - Seeking help from colleagues in industry is not crossing a line, but desirable
Why Global Engineering?

● Cultural Differences #4:
  » ABET criteria (11)
    – 1\textsuperscript{st} = ability to apply math and science
    – 6\textsuperscript{th} = understanding professional responsibility/ethics
    – 8\textsuperscript{th} = global, societal, environmental, economic
  » JABEE criteria (8)
    – 3\textsuperscript{rd} = ability to apply math and science
    – 2\textsuperscript{nd} = understanding of “social responsibilities”
    – 1\textsuperscript{st} = ability to “consider . . . issues from a global and multilateral viewpoint.”
  » Explain
Why Global Engineering?

- Cultural Differences #4:
  - Japanese engineers
    - Strong sense of obligation to the household
    - Recent interest in accreditation is response to concerns about failures of corporations to fulfill their obligations
    - Professional societies insuring that engineers fulfill obligations to national household
Why Global Engineering?

Automotive Marketplace

Brand?
USA - Chevy

Market?
Brazil

Design?
Germany-Opel

Production?
Australia

Source: Jan Helge Bøhn, Virginia Tech, 2008
Why Global Engineering?

Boeing 787 Dreamliner
Why Global Engineering?

Boeing 787 Dreamliner

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Total of 9 Countries!


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Defining the Global Engineer

● “U.S. engineers must become global engineers. They will have to know how to replenish their knowledge by self-motivated, self-initiated learning. They will have to be aware of socioeconomic changes and appreciate the impact of these changes on the social and economic landscape in the United States and elsewhere.”

Defining the Global Engineer

● The Global Engineer is …

» Prepared for globalization of manufacturing industry
» Able to function on global teams
» Understands Engineering in global context (environment, sustainability, economics, etc.)
» Versed in global product platforms
» Appreciative of other languages and cultures
» Proficient in tech-based global enterprise culture
» Prepared for/desires international assignments

(Groll and Hirleman, ASEE GCEE, Istanbul, Oct. 2007)
Defining the Global Engineer

- The Global Engineer is …
  - Technically adapt
  - Broadly knowledgeable
  - Multilingual and culturally aware
  - Innovative and entrepreneurial
  - Knowledgeable about world markets
  - Commercially savvy
  - Professionally flexible and mobile

(S. Kraft, Continental AG, 10th ACIEE, Nov. 2007)
Defining the Global Engineer

- The Global Engineer …
  - Treats others with dignity and respect
    - Understands the culture … the big dos and don’ts
    - Respects their culture
    - Learns language and history
  - Is receptive to people and their ideas
  - Has experience integrating into a culture different than their own by being flexible and open-minded
  - Understands that locals are not trying to upset foreigners, it’s the way they work … gently gets on with it
  - Is less directive outside own culture
  - Treats international interaction as an adventure!

(C. Hobbs, Cummins, 10th ACIEE, Nov. 2007)
The Global Engineer is …

… prepared to function immediately and effectively in the global workplace!

So, how to we get there?
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- **Educating the Global Engineer**
- Assessing Global Engineering Programs
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Three Axes of Engineering Education

**Global Competency:**
- Based on 2005 NAE Report “Educating the Engineer of 2020: …”:
  - Work effectively in diverse & multicultural environments
  - Work effectively in the global engineering profession
  - Synthesize engineering, business, and societal perspectives
  - Ethically responsible in a global, social, intellectual, and technological context
  - Adaptable in a changing environment

**Technical Competency:**
- Based on 1955 ASEE criteria to modernize engineering education (Grinter Report) by:
  - Science & math
  - Engineering fundamentals
  - Analytical skills
  - Experimental skills
  - Open-ended design & problem solving skills
  - Integration of analytical, problem solving, and design skills

**Professional Competency:**
- Based on 1996 ABET Board of Directors Engineering Criteria 2000:
  - Leadership, Teamwork
  - Communication, Decision-making
  - Recognize & manage change
  - Multi-disciplinary within and beyond engineering
  - Innovative, Strong work ethic
  - Entrepreneurial and intrapreneurial
  - Curious and persistent continuous learners
Spectrum of Global Programs

Increase Level of Global Competency

- Integrated long-term programs, e.g., International Plan
- Independent long-term programs, e.g., traditional one-year SA
- Integrated mid-term programs, e.g., language, culture and SA
- Independent mid-term programs, e.g., traditional one-semester SA
- Integrated short-term programs, e.g., summer research experience
- Independent short-term programs, e.g., Maymester or summer course
- On-campus programs, e.g., design project with int'l peers

Long-term: two academic sessions or more
Mid-term: one academic session
Short-term: 4 weeks or less
State of Global Competency

● Small percentage of U.S. engineering students have substantial international experience before graduating (5+%)  

● The barriers, real and perceived, are:  
  » Cost  
  » Graduation time  
  » Community (language, leave family and friends, fear of the unknown)  

● Need to design innovative programs so that U.S. engineering students will reach substantial level of global competency before graduation
GEARE Program Overview

- Multiple Pillars
  - Minimum of 12 credit hours of foreign language before going abroad
  - Orientation in foreign culture before going abroad
  - Two internships
    - Domestic internship first
    - Subsequent international internship
  - One semester of study abroad with fully transferable course credits
  - Global design team project
    - Multi-national, multi-university design teams working on industry-inspired projects
## GEARE Program Schedule

For Purdue Students

<table>
<thead>
<tr>
<th></th>
<th>1st Sem.</th>
<th>2nd Sem.</th>
<th>1st Sum.</th>
<th>3rd Sem.</th>
<th>4th Sem.</th>
<th>2nd Sum.</th>
<th>5th Sem.</th>
<th>6th Sem.</th>
<th>3rd Sum.</th>
<th>7th Sem.</th>
<th>8th Sem.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regular Freshman Semester</td>
<td>Regular Freshman Semester</td>
<td>GEARE Selection</td>
<td>May-semester course at Partner Univ.</td>
<td>Regular Sophomore Semester</td>
<td>Regular Sophomore Semester</td>
<td>Domestic Internship</td>
<td>Regular Junior Semester</td>
<td>International Internship</td>
<td>Study Abroad Semester</td>
<td>1st Semester of Global Design Team Project</td>
</tr>
<tr>
<td></td>
<td>Foreign Language 1</td>
<td>Foreign Language 2</td>
<td>Foreign Language 3</td>
<td>Foreign Language 4</td>
<td>Cultural Orientation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd Semester of Global Design Team Project</td>
</tr>
</tbody>
</table>

For Purdue Students
University Partners

● Focus on Strategic Partner Universities
  » Limit number of universities available for each discipline
  » Ideally, one university per language spoken or per region of the world
  » Elevate these universities to partner status
  » Identify and list pre-approved courses for each university
  » E.g., School of ME at Purdue:
    – KIT, Germany
    – SJTU, China
    – Tec de Monterrey, Mexico (Univ. Carlos 3rd Madrid, Spain)
    – IIT Bombay, India (University of Queensland, Australia)
Corporate Partners

- **Partners**
  - Chrysler
  - Cummins
  - John Deere
  - DOW
  - Ford
  - GM
  - Shell
  - Siemens
  - United Technologies (Otis, Pratt & Whitney, Carrier, etc.)

- **Supporters**
  - GE
  - Kimberly-Clark
  - Bosch
  - Rolls-Royce
  - Whirlpool
GEARE Student Participation

GEARE STUDENTS BY DISCIPLINE

Students

Year


6 10 12 11 8 18 9 7 11 8

AAE  ABE  CHE  CE  CMPE  EE  IE  ME
GEARE Student Participation

GEARE STUDENTS BY COUNTRY

Cohort

Students

2003: 6
2004: 9
2005: 7
2006: 5
2007: 6
2008: 11
2009: 7
2010: 5
2011: 12
2012: 6
Global Experiences of ME Students

Source: International Programs at Purdue website, Study Abroad: Student Reports, Major Stats, 5 Mar 2010

81 of ~280 BSME = 29%
4X participation of US Engineering & 7X growth rate
Global Experiences of ME Students

(Percentages are total annual study abroad numbers divided by the number of same-year BS+MS+PhD degrees awarded. 07-08 last year US data available from Open Doors. Growth rates from linear regressions. PU degrees estimated 09-10)

- **US**
- **ME PU**

**Purdue ME SA Growth**
- Trend = 2.21%/yr

**US Engrg SA Growth**
- Trend = 0.29%/yr

**85 w/ 350 est. PU ME Degrees**

**8,135 w/ 122,242 Engrg Degrees Awarded in US**
Financial Support

- Endowment of $600,000 by retired Siemens VP
- Seed grants from International Office at Purdue
- Industry partners pay yearly participation fee
- Funds are spent on:
  - GEARE Stipend for students
    - Up to $1500 depending on location
    - Compensate travel expenses
    - Equalization of student internship salaries to make different GEARE locations equally attractive
  - Administration
  - Travel by administrators
Quality of Students

- Very good GPAs: 3.7 on average (Several 4.0’s)
- Typical honors include:
  - Outstanding Graduating Engineer 2004
  - Purdue President's Leadership Class (30 of 7,144)
  - Mauzy Emerging Leaders Program (60 of 7,144)
  - National Merit and Indiana Top Resident Scholar recognition
  - Class Student-of-the-year Awardees, HS class Presidents, student rep of local HS Board (1 of 1200)
- Average of 4.5 semesters of university-level language courses by the time they study abroad
- Several students lived abroad
- ~26% women, compared with 13% overall in ME
Student Feedback

- Cultural differences had significant impact on their interactions
- Ability to accommodate to changes in a foreign environment improved with experience
- As they became more confident in new environment, productivity increased
- Foreign students likely to adapt more readily to cultural differences due to familiarity with US culture through mass media
- US students, in contrast, emphasized a much greater personal change due to adaptations to cultural differences
- English was the language of last resort in communications between members of both groups.
- US students indicated that foreign language skills improved considerably in both social and business settings
- Overall, development of communication skills was considered best outcome
GEARE Program Summary

- Typically, outstanding students apply to program
- 2x more women in GEARE than overall
- Internships and study abroad work well
- Multi-university, multi-national design team projects work very well
- Curriculum articulation is necessary, but only a start
- Faculty participation is critical
- Research collaborations will be imperative
- Significant trickle-down effect
GEARE Program Summary

- Administration is time intensive
- Close interactions between partner university and Purdue is a must
- Selection of students is critical
- Resident faculty is must to start program
- Overall program has become extremely valuable experience for students
- Our goal:
  - 5% of Engineering graduating class (1200 students)
  - 60 students per year
GEARE Program Summary

- Minor in Global Engineering Studies
  - 12 credits in one foreign language program
  - One semester of study abroad at partner university
  - Three-month domestic internship at industry partner
  - Subsequent three-month international internship preferably, but not necessarily, at the same industry partner
  - Participation of global design team project
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Assessment of GEARE Program

● Pre-departure Orientation Course
  » 1 credit hour seminar
  » Forum in preparation of study and work abroad as part of undergraduate GEARE program.
  » Understanding cultural differences and collaborating across cultural boundaries.
  » Professionalism and ethics in foreign work and academic environments.
  » Leadership and teamwork options in foreign environments.
Assessment of GEARE Program

● Assessment of Preparedness
  » 17 students enrolled in course (GEARE 2012 Cohort)
  » Sojourn Readiness Assessment (SRA)
    – Designed to study:
      • How different kinds of global experiences enhances the global competency
      • Examines the relative effectiveness of orientation and global education
    – 3 parts:
      • Demographic information and previous international experience
      • 20 items of readiness statements by Jesiek et. al.
      • Miville-Guzman Universality-Diversity Scale (MGUDS-S)
## Sample Readiness Assessment v2

### Readiness Assessment

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

Please evaluate each statement listed below:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Disagree a little bit</th>
<th>Agree a little bit</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am anxious about going abroad.</td>
<td></td>
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<tr>
<td>2. If I need help while abroad, I will know who to contact.</td>
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<tr>
<td>3. While abroad, I know how to keep in touch with my family.</td>
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<tr>
<td>4. I am prepared to go abroad.</td>
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<td>5. I question if going abroad was a good decision.</td>
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<td>6. Adapting to the host country will be difficult for me.</td>
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<td>7. I worry about being isolated.</td>
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<td>8. The benefits of going abroad are worth it.</td>
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<td>9. I will make the most of my time abroad.</td>
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<tr>
<td>10. Thinking about going abroad excites me.</td>
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<tr>
<td>11. I have adequate knowledge about the destination.</td>
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<tr>
<td>12. I am concerned about certain aspects of going abroad.</td>
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<tr>
<td>13. I am ready to interact with my foreign peers, colleagues, partners, etc.</td>
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<tr>
<td>14. I have sound reasons for deciding to go abroad.</td>
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</tbody>
</table>

### Factors

- Knowledge and Readiness
  - Doubt
  - Benefits
  - Anxiety
Assessment of GEARE Program

- Sojourn Readiness Assessment (SRA)
  - Pre Test: First week of Fall 2011
  - Post Test: Last week of Fall 2011

- RESULTS:
  - 12 students who completed SRA pre/post-orientation.
  - From pre- to post-orientation, total SRA scores increased an average of six points (scoring range for the instrument ranges from 20 to 120)
  - 10 of 12 respondents had increases in their total SRA scores.
Assessment of GEARE Program

● Assessment of Student Satisfaction
  » Pre-departure Course Evaluation (Mean Score)
    – Rating of Instructor: 4.7 out of 5
    – Rating of Understanding: 4.7 out of 5
    – Overall course: 4.6 (S.D. = 0.65)
  » While Abroad:
    – Month #1 (Beginning) - ongoing
    – Month # 4 (Mid-point) – ongoing
  » Re-entry to the U.S
    – Ongoing for 2012 cohort
    – Completed for 2011 cohort
Assessment of GEARE Program

● Student Satisfaction (2011 cohort)
  » 18 students re-entered U.S in Fall 2011
  » Instrument: Qualtrics via e-mail (5 point scale)
    – Better understanding of global engineering profession (M = 3.6)
    – Better understanding of cross-cultural communication (M = 3.8)
    – Increase in personal development & maturity (M = 4.2)
    – Overall satisfaction of GEARE program (M = 2.6)
Assessment of GEARE Program

- Comparison to different types of global experiences that enhance global competency
  - Instrument: M-GUDS
  - Statistically significant between 4 groups of students/programs/international exposure
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In Summary

- As we continue to grow ...
  - ... need to balance global engineering program offerings with the recruitment of student
  - Barriers for student participation, real and perceived, are:
    - Cost
    - Time to graduation
    - Community (language, leave family and friends, fear of the unknown)
  - Need to design innovative programs to address these issues
In Summary

● “The world is flat” and is only getting flatter!
  » You need to get involved in global activities – now!
  » Work with administrators to develop different global programs to choose from
    – Number of programs is increasing
    – Work abroad, study abroad, experiential learning abroad