2006-1178: PRODUCING GLOBALLY COMPETENT ENGINEERS: RESULTS OF TWO WORKSHOPS

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Offering Global Competency in Engineering Education: The Results of a Symposium on Global Engineering Education

Abstract

Global Competency is a desired quality in engineering graduates today. Global Engineering Education to produce such graduates comes in many sizes and styles. Some universities concentrate on sending students abroad while others create globally distributed teams based at home and abroad to give students a taste of the global economy and supply chain after graduation. Companies agree that global competency is an important attribute of new graduates in many fields including engineering. Universities and faculty are struggling with knowing how best to both define Global Competency and to implement and fund global education to give both students and industry what they need. The first Global Engineering Education (GEE) Symposium at Arizona State University, held in February 2004, was designed to allow free-form, yet directed conversation about how best to produce globally competent engineering graduates. Results included ranked issues and strategies to address barriers to GEE, together with a prediction of what GEE will look like in the year 2030. The participants' enthusiasm has carried over and they are organizing a follow-up GEE Symposium to be held in 2006. This paper presents, but does not analyze the results of the first symposium to characterize definitions and approaches to Global Engineering Education from the standpoint of faculty, students, government and industry. The emphasis on the first workshop was in defining the environment and goals. The second workshop will focus on strategies both directly about program implementation and in how to assess Global Competency.

Introduction

Many conferences and symposia have been held in the past few years with the format of presenting papers on progress in global engineering education (GEE). By GEE, we mean educating engineers with a global mindset to improve their Global Competency. This can be done in many ways and many conference papers explain how a given university has created programs to help engineers be exposed to global technology, culture, communication and collaboration. Typical programs offer study abroad for engineering students, but some also offer multi-national teaming on projects with common objectives.

Conferences and symposia have their place, but sometimes the participants need extended time for goal-directed discussion. With this purpose in mind, faculty who were known to be involved in GEE programs gathered for a workshop held at Arizona State University, Tempe, Arizona, February 26-27, 2004.

The workshop structure included sessions entitled Inspiration, Discernment, Breakout Discussion and Collective Summation and Planning. The overall goal was to define the major issues in GEE and to reach consensus on action items to further the success and spread of GEE. Concluding with action items was a strategic necessity. Ending the workshop with a list of issues and conclusions without "marching orders" would have been incomplete. The action items help the attendees to continue the workshop discussion as they return home and give a sense of purpose and a plan for continuing the workshop in coming years.

Among the workshop goals were to focus on a vision and a roadmap, plan the next steps and develop action items. This paper presents the results of this workshop as they were submitted by the individual discussion groups. It also attempts to comment on and put in perspective the symposium output. Subsequent papers, including the one to be written after the second Symposium, will compare these results with those of other similar conferences and develop a corporate definition of Global Competency. This paper only presents the symposium output for readers to develop their own conculsions.

The attendees first developed a definition of Global Engineering Education by individually contributing definition-statements in a list as seen in Table I. These statements were collected quickly and seem somewhat detached from one another until one reads the last item.

Table I: Statements Defining Global Engineering Education

- Prepare engineers for designing products for global deployment
- Provide engineering graduates with international experience virtually and personally
- Study abroad
- Degree programs
- Internship abroad
- Educating engineers globally
- Ability to communicate over time and distance
- Teach language
- Develop Common, global perspectives
- What you do/ How you do it
- **Educating engineers with a global mindset**

The last item in the list is a good synopsis of the goals of all of the list items before it and was considered a reasonable way to develop graduates with *Global Competency*.

Presentations were made by industry and academic experts in globalization, socialization and technical competence. The two industry presentations stressed that all engineering and product development and manufacturing are global activities. The conclusion: a global mindset is becoming a requirement for graduating engineers and is coming faster than expected.

From the social, humanitarian and environmental perspective, ASU President Michael Crow diagrammed the current situation in technology and how it relates to socio-cultural progress (Figure 1). Obviously, technology has grown and will continue to grow immensely and overshadows the current and predicted future progress in solving social and cultural problems. Technological capabilities are not effectively applied to socio-cultural problems. Progress would be shown as these two areas coming closer together and becoming similar in size as predicted for the year 2030. Although technology seems to be necessary to solve many of the problems, it seems that closing the gap between technology solutions and world social issues such as sustainable resources, housing, food and health is too slow. Crow suggested that one factor having potential to improve this linking of technology solutions and social problems is training

technology leaders such as engineers with global experience and, more importantly a global mindset.

Definition: We can define *Global Competency*, therefore, as the ability to see and enable the coordinated progression of Technological and Cultural/Social capabilities throughout the world.

This ability applies to any discipline, but it seems to fit engineering very well because engineering embodies the connotation of solution creation. William Wulf, president of the NAE has said[1]:

"Engineering is global, and engineering is done in a holistic business context. The engineer must design under constraints that include global cultural and business contexts—and so must understand them at a deep level. They too are the new 'fundamentals'."

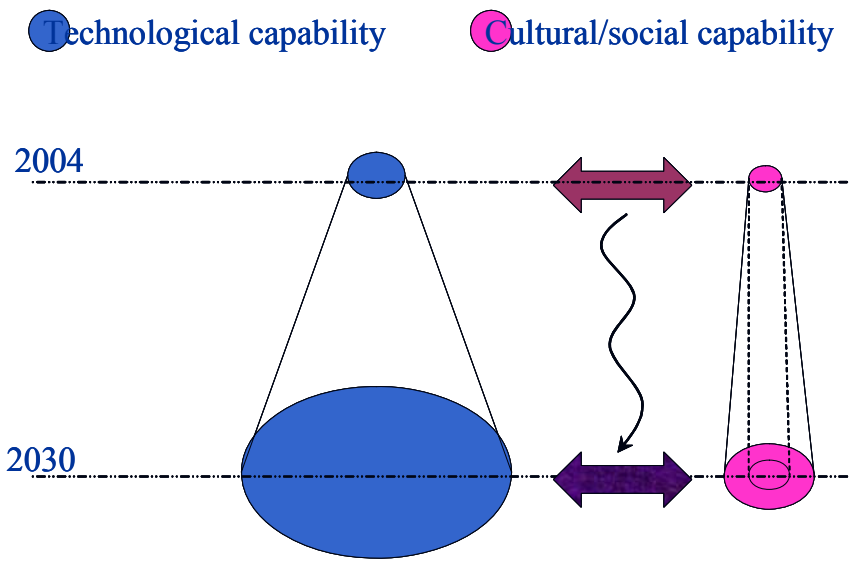

Figure 1: Technology and Its Distance from Socio-cultural Issues

The question then is: How can we as engineering educators and mentors create an atmosphere to engender this Global Competency?

Engineering education routinely addresses technology and does it well. However, typical engineering students avoid social and cultural subjects because they either would rather tinker with technology or because there is no room in the curriculum for that material or both. Adding global content exacerbates the problem by increasing the material in an already bulging curriculum.

The Symposium attendees did keep this problem in mind throughout the discussions which included breakout sessions on the following issues. These issues were extracted from the discussion using the affinity process technique.

1. Institutional Barriers to Success
2. Stakeholder Value Proposition
3. Research in GEE Pedagogy
4. Outcomes and Assessment
5. Socio-cultural connections/imperatives
6. Communication - Tools & Issues

The workshop attendees were divided into subgroups. Each breakout group was assigned two of the topics above plus the task of defining what GEE would look like in the year 2030. The assignment was to develop a more focused definition of the issues within each topic, the barriers to moving ahead and strategies to move beyond the barriers. The following sections summarize the results of these breakout reports.

Institutional Barriers to Success

Institutions in this case are any involved in GEE including universities, industry and government. And, the success we are talking about is the educating of Global Competency. If we look for a moment at how GEE involves institutions, we see obviously that universities provide students with global opportunities which sometimes are funded by industry and government and also sometimes involve on-site industry experiences such as internships and projects to solve industry problems involving global issues such as supply chain management or involving global distributed teams. Some specific examples include the Global Engineering Design Teams developed by Arizona State University and Leeds University in which teams of students from each university join as one team working on an industry project as part of their capstone experience[2] or the Global Product Development Program at University of Michigan in which graduate students on three continents are simultaneously taught product design using electronic communication and shared faculty. Projects are sponsored by corporations and are assigned to distributed teams of students.

Therefore, institutions can promote GEE, but also problems can occur which cause barriers to be erected. These include issues between institutes (inter-institutional barriers) and within an institute (intra-institutional barriers).

Inter-institutional barriers can include multiple languages, time schedules that are off by several time zones, difficulty in communication both technically and personally and the cost and time to coordinate between institutions. This is especially true in universities in which joint courses or distributed teams require mentoring and other resources that can be expensive.

Inter-institutional barriers to GEE and Global Competency

- Schedule
- Language
- Communication
- Cost and Time

Furthermore, barriers within an institution are also common and include mis-perception of cost and time which means that the amount of expense and time commitment to produce GEE

experiences is typically much higher than administrators realize. Within a university, courses involving GEE are usually counted the same in terms of faculty effort as regular courses. Also, within one institution, there can be inter-departmental issues as well. For example, in a university, especially in multi-disciplinary GEE courses, requirements for student work can be vastly different among departments and can prevent students from participating. Culture within an institution can be a barrier. In a company for example, a rigid work schedule can prevent distributed team members in distant time zones from having an opportunity for real-time communication. And, lastly the lack of incentives for global programs can be a death knell to GEE. Participants work harder in GEE typically than in regular teams or programs and incentives such as release time or supplemental funding can send a signal of support to the leaders of GEE in an institution.

Intra-institutional Barriers to GEE and Global Competency

- Perception of cost and time.
- Inter-departmental issues
- Culture
- Incentive structure to promote global design.

In responding to these barriers, the group developed a list of strategies to deal with them. Some seem obvious such as using project management tools to coordinate resources and schedules, language training, strong leadership and change the reward structure of leaders and faculty. But, others such as the creation of organizational structures to facilitate GEE is a strategy not often considered. Creation of a center for global studies in engineering or even just assigning staff support to GEE faculty can make a large difference. Some universities have established such centers, but funding can be a problem. The last strategy (ROI) has power because it demonstrates a value proposition to the institution in terms of cost and benefit, or return on investment. Institutions usually listen to ROI arguments. The problem is that the benefits are difficult to measure in monetary terms unless specific things happen such as the GEE alumni encouraging funding to be provided by their employers.

Strategies to Overcome Institutional Barriers

- Adopt Industry Project Management tools
- Language training
- Global Courses with synchronized schedules
- Organizational structures to facilitate GEE
- Changed reward structure
- Funding to support cross-disciplinary work
- Strong leadership
- Cost/benefit justification = ROI

Global Engineering Education research

Research is obviously a currency of universities and faculty. An element of research must be involved in a GEE program for it to be sustainable. Research in this case deals with the pedagogical methods to teach Global Competency on a wide scale. Research funding can be provided and papers written, but the discipline must be organized. By that, we mean that among

all the forms of GEE at all university/industry/government sites, the experiences must be studied and compared as a body of knowledge. This requires organization of the discipline. A suggested taxonomy for some GEE programs is shown in Figure 2. The three axes are team distribution (collocated vs. scattered), team member location (home vs. away) and the team discipline (uni-disciplinary vs multi-disciplinary). Most programs can find where they fit in this 3D domain. The Global Engineering Design Team (GEDT) at Arizona State Univeristy involves several engineering disciplines and two sites of students working at their own universities. These parameters locate GEDT in the front, top right octant. If the students are exchange students, then since the students are not at their home location, the program would reside in the front, bottom right octant.

Categorizing programs like this can help in comparing programs to one another for best practices as well as identifying opportunities where no program exists. Research can be done using normal procedures, but the taxonomy adds new significance to the results. Research questions we can ask are:

1. Which octant is most effective at bringing together the technological and social issues evident in Global Competency?
2. How can these quadrants be assessed for the effectiveness?
3. What other variables can be added to this study to optimize the teaching of Global Competency?

Of course, funding sources must be identified for research support and that is an area that needs development. Industry will participate as long as they see a benefit, which brings us back to the ROI from above and leads us into the next section on value.

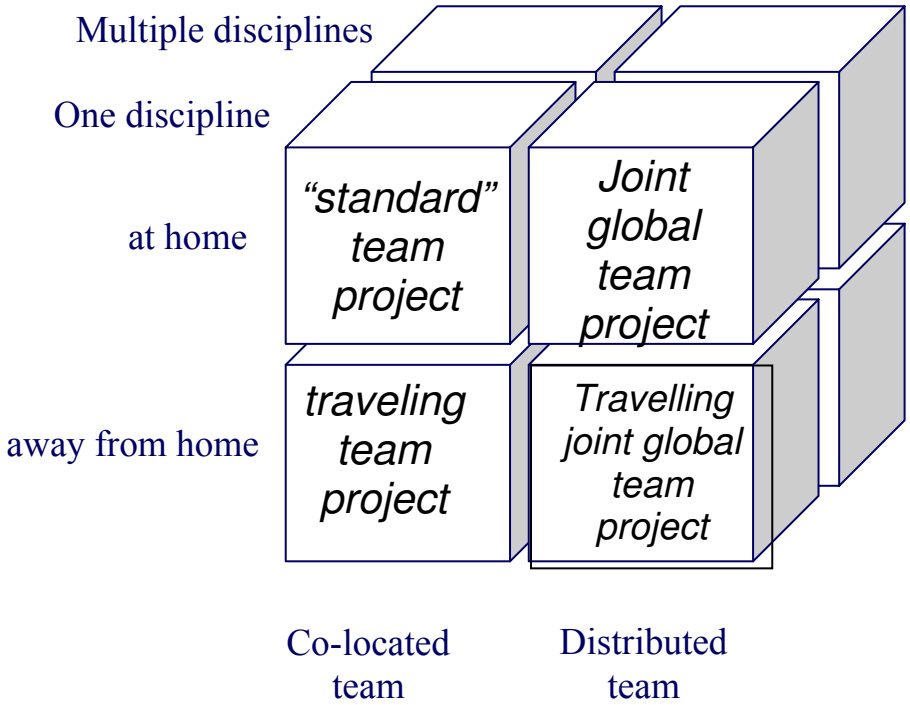

Figure 2: A Taxonomy for GEE Research

Action items for helping the research within GEE include the following:

- Map out the landscape of current GEE efforts using a taxonomy.
- Systematic literature review / pose research questions
- Coalesce the literature and the authors: e.g. Using bibliographical coupling techniques
- Create a GEE conference on GEE Research

Stakeholder Value Proposition

For GEE to appeal to institutions, students and faculty/mentors, each stakeholder must comprehend a real value proposition. The stakeholders in GEE are many and include the obvious students, faculty and institutions. We can eliminate universities from this value proposition because if students and faculty and industry all see a positive value in participating, typically the university will also see value. Therefore, the key stakeholders are the students, faculty and industry. One other stakeholder the workshop group identified is Society in general. If we return to Figure 1, it is obvious that there is a relationship between the technology of GEE and social/cultural benefit. Society is a bit confused today about the value of globalization because outsourcing has caused some pain, especially in the United States with unemployment rising and companies moving off-shore. To help society realize a value to GEE, the benefits must be made clear. This is a challenge that GEE participants need to realize and solve. GEE is valuable to society in many ways including innovation and cost, but for each country that is growing because of outsourcing, there are others that are seemingly retracting. Again, illuminating society value should be on the GEE to-do list.

Suggested value propositions for the three stakeholders (students, faculty, industry) are listed below:

Value to Students

- Career potential
- Jobs / globally competitive
- Resume
- Salary
- It's cool, exciting, intellectually stimulating
- Creation of new opportunity

Value to Faculty

- Intellectually stimulating (advancement of knowledge)
- Promotes peace
- It's Cool, exciting
- Helps them Remain relevant/competitive
- Helps Invigorate/sustain industry connections
- Expand and Exploit synergies with (international) research programs
- Expand network diversity internationally

Value to Industry

- Improve coverage of global markets (new markets)
- Global engineers are necessary for managing global engineering
- Global engineering is a necessity for company's competitiveness

- Reduce "in-company" training for global engineering

The workshop results have been presented to industry groups since the workshop and the audience members have suggested additional value propositions. Some of them are listed below:
Industry Value Propositions Suggested by Industry

- Global Engineers have a head start and will require less development on the job
- GEE engineers bring ideas to the team that are not US or ethni-cetnric
- Their background would cause them to be open-minded, hence better at problem solving
- GEE engineers will make minimal social mistakes
- Pre-trip country familiarization is not required

Outcomes and Assessment

Making progress in GEE requires benchmarking and assessing outcomes for continous improvement. The attendees suggested the following outcomes as a start to a more complete list. Certainly the engineering program accreditation boards operate according to outcomes so this is a useful exercise.

Suggested Student Outcomes

- Competition in job market
- Cross-cultural fluency
- The ability to place technology within social context
- Demonstrate globalized technical knowledge
- Adaptable to new environment
- Improved communication skills
- Awareness of relevant factors in global economy
- Increased disposition to work in global economy
- Synthesis of engineering and culture and communication technology subsystems

Assessment of these outcomes can be difficult. For example, how does one measure awareness of relevant factors in global economy other than an exam? The following suggested assessment instruments were suggested as possible ways to evaluate the outcomes.

Assessment Instruments

- Student reports/presentations and surveys (pre, post survey with universal instrument)
- Industry feedback
- Student enrollments up, steady or down
- Learning portfolio
- Anecdotes
- Verbal Protocol Analysis

The learning portfolio occupied quite a bit of discussion time. The learning portfolio documents the significant products of a student's educational experience. They exhibit evidence of design

and other work which demonstrates a student's capabilities directly. Student reports/presentations are typical contents of a portfolio.

Socio-cultural connections/imperatives – The Global Competency Links

This topic is a direct result of the visioning talks on Global Competency. It became obvious from listening to the attendee comments that this topic struck a nerve. One goal of an engineering education is to enable a graduate to improve the quality of life of others on the planet. And, the first-hand experiences of the GEE practitioners have shown that students change their view of themselves and the world as a result of GEE experiences, especially travel and living abroad. The workshop team suggested the following as socio-cultural responsibilities of a GEE program.

Dimensions:

- Ensure diversity and inter-disciplinarity in GEE experiences
- Increase curriculum coverage of topics such as…sustainability
- Social conscience factored into education experiences

Strategies:

- Include experts/students from other disciplines
- Integrate private sector
- Develop courses/best practices
- Marketing for GEE (industry, society, university)
- Improve Tolerance
- Appropriate solutions/methods/technology for a culture

And, the result of implementing these strategies to ensure socio-cultural content and emphasis in GEE can be demonstrated by the following outcome, related to Figure 1.

Outcome

- Improve the <u>Bridge</u> and balance between Technology and Social/Econ Growth

If the above outcome is successful, Figure 1 can be moved over time to the situation represented in Figure 3. Technology and Socio-Cultural capabilities are more synergistic and collaborative and each benefits from the other by 2030.

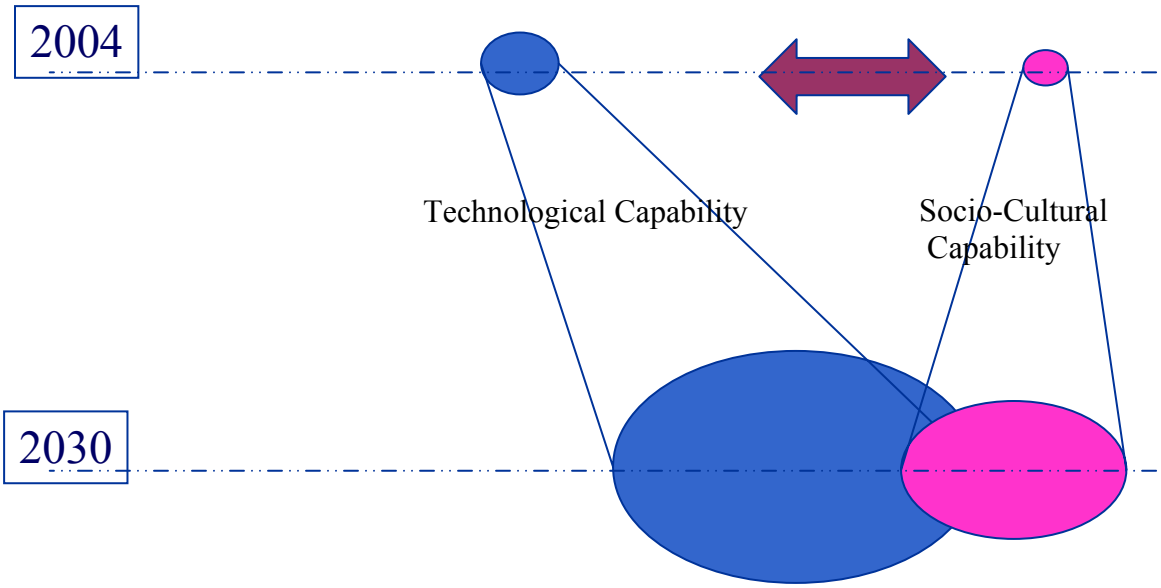

Figure 3: An optimistic trend for the future of Technology and Socio-cultural Capabilities

Communication - Tools & Issues

Typically the most consistent and uniform problem in creating global experiences, whether collocated or distributed, is communication. Time and distance distort communication and make it difficult to accomplish easily and quickly. Video conferencing helps, but the inherent delays and technical difficulties keep it from being natural and totally effective in removing the distance. Speaking the language of the other party helps, but if that doesn't exist, then at least a sensitivity to the language differences makes the relationship stronger. The following are strategies to improve the communication of distributed teams.

Language

- Promote language sensitivity, 2nd language. ESL sensitivity
- Translation tools/techniques

Culture

- Promote cultural difference understanding
- Encourage exchange programs
- Assure broad appreciation across all faculty
- Guarantee cross-cultural team experience
- Articulate differences in business models

Technology

- Promote awareness collaboration tools
- Define tool sets – Alibre, Net Meeting, etc.
- Guidance for appropriate tool selection (includes infrastructure difference considerations)
- Tech training and support
- Online Teaching Tools

Global Competency in 2030: A Vision

Each team was given an extra charge to define the attributes and issues of Global Competency (GC) Education in 2030. The responses showed a hope and confidence in GC and its growth and effectiveness. One statement said: GEE is all there is! That implies that the issues outlined in this paper will be significantly solved or reduced and that the value propositions discussed above will be real. The following lists show the predictions for global engineering education in 2030.

Attributes of GEE toward GC in 2030

- Understanding exists that engineering is globally competitive/GEE value
- Effective cross-cultural collaboration (face-to-face and distance)
- Ability to anticipate social/economic/political implications
- Pre-eminent at synthesizing heterogeneous input to create markets for engineered products/systems

GEE in 2030: Issues

- Same issues as now but less impact than now
- Other subject matter covered: Students able to understand well.
- Politics of collaboration and IP
- The bridge between technical and socio-cultural progress will change as technology capability grows faster than cultural-social capability so the balance gets worse

These last two bullets deserve some elaboration. Intellectual property will become more of an international competitive advantage. Therefore, global teams must deal with the politics of this important economic tool. IP issues will have to be explicitly stated and understood by anyone running a GEE program. This could be a large potential problem, especially if the individual students involved expect monetary rewards from their joint IP. The last bullet predicts a different outcome to Figure 3 in which the technology oval increases at a rapid pace compared with the socio-cultural oval. Furthermore, the prediction is that they may drift apart becoming less synergistic. This is one view.

The predictions of the status and features of GEE in 2030 are listed below. Some of them such as language translators are imminent. Others such as dominant sustainability will require significant effort.

GEE Predictions

- GEE is all there is!
- Personal language translators
- No firewalls
- Semantic web
- Design repositories remove boundaries
- Global "classrooms" the norm (global spaces)
- Transparency of natural resources – sustainability will be dominant
- Global language: universal immediate voice-recognition for translation, technology enabled language aid.
- Global universities will exist worldwide
- Technology will move faster, while cultural differences won't bridge that fast so the <u>net difference increases</u>.
- Deep generalists are popular/common

■Funding: institutionalized; common fee structure improves mobility

Summary

It's obvious that Global Competency Education for Engineers is on the upslope. Industry is demanding global performance and the universities are struggling to keep up. The workshop attendees represent a small slice of the world's GEE proponents and the lists of issues and strategies are therefore, incomplete. The attendees did establish a feeling of community during the workshop evidenced by their desire for regular meetings to address these questions and others again and more fully. Much is left to be done to round out the list of issues and especially the strategies. Eventually tactical actions will be added to make these strategies real and successful.

Three major consensus points reached during this workshop were the following:

1. The goal of GEE is to help develop engineers who have Global Competency.
2. GEE is going to grow in both size and significance.
3. Global engineers are changed engineers.

The Second GEE Symposium

This paper has concentrated on the results of the First GEE Symposium at Arizona State in February 2004. The Second GEE Symposium is in the planning stages to be held in the fall 2006 at ASU. We have received notice from ASEE that they have agreed to sponsor the second Symposium. The planning is building on the results of this First Symposium and the discussions will be in more depth and more tactical, but the focus will be squarely on preparing Globally Competent Engineering graduates.

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