Globalization Effects on ECE Education for the Engineering Profession Workshop

A National Science Foundation Workshop organized by the Electrical and Computer Engineering Department Heads Association

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Workshop on Globalization Effects on ECE Education for the Engineering Profession

1. Executive Summary

There is a recognized need to educate engineering students for competitive careers in a global economy. Educators need to carefully consider how to educate engineering students to prepare them for changes in the profession due to globalization and outsourcing. Educators also face the challenge of recruiting students into ECE programs in the face of negative publicity of out-sourcing, and the perceived undercutting of the value of an engineering degree in the United States due to global competition. Another challenge to educators is the retraining of engineering professionals in fields that have suffered from excessive out-sourcing. Addressing this challenge requires a new emphasis on continuing education in providing opportunities for engineers at all career levels to refresh and change the direction of their evolving careers. In response, the Electrical and Computer Department Heads Association (ECEDHA) and the International Engineering Consortium (IEC) organized a workshop on this topic that was held at the National Academy of Engineering in Washington D. C. on November 14 and 15, 2005.

The two day workshop was opened by a plenary talk by William Wulf, President of the National Academy of Engineering and included talks from various constituencies, including NSF, industry, and academia. Breakout sessions were held on the second day for participants to address three issues, global awareness, technical skills for global engineering, and recruitment and retention of students and faculty in the face of globalization.

A number of action items came out of this workshop following the presentations and break out sessions. These include:

Recommendations to Prepare ECE Students for a Global Economy

- International Student Experiences
- Cultural Education
- Collaboration and Multidisciplinary Experiences
- Service and People Oriented Educational Experiences
- Enhanced Technology in Education

Action Items for NSF

- International REU Programs
- Cooperative International Programs
- Benchmark Studies with Foreign Institutions
- Development of Model Curricula
- Making ECE Programs More Attractive - Workshop on attracting K-12 students to engineering

Action Items for ECEDHA

- Follow-on programs on global engineering at 2006 and 2007 ECEDHA meetings

- Follow-on workshop organized jointly with NSF on best practices and curricular development for global education

2. Overview of the Workshop

In response to significant interests in globalization, public policy, and engineering out-sourcing that emerged during the 2004 ECEDHA Annual Meeting, the Electrical and Computer Department Heads Association (ECEDHA) and the International Engineering Consortium (IEC) organized a workshop on this topic. The workshop was held at the Constitution Avenue location of the National Academy of Engineering, Washington D. C., on November 14th and 15th, 2005. ECEDHA is grateful to Dr. William Wulf, President of the National Academy of Engineering (NAE), for arranging to hold the workshop at the NAE. It is hoped that this workshop will stimulate further debate on globalization, public policy, and out-sourcing of engineering jobs, and the impact of this evolution on engineering employment opportunities in the United States. Funds were provided though a grant from the National Science Foundation to provide partial travel support for invited workshop attendees and to cover basic administrative expenses for the organizers. All of the talks presented at the globalization workshop were video taped and have been posted on the workshop website that is linked to the ECEDHA homepage. The videos and PowerPoint presentations can be downloaded from the workshop website at:

http://www.ecedha.org/meetings.html#workshops

There is a growing need to educate engineering students for competitive careers in a global economy. Educators need to carefully consider how to educate engineering students to prepare them for changes in the profession due to globalization and outsourcing. Educators also face the challenge of recruiting students into ECE programs in the face of negative publicity of out-sourcing, and the perceived undercutting of the value of an engineering degree in the United States due to global competition. Another challenge to educators is the retraining of engineering professionals in fields that have suffered from excessive out-sourcing. Addressing this challenge requires a new emphasis on continuing education in providing opportunities for engineers at all career levels to refresh and change the direction of their evolving careers.

3. Challenges and Opportunities of Globalization

The workshop was opened with a welcoming address delivered by Dr. William Wulf, President of the National Academy of Engineering. In his welcoming comments Dr. Wulf spoke of Tom Friedman's book *The Earth is Flat* very positively, indicating that while it is not perfect in many ways, its publication in 2005 was very timely [1]. While Friedman is not the first author to write about globalization, his book has had enormous impact because it has captured people's imagination. It has led the western world to the realization that many of the engineering graduates being produced in China and India are very good, as they are basically skimmed off the top of very large populations.

The National Academy of Engineering (NAE) has become increasingly concerned about globalization and is trying to help to educate the next generation of engineering graduates as to what they will face in the engineering workplace of the future. The NAE can help to motivate actions primarily through its high level of prestige, but it has little in the way of financial resources to initiate actions unilaterally.

Dr. Wulf explained that the NAE has 750-800 influential committees. As President he has led the NAE in pushing an engineering education agenda through the following activities:

- Formed the committee that has produced the Engineer in 2020 reports (Chairman, Steve Director)
- Changed criteria for membership to add engineering education
- Established the $500k Gordon prize (endowed by Bernie Gordon)
- Created the NAE Center for the Advancement of Scholarship on Engineering Education (CASEE-NAE, directed by Norm Fortenberry)

The fundamental challenges that the engineering profession will face in the future are to:

- Set bold goals like those put forward by CASEE. Engineering educators should try to teach as much in two years as we now do in four.
- Modernize both curriculum and pedagogy – engineers are often arrogant, especially when thinking about people in education.
- Face up to what can be deleted from a traditional engineering curriculum.
- Be mindful of recommendations of the 2020 reports and use the freedom that EC2000 gives us. (e.g. work toward establishing the MS degree as the first professional degree rather than the BS degree)
- Quickly involve students in the practice of engineering.
- Be sensitive to the problems of teaching technological literacy to non-engineers (liberal arts majors) and to view engineering as a preparation for other jobs (about 25% of CEOs are engineers; about half of engineers do not plan to practice engineering).
- Recognize that while starting salaries do not suggest either a shortage or excess of engineers, the U.S. currently imports about 25,000 engineers each year.

Dr. Wulf used the example of the Information Technology (IT) minor at George Mason University as an attempt to offer technical education to non-technical majors. As he concludes his presidency of the National Academy of Engineering and returns to his academic life at the University of Virginia, he hopes to become engaged in teaching technical material to students in non-technical majors. Inherent in this comment was the suggestion that many of the workshop participants who are in leadership positions in engineering programs are well advised to pay more attention in the future to providing technical education to students outside of the engineering majors.

4. National Science Foundation Perspective on Globalization

4.1. Overview

The NSF Engineering, Engineering Education and Centers, and Electrical Communications Systems (ECS) leadership, provided their views of national and international trends, ideas from popular authors and NAE study groups, and the corresponding funding and programmatic directions at NSF.

4.2. *Plenary Address:* "External Forces and NSF Engineering"
Richard Buchias *(Acting Assistant Director of Engineering, NSF)*

Dr. Buchias began his talk with a discussion of innovation and international competition, citing rankings of first university degrees at many universities throughout the world. He presented a 30-year history of awarded engineering degrees on a world-wide basis at the BS, MS, and PhD levels. He also discussed the engineering workforce trends for women in engineering and for underrepresented minorities in engineering. The data show that, on a world wide basis, the engineering workforce in most categories has been steadily increasing, counter to the trend seen in the U.S. alone. The latter part of Dr. Buchias' presentation turned to a discussion various research and education programs funded by NSF, including CAREER, ERC, REU, RET, EEC, and ADVANCE Programs. His presentation concluded with an overview of the recent NSF reorganization and how it has been designed to stimulate new initiatives. His presentation can be downloaded from the workshop website.

4.3. *Plenary Address:* "Engineering Education Today: Meeting the Global Challenge"
Gary Gabriele *(Division Director, Engineering Education and Centers, NSF)*

Dr. Gabriele began his presentation with a discussion of Tom Friedman's book "The World is Flat" [1, 2] and the various NAE reports that have appeared in the same time frame [3, 4, 5]. His presentation then summarized the current environment that globalization has created in the engineering profession and how it has impacted engineering education from the point of view of the National Science Foundation. Dr. Gabriele presented data showing a declining interest among students in the U.S. for pursuing engineering degrees, particularly at the undergraduate level. He then cited eight items that he believed is missing from a typical engineering curriculum: 1) systems design and complex problems, 2) global and social relevance, 3) production systems and logistics systems, 4) project management, 5) research experience, 6) creativity and innovation processes, 7) business and marketing principles, and 8) the use of modern computing infrastructure and tools. The presentation concluded with an overview of many NSF programs that are designed to influence "major leverage points for moving forward." Dr. Gabriele's presentation can be downloaded from the workshop website .

4.4. *Plenary Address:* "Research and Education Priorities in the Electrical and Communications Systems (ECS) Division"
Usha Varshney*, Division Director (Electirical and Communications Systems, NSF)*

Dr. Varshney's presentation dealt primarily with both the current funding trends at NSF and the recent NSF re-organization that results in a new program in Cyberengineering within the ECS Division. She described the future Key Technologies as 1) integrative and complex systems, 2) communications systems, and 3) Cyberengineering systems. The focused areas within ECS will be 1) nanoelectrics, nanophotonics, and nanomagnetics, 2) critical infrastructure technologies and systems, 3) flexible electronics, 4) diagnostic and implantable devices, and 5) renewable and alternative energy sources. Dr. Varshney's presentation then turned to a discussion of Cyberengineering Systems examples, of ENG research priority areas, of ECS investments for FY '06, and an to overview of recent ECS initiatives. In particular she described in considerable detail the Active Nanostructures and Nanosystems (ANN) Program, the Major Research Instrumentation (MRI) Program, the Katrina Small Grants for Experimental Research (SGER) Program, and the National Nanotechnology Infrastructures Network (NIN). Dr. Varshney's presentation can be downloaded from the workshop website.

5. Industry Perspectives of Globalization

5.1. Overview

In this session we heard the viewpoints from a wide variety of companies: very large, very small, commercial, defense, well established and brand new. Globalization affects companies of all sizes and types, but in somewhat different ways, especially in which activities can be provided by another company. However, there are some common themes. First, companies now view themselves as global rather than multinational in that each local unit has become quite specialized and collaborative working environments and modern collaboration tools eliminate the need to duplicate capabilities even from country to country. Engineering groups are no longer co-located, thus, engineers have to do their job without ever seeing all of their collaborators. Whether designing a system or a component of some kind, the combination of talents from many sites within a company and at partner organizations, puts a premium on communication skills and understanding of other cultures (including business cultures).

5.2. Linda Sanford *(Senior Vice President, Enterprise on Demand, Transformation and Information Technology, IBM)*

Linda began her comments by recalling a topic of one of ECEDHA's earlier workshops – diversity. There have been several NAE studies of this issue, with a great deal learned and yet little has changed. She challenged us to make something happen this time. We need a sense of urgency. Globalization is here now and is real. In the past we had a wonderful reputation in engineering, but we need to continue to raise standards on ourselves or other countries will leapfrog past us. How are we going to educate the next generation of engineers for a global world?

To lay the groundwork for her comments she noted that the business era driven by cost cutting alone is now over. Growth will now be the driver and will, at least, balance strategic cost reductions. After more than 10 years of nothing but cutting, the number one topic in a recent IBM CEO report is growth. And yet, growth is very hard now. The odds of a company exceeding the growth of the overall economy are less than 10%. Companies are driven to go where growth opportunities and talent can be found. Growth can take us in to emerging markets like China and India. More organizations will also become people based, service businesses.

Companies have always changed with the times. In recent years, possibly the most significant overall trend has been the move to the globally integrated company from the multinational model. The many recent changes that have occurred at IBM serve as an excellent example. In the past, IBM was definitely an international, multinational company. After WWII, IBM built very self contained, self sufficient units in each national market (IBM Japan, IBM UK, etc.). Recently they have found this model to be far too cumbersome and complex. It is now possible to evolve into a globally integrated company – there are now skills emerging all around the world and high growth markets in the developing world. The WTO and free trade have helped, but the ubiquitous global network is the key to this change. They now leverage their global presence to go after growth and also to obtain operational advantage. Where are the right skills and the right talent? They looked at all of their units throughout the world and identified the best place for each function. Examples include a Center of Excellence for Procurement in Scotland; primary software labs in Toronto, San Jose, Austin and the UK; a Center of Excellence for the Shipping Industry in Scandinavia; purchase order operations consolidated in China, Hungary and India; and a Finance Center of Excellence in North Carolina.

The move to a globally integrated company involves the component business model framework in which business practices are broken up into components. Then each component is considered to see if it is critical to the business. Is the component something that has value? Components can be viewed as Lego blocks. Open industry standards make it possible to put the blocks together in many new ways that can change business processes. Technology allows the integration of middleware and open industry standards. The application of this model makes it possible to deconstruct and reconstruct businesses for enhanced productivity and profitability. Applications now drive everything – science, engineering, and technology for their own sake is not where it is at. Grid computing as an example of what one can do with open architectures. Collaborations like the *World Community Grid* (http://www.worldcommunitygrid.org/) are rapidly democratizing access to enormous computing power.

IBM has become service and people based showing that the next frontier in engineering is OR (Operations Research) based. OR is moving from the supply side to also address the demand side and replacing art with science to solve complex business problems. OR plus MBA plus sales people are now working together applying very disciplined engineering principles. In addition to moving into service, most growth will occur in developing countries (60% is expected for GE). All international companies are now focused, right down to their DNA, on competing in the developing world. China and India have huge talent pools. China is dominant in manufacturing while India is so in service because of the high level of English proficiency. China spends 8 times as much as India on infrastructure, so we are only seeing the tip of the iceberg in China

There is a new model of innovation that is open, collaborative, multidisciplinary and global. In the old model, power was based on what we know alone. New innovation will come from collaboration, but collaboration is tough. We need to learn to listen to one another and openly share ideas to get the best of everyone's thinking, not just the lowest common denominator (not just consensus). This approach requires diversity of disciplines beyond engineering, a diversity of people, and a diversity of experiences. The next generation of innovation leaders is already collaborative. How do we attract, retain and educate them? How should engineering education change to serve such people?

From the IBM experience, Linda has two key recommendations for ECE education. First, every major university should establish partnerships with universities in China and India. Exchange programs and year abroad programs exist, but more is needed. Second, use more technology in engineering education to reinvent education. Two industries have not embraced technology – healthcare and education. We should not be the last.

5.3. **William Aspray** *(Rudy Professor of Informatics, Indiana University; past Executive Director, Computing Research Association)*

William Aspray served as the executive consultant for the Association of Computing Machinery (ACM) Job Migration Task Force, which was commissioned to perform an analysis of information technology (IT) employment trends, particularly global migration of jobs. The report was released in January 2006. It involved 30 members from the US, UK, India, Germany, Sweden, Israel, Japan, and China, who provided analysis only from an international perspective, involving no new research, basically expert testimony, literature review, and expert members. It only addressed IT jobs related to programming, software testing, and software maintenance; high-end jobs such as software architect, product designer, project manager, IT consultant, and business strategist, as well as IT research and development. Dr. Aspray discussed some of the issues with collecting data, including problems with definitions (outsourcing, versus off-shoring; multinational or national/local, captive or independent, export or domestic market, etc.). He discussed the various reasons companies offshore, including reduced costs, access to skills and experience, time shifting, time to market, market access, ramping up/down, capital burn rate, and process improvement. Drivers for off-shoring include telecommunications, standardized IT, the pace of innovation, downsizing of corporations, venture capital, forced re-engineering, intermediaries, work process, higher education, free markets, immigration, English language and an aging population in first world countries. He also discussed several reasons companies choose not to offshore. Some of the disincentives occur when the job process is not routinized, when a job cannot be performed at a distance, when the infrastructure in the vender country is too weak, when off-shoring impacts negatively on the client firm's workplace, when there are risks to the client company in off-shoring the work, when there are not workers in the offshore company with the requisite knowledge, and when the cost of opening or maintaining the offshore operation is prohibitive.

An interesting set of statistics from Dr. Aspray's talk are given in Table 1, which shows a comparison of IT jobs in 1999 (close to the peak of the technology boom), and 2003. Contrary to what is perhaps common perception, the total number of IT jobs between 1999 and 2003 in the U.S. actually went up during this period rather than decreasing. The main losses, which are most likely associated with outsourcing, are programmers, database administrators and computer systems managers. This data clearly echoes some points made by other speakers, that, while routine or standardized jobs are in decline,. the overall IT job market remains strong.

Table 1. U.S. IT Jobs 1999/2003 (Bureau of Labor Statistics)

	1999	2003
Programmers	529	403
SE applications	289	410
SE systems	209	293
Computer support	463	481

Computer systems analysts	428	486
Database administrators	101	97
Network and systems admin	205	245
Network & data communications analysts	98	156
Computer systems managers	281	257
Hardware engineers	60	70
Total	**2688**	**2922**

5.4. Galen Ho *(Senior Vice President, Performance Excellence, BAE Systems)*

BAE Systems faces many of the same general challenges seen by other global companies: achieving cultural integration of languages and management styles, and generally finding the best approaches to working in a wide variety of local cultures. Trying to find common solutions that can help all or most customers is daunting. It requires seamless collaboration characterized by common practices, sharing of knowledge, communities of practice, communities of interest, expert locators and tools that permit the use of unstructured databases have to be able to go from data to information to knowledge and create intelligence. They also strongly emphasize mentoring; using senior people as teachers should be the focus of the last 5 years of their career.

Since they work primarily in defense, they have some additional challenges. How can people participate in knowledge management given security restrictions? One cannot have a help desk in India for defense work. National regulations and restrictions create impediments to global approaches. For example, foreign ownership of US companies may be limited or prohibited. First and foremost, it is necessary to be a national citizen in the countries where we work. We need to serve the country as well as the company in this business.

5.5. Steve Mezak *(Founder & CEO, Accelerance)*

Many small companies are under pressure from investors or stockholders to outsource at least some of their functions, so that they need to learn how to make it work productively for them. His company has created a network of partners available for such work. The open source movement has helped to establish strong technical capabilities in other countries but each company needs to find the right strategies for their specific business goals.

Based on his experiences in this business and as a student at WPI, where he was able to spend a term in London, he has several recommendations for our students and for us. For our students he recommends that they learn how to establish and maintain long distance relationships, learn about foreign languages and cultures (e.g. know holidays), and learn how to collaborate professionally. Students already use collaborative tools like Instant Messaging and Wiki now, but they need to address real collaboration. In addition, they should learn software and hardware development methodologies rather than just doing it directly (so called agile methods). He recommends that we do design projects with sister colleges in other time zones and countries, maybe even letting students outsource part of a project using freelancers (rent a coder), but he was not sure how this should be done.

5.6. ***Ahmad Bahai*** *(Chief Technologist, National Semiconductor)*

Dr. Bahai spent much of his career at Bell Labs before coming to National Semiconductor. Thus, his comments stem from his experiences in both organizations. He feels that innovation is the key in a global industry. It is not just the growth of competitive capabilities in other countries that requires innovation to remain in the game; old rules are also changing. Take Intellectual Property, for example. It now appears that patents enable competition. (A few kids in India with access to the internet and a few tools like Cadence and Synopsis can compete with you.) Patents used to provide protection but now they open up what you know to others.

The cycle of ROI (Return on Innovation) is very long and it is now very difficult to support a project with a 10-year cycle. Such cycles take a lot of patience and investment, more time that we think. His background is communication, so he offers several examples of ROI cycles from that fundamental ECE discipline, all of which had significant contributions from Bell. Satellite Radio took about 12 yrs and more than $2B to get to XM and Sirius and this technology is not a fundamental breakthrough. Fourteen years were required for wireless LAN to become ubiquitous. HDTV started in the mid-80s and is only now taking over the television business. In spite of what we have learned from these ROI cycles, everyone wants quick return on investment, even the government (DARPA).

Innovation now requires collaboration. It is essential that universities engage in interdisciplinary and multidisciplinary research. For example (from a discussion Ahmad had at Stanford) there is much benefit to be gained from combining biology with electrical engineering. However, universities have a hard time thinking that way. It has not been possible to get tenure by having 10 papers in 10 different journals in different areas. This model needs to change. Even in universities, research funding is too short term. The same pie is distributed among more faculty members so each piece is shrinking. How can innovation come out of this small grant model? Maybe the national labs can fill the same role as Bell Labs did previously, since at least some of their funding model appears to be longer term.

6. Academic Perspectives on Globalization

6.1. *Overview*

Various presentations were given from the perspective of academic institutions on the issue of globalization and engineering education. Such presentations included both plenary presentations as well as a panel discussion chaired by Joseph Bordogna, Deputy Director of NSF. The main challenge for educational institutions is how to educate students in engineering for competitive careers in a global economy. There are many issues that were addressed including the importance of broad and multidisciplinary engineering skills, leadership and communication skills, cultural awareness and international experience for students in science and engineering. The panel represented both engineering programs in private and public universities, as well as the viewpoint from the arts and humanities.

6.2. Lester Gerhardt *(Vice Provost and Dean of Graduate Education, Rensselaer Polytechnic Institute)*

Lester Gerhardt's plenary talk began with an analogy between the divestiture of ATT (and its monopoly on telephony), and US Universities, and their historical virtual monopoly on higher education. The landscape has changed dramatically over the past half century, where early on, US universities were the premier institutions for advanced degrees, but now face global competition from Europe and Asia in terms of students being graduated and perceived degree value. Europe and Asia now produce 3-5 times as many engineers as the US, and in Asia are paid at 20-30% of the cost of a US engineer. China has the most students in colleges and universities of any country, and has doubled the number of science and engineering Ph.D.s since 1996 to greater than 8000. Schools such as Tsinghua University in China, and the IITs in India have high international visibility. In both India and China, applications to US graduate schools were down more than 40% in the 2003 and 2004, although this has started to increase again. Elsewhere, increasing numbers of universities in Europe and Asia are offering degree programs in English to compete for international students. At the same time, enrollment in engineering in the US has been level, after declining by 15,000 students from 20 years ago. Most US undergraduate programs are predominantly populated by US students, while grad engineering programs in the US are more than 50% international, with decreased applications for graduate study seen in the US. This dependence on international students for US graduate programs, coupled with decreased applications and more competition abroad both in cost and quality of foreign education, poses a great challenge to US engineering programs.

Dr. Gerhardt's talk focused also on the need for globalization of education and the use of advanced distance learning technology to enable global education. Increasingly the world is becoming technologically borderless, with a globally interactive economy and a more distributed educational system. The idea of a global engineer is needed, and universities need to look at the need for balancing cooperation and competitiveness in addressing this global market for education. He discussed various distance learning modalities in use today, the increasing two-way nature of distance education technology between instructor and student, and the impact of future technologies such as wireless devices.

Another focus of his talk was on the need in the US for International Exchange experiences for students. While 96% of humanity lives outside of US borders, he pointed out that only 1.35% of Americans in higher education have any kind of international educational experience annually, only 0.04% of engineering students, which is much too small a percentage in an increasingly global environment. He went on to discuss various models of international exchange programs, the need for global quality assurance in such programs, and advocated the idea of international accreditation of programs. In the future he envisions a trend towards uniformity in international exchange programs, more diversity of the students entering such programs, and a particular focus on safety to make such programs more attractive. The standardization of educational programs in the EU through the Bologna Declaration, for example, will reduce some of the barriers for the transfer of credit and determination of equivalencies in courses and degrees. Language is becoming less of a barrier for US students as well, as many universities adopt English in educational programs.

Looking towards the future, he discussed the changing face of competition, from traditional campus based universities, to distance learning virtual universities (e.g. University of Phoenix, Open University) and industry based universities (e.g. Kettering, Motorola, etc.), and in particular the potential evolution of a global virtual university. US universities must decide whether to compete and/or cooperate in this evolution. In this context, he went on to discuss the required aspects of engineering higher education in terms of breadth and depth, flexibility, multidisciplinary skills, communications, language, leadership, entrepreneurship, and understanding societal impact. He also emphasized the responsibilities of universities, both cultural and technical, in integrating research and academic programs, matching global needs with degree objectives, educational outreach for both K-12 and professionals, and in promoting diversity.

In concluding, Dr. Gerhardt looked at selected issues such as engineering as a commodity or a profession, the conflict of decreasing technological time constants with longer cultural/societal reaction times, issues of privacy and security in the context of rapid technological change, the management of the global university in terms of a seamless flow of basic and continuing education, and the balance of cooperation and competition in global education.

6.3. ***Karen Kelsky*** *(Head, Department of East Asian Languages and Cultures, University of Illinois Urbana-Champaign)*

Karen Kelsky discussed the role of liberal arts in global education from her perspective in the Department of East Asian Languages and Cultures. There is increasing interest among engineering students in improving language skills, in particular East Asian languages such as Chinese and Japanese, due to the future importance of this region. In addition to language skills, cultural fluency is important. Knowledge of the history, religions and customs of different cultures is critical in developing global engineering, business and economic skills. Present graduates from engineering programs will at a minimum work with employees from other countries even in the US, and more likely, will be employed by global companies working on international teams, especially in high-tech fields, which will require sensitivity, and adaptability to succeed. Students in most electrical and computer engineering programs have enormous pressure in terms curriculum and lack flexibility to take a large number of elective classes devoted to foreign languages and cultural awareness. At the same time, there are strong budgetary pressures from most universities on liberal arts and humanities programs which are reducing program offerings and eliminating departments in some cases. Hence, there is strong motivation for joint partnerships between Engineering and Liberal Arts colleges in developing specially tailored programs in global awareness for engineering students (as well as other disciplines such as business, sciences, etc.) in preparation for global careers.

6.4. ***Sherra Kerns*** *(Vice President for Innovation and Research, Olin College)*

Sherra Kerns presentation focused on the need for educating engineers in a fundamentally different way, which was a founding principle for Olin College. A basis for her talk was the book by Daniel H. Pink, "A Whole New Mind, Moving from the Information Age to the Conceptual Age," which argues that in the future, right brain qualities will predominate. Presently, the engineering identity is a left-brained, disciplined, technically competent engineer that excels in dealing with numbers and things. She argued that in the future, engineers will have to become socially effective, whole-brained global citizen engineer with perspectives, ethics and values to advance technology and improve the lives of societies. Engineering educators need to recognize this in order to attract more students to engineering particularly students from diverse backgrounds that are historically underrepresented in the profession. Dr. Kerns discussed the Olin engineering curriculum, and its attempt to create a flexible, student oriented, curriculum to achieve such goals and its very effective emphasis on engineering as "hard fun."

6.5. ***Pradeep Khosla*** *(Dean of the Carnegie Institute of Technology (College of Engineering), Carnegie Mellon University)*

Pradeep Khosla's presentation began with a background on globalization, how companies have transformed from doing business globally to being global enterprises, thanks to computing and communications technologies. Manufacturing of products is already global and industry supported research and development is going increasingly global. There are several drivers, including the availability of trained human resources and usually a more effective cost basis. The ability to solve problems and develop products of local interest is also important for companies seeking entry and expansion in global markets. The IP provisions in foreign countries are also more attractive to companies in terms of off-shoring R&D; 50% of respondents to a 2004 Industrial Research Institute study indicated that they are funding research at foreign universities. 10 years ago about 40% of engineering work hours was within the US. By 2010, it is predicted that only about 10% of the engineering work hours will be based in US. Commensurate with this projection, India and China presently graduate about 15 times more engineers every year than the 65,000 in the US. At the same time, the cost of an engineering work hour in India/China is between 10%-20% of that in the US. As a result, routine engineering jobs are being outsourced at a very fast pace while downward pressure on salaries in the US will continue.

Dr. Khosla argued that at present, the 21st century university is still local, that education is local, not scalable, and relatively expensive. Research is also performed locally; and issues exist with IP (Bayh-Dole, tax free bonds etc). Students from all countries come to campus, but a decrease in the number of international graduate students is expected due to ITAR regulations and VISA issues. Future engineering graduates in the US will be required to operate in a global (multi-national and multi-cultural) environment and must appreciate the needs of the people where products are manufactured and sold.

The real issues, Dr. Khosla argued, are not that other countries are graduating more students, but at what point these countries will have the culture of the US that integrates research, education, economic development in a cohesive strategy, and compete head-to-head with the US success model; and when will foreign universities establish more economically affordable models for delivering education within the US and to US students within foreign countries. Since this will happen, how should a university respond to this threat?

Carnegie Mellon's response is to rethink how to educate undergraduate and graduate students so that they are able to compete, succeed, and lead in the new global business environment, to rethink education to create the "Carnegie Plan for a Flat World," i.e. managing innovation in a global multilingual and multicultural environment, coupled with a holistic education. CMU's strategy is to take the culture of CMU graduate education and R&D to foreign countries by creating a collaborative and scalable research and education infrastructure, to capitalize on the R&D investment of foreign governments and industry, and to offer opportunity to graduate students and faculty to operate globally and in diverse cultures. The goal is to create more visibility for Carnegie Mellon. Global partnerships greatly enhance competitiveness for corporate research by U.S. companies. Therefore, CMU's goal is to be seen as a global research and education partner. The current CMU strategy is currently focused around CMU`s key strengths – CyberSecurity and System-on-a-

Chip technologies. Some examples in Cybersecurity and IT include the CyLab Athens – offering a MSIN (MS in Information Networking) degree thru the INI (Information Networking Institute), CyLab Korea – focused on research with investments in Korea and Pittsburgh, CyLab Japan – which offers MSIT-IS (MS in Information Technology – Information Security) degree in Kobe Japan. (See http://www.cylab.cmu.edu/default.aspx?id=1) In terms of SoC, there is the ITRI Lab@Carnegie Mellon which is focused primarily on research. Other CMU examples include the Carnegie Mellon Qatar Campus (CS and Business), and the Carnegie Mellon Heinz School Campus in Adelaide, Australia.

7. Breakout Session Summaries

7.1. Overview

Following the presentations by the plenary and topical speakers, the workshop participants organized into three breakout groups to address the educational response of ECE programs to the issue of globalization. Each group was given a series of questions to address and were encouraged to be creative.

7.2. Breakout Session 1: Global Awareness

Participants: Richard Blahut, UIUC (co-chair)
Stephen Goodnick, ASU
Lloyd Harriott, UVA
Bob Janowiak, ECEDHA
Fred Looft, WPI
Stephen Phillips, ASU (scribe, co-chair)
Frank Splitt, IEC, Northwestern
Bruce Wessels, Northwestern

What are the current issues, problems, and opportunities for students and faculty in ECE relative to Global Awareness? What incentives make us want to address these issues?

A motivation for considering global issues is the recent off-shoring of software and information technology jobs to Asia, especially India. In ECE the off-shoring of integrated circuit manufacturing is largely under way. It appears that off-shoring of circuit design is now beginning, enabled in part by the high degree of standardization of design tools coupled with a highly capable workforce. ECE students and faculty are, in large part, not sensitive to specific cultural differences in economic, political and business practices. These topics form an important part of the professionalism of our students, a key factor in the competitiveness of our graduates.

Obtaining faculty and administration buy-in for inclusion of global awareness in ECE curricula is an expected obstacle. Additionally, the general failure of K-12 education to inspire the best students and guide them into engineering reduces our ability to excel in global awareness. Providing lifelong education in ECE requires the inclusion of global awareness in order to keep pace with the quickly changing landscape of worldwide business.

What are some of the existing best practices in the area of global awareness?

A suite of educational programs should be developed within the liberal arts colleges of our universities that will enable our engineering students to select a level of global awareness suitable to their educational goals. Some engineering schools may desire to make at least one of these programs described below a requirement. The suite may include a four year course sequence in Chinese, Korean or Japanese for engineers, an international study abroad program, a single course on global awareness, and an opportunity to collaborate through distance programs to enable a senior design experience.

The one semester course on global awareness will consist of the following items: Overview of the history of Asian culture, Asian business practices and social customs, language and alphabet overview. The student will be able to identify written Asian languages, recognize numbers and simple signage, understand social situations and etiquette, participate in polite conversations about Asian history and politics, understand business structures and intellectual property expectations.

The collaborative distance program will be a senior design project constructed jointly by students at a U.S. university and a student at an Asian university communicating by electronic means.

The study abroad program already exists in many forms and at many universities. Our expectation is that the NSF undergraduate research experience program can be expanded to include international components, perhaps in cooperation with NSF-like entities in other countries.

The four-year course in Asian language for engineering and business students will consist of the usual intensive language experience, possibly rescheduled to fit the usual three-day engineering curriculum.

Because most engineering curricula are flexible, these four options allow each student to design an appropriate and individualized course of study. The course work should be taught within the liberal arts colleges because this where the expertise is. Consequently, there must be collaborations in course development between engineering and liberal arts.

How should the ECE curriculum overall be redesigned to enhance global awareness?

A modern engineering curriculum should be a mixture of fixed fundamental courses and flexible elective courses, approximately one half of each kind. The elective courses should be weakly constrained with regard to area and sequencing. For example, there should be constraints on the number of in-department courses and the number of out of-department courses. There should be an emphasis on breadth with some emphasis on depth in a single area. This is the T model of engineering education. It is the model that supports the evolution of a systems engineer. Breadth is essential so that systems engineering has some understanding of all aspects of a large, multifaceted system. Depth in a single area, perhaps not even relevant to a given project, is important so that the systems engineer is fully aware of the level to which a specialization must reach.

The modern electrical and computer engineers must be fully immersed in the fundamentals of their engineering discipline subject and the fundamentals of physics and mathematics including calculus and discrete mathematics. These are foundational and go beyond simply the content of these subjects. Within the learning process, properly mentored, these subjects teach patterns of thought and creativity that go beyond the actual factual content. It is also a part of the culture of the engineering discipline and a student who has not been exposed to the fundamentals will be encumbered throughout the career.

Furthermore, a modern curriculum should promote professionalism, entrepreneurship, and business sense. Part of this should come from mandatory humanities courses that read and analyze the classical literature. The current practice of effectively eliminating humanities from the curriculum by the advanced-placement system must be dissuaded since a university-level humanities course is essential to professionalism and to the later twenty years of an engineering career, years of leadership that must be guided by a strong sense of values. Professionalism refers to leadership to advancing the national and comparative agenda, to advocacy of the views of the community. Familiarity with the humanities is the long-standing means to this level of professionalism. Among the optional study tracks that students can elect there should also be a track in international management taught by the business school.

7.3. Breakout Session 2: Technical Skills for Global Engineering

Participants: T.E. Schlesinger, Carnegie Mellon University (Co-chair)
Mohamed Chouikha, Howard University (Co-chair)
James Peterson, Montana State University
Maurice Aburdene, Bucknell University
Gordon Silverman, Manhattan College
Anil Pahwa, Kansas State University
Ashok Iyer, Virginia Commonwealth University
Bing Chen, University of Nebraska
Eva Wu, SUNY Binghamton
Ken Jenkins, Penn State University
Yaobin Chen, Indiana University Purdue University Indianapolis

Globalization has caused and continues to have three primary effects on the field of electrical and computer Engineering. These include the transfer of lower value added or routine engineering tasks outside the U.S., the acceleration of change in the engineering landscape and hence job functions, and a diversification of the types of careers that engineers pursue. The preparation of students who will remain marketable, adaptable, and able to provide higher value-added functions requires the education of engineering students in areas and in a manner that reaches well beyond the traditional constrained curriculum.

We take it as a given that the traditional skills and fundamental components of an ECE program will be included in any program (Math, Science, core engineering, etc.). Questions that relate to the standard or traditional parts of a typical ECE curriculum include:

- Will these traditional parts of the curriculum be outsourced to teachers outside the U.S.?
- Will these be outsourced to lower cost or more expert teachers within the U.S.?
- Will these be taught prior to college entry via modules, via web, via distance learning, or in K-12? What will be the assessment methods to ensure quality of content and delivery?
- Should our faculty focus on greater value-added (specialized) courses?

While we may or may not advocate outsourcing the teaching role this may inevitably happen and we need to be prepared to meet this possibility.

To meet the challenges of a global quickly changing marketplace for engineers an ECE curriculum should first and foremost provide the flexibility for students to pursue programs tailored to their skills and career interests. In addition to flexibility ECE programs should include the following elements:

- Breadth and depth
- A hands-on project orientation beginning in the first year (a natural advantage)
- Systems perspective/System Engineering approach/Constraints (e.g. cost)
- Integration across courses
- Management of a team and project, and innovation
- Design at a distance project (work in teams across the U.S./World)
- Ability to quickly expand into non-traditional ECE disciplines (bio, etc.)
- Adaptability to change (lifelong learning as a mechanism to retain lifelong employment

In addition content should be included in ECE curricula that cover topics including: 1) business awareness and skills, 2) an understanding of companies, their organization and management, 3) economics, 4) off-shoring vs. globalization, and 5) entrepreneurship. In adding new materials and areas to the ECE curriculum we should ask the question as to what topics currently taught at universities can be included as part of standard K-12 curricula (introduction to circuits, calculus, physics) that is not taught today. We also feel that it is important that U.S. universities develop partnerships with non-U.S. institutions. NSF should support programs that benchmark U.S. institutions and curricula against our non-U.S. competitors (i.e. what are their advantages, constraints, etc.).

Finally, in anticipation of U.S. engineers moving to higher value-added job functions we feel it is important to have an emphasis on what may be termed soft skills. These include: 1) communication and leadership, 2) culture, history, language of other societies, 3) role of the engineer in U.S. and global society (engineer as a societal leader), 4) ethical and moral issues, and 5) international experiences (academic and industrial exchange programs).

7.4. *Breakout Session 3: Recruitment and Retention of Students and Faculty in the Face of Globalization*

Participants:
Patricia Arnold
Vijay Bhargava
Ken Connor
Gurdeep Hura
Can Korman
David Lowther, McGill (Co-chair)
Pamela Leigh-Mack
Sami Mourad
Pritpal Singh
Mark Smith, Purdue (Co-chair)

The following questions were addressed in Breakout Session 3:

- What are the most important issues affecting ECE recruiting in a global economy?
- ECE departments have not aggressively recruited undergrad students. Should this change significantly?
- Should ECE departments be recruiting from non-traditional pools of students?
- Are there new kinds of recruitment activities that should be tried?
- What message should we give to prospective students (undergrad and grad) and faculty regarding the EE and CE professions in a global economy? What message should we give to the general public?

Faculty

The problem with faculty recruitment and retention is a longer term issue than the recruitment and retention of students. Increased competition from improving standards in overseas universities will become serious over the next decade

Graduate Students

Competition is increasing and incentives in terms of scholarships, etc. are improving in China, India, and at the same time the U.S. is no longer as attractive as it once was. Good home schools pull off the best students AND there are jobs in the home countries. Also, a lot of students seem to be staying home to do MBA's. In the future the U.S may not get best foreign students

U.S. institutions need to develop improvements in attractors such as establishing more scholarships. We need to find creative way to address this. Maybe we should use undergraduate international exchanges as a way to recruit future graduate students.

Undergraduate Recruiting

An important question is does the general public understand what an electrical or computer engineer is and how our graduates can contribute to the improved quality of our daily lives? Is the visibility of our profession good enough, and does the general public understand who and what we are? Unfortunately the dotcom bust of the early 2000's had a negative effect on the image of electrical and computer engineering that was more detrimental than it should have been. ECE educators need to work to overcome this negative image, and to get a message out that in many ways EE and CE are students among the most flexible engineering graduates. One approach is to leverage IEEE publicity and to use the web to achieve a higher profile on Google. We also need to gain better access to the press to help us present a more positive image of the engineering profession to the public.

One of the major deterrents to beginning students in an EE or CE curricula is that the first semester is very challenging. This message goes home at thanksgiving and has a negative effect on future students. Can we add more social relevance to curricula so it becomes more attractive to women and minorities? Can we improve peer mentoring through outreach experiments from which we can we accumulate/analyze data?

Finally, NSF has already done some things to help change the culture in the K-12 education system, such as the K-12 outreach programs associated with NSF Engineering Research Centers and with the recently initiated Research Experience for Teachers (RET) program. NSF should be encouraged to continue to sponsor programs that have potential to reach young students with positive messages about careers in science and engineering.

Undergraduate Retention

It is important for ECE educators to address the question of how to make our programs more attractive and more fun. This can be done through proper curriculum development by adding international perspectives and encouraging exchange programs. But how do we get the message to the students early and retain the fun all the way through their university careers? Perhaps this is a topic on which NSF should sponsor a future workshop where many innovative ideas could be proposed and evaluated.

Although it was an outlying point of view, some of the workshop attendees expressed a belief that we should do away with the semester and quarter systems completely and replace them with intensive design projects that begin every few weeks. The question was also floated as to whether the tenure system is a disincentive to changing our traditional approaches to undergraduate teaching and learning. Presently there seem to be no real rewards for experimenting in these educational areas, since in the traditional academic department educational research does not generally help a young faculty member achieve tenure.

Finally we need to look at new pedagogies for EE/CE education. Innovative programs at Virginia Tech and Olin College were cited as examples of new pedagogies that are worthy of further

8. Workshop Summary and Action Items

8.1. Recommendations to Prepare ECE Students for a Global Economy

8.1.1. International Student Experiences

ECE programs should strive to provide some kind of international experience for every student. Such an experience does not have to involve travel abroad, although that is clearly preferable. Student exchange programs should be implemented with Asia, Latin America and Africa. ECE departments should encourage international capstone design projects, international industry internships and international management programs. Other joint activities (research, outreach, curriculum development, etc) are also encouraged.

8.1.2. Cultural Education

ECE students should learn more about a wide variety of cultures, with components that are both societal and corporate (company cultures around the world). ECE programs should work with liberal arts and business departments to develop specific courses, sequences and minors in global economic, political and business practices. In light of the existing pressures in the software industry, a review of best global awareness practices in that community should be undertaken and their relevance to ECE investigated.

8.1.3. Collaboration and Multidisciplinary Experiences

All ECE programs must include significant collaborative experiences and engage modern collaboration tools. Multidisciplinary and interdisciplinary projects and courses must be worked into all programs. For such experiences, at least some aspects of the collaboration should require students to work with collaborators at another physical location so that they are rarely, if ever, able to meet in the same place. Students must also work with other engineering disciplines, business, liberal arts, and other disciplines we have traditionally seen as very separate from engineering.

8.1.4. Service and People Oriented Educational Experiences

Students should be provided with experiences that prepare them for the service business. This likely requires a systems viewpoint that is a key fundamental area in ECE, but has not been applied in this general direction. Companies need people who can see the big picture and integrate total solutions that bring customer satisfaction.

8.1.5. Technology in Education

ECE education has embraced both software and hardware tools, but it has not fully embraced the effective use of technology. ECE education is challenged to not be the last industry that does so. Fortunately, intense international competition is a serious stimulus to move forward rapidly to embrace the use of technology in ECE education.

8.2. Action Items for NSF

A distillation of many different ideas presented, analyzed and evaluated at the workshop resulted in the following proposed action items for NSF:

8.2.1. International REU Programs

NSF should devote funds and publicity to an International Research Experience Undergraduates (REU) program in which U.S. students can complete research in another country and international students complete research in the U.S. Currently NSF REU programs restrict participation to U.S. citizens and Permanent Residents.

8.2.2. Cooperative International Programs

NSF should establish high-level relationships with the corresponding institutions in other countries to enable multi-country funding of international research and student programs. The International Engineering Consortium could help coordinate this effort.

8.2.3. Benchmark Studies with Foreign Institutions

The National Science Foundation should consider supporting a study to benchmark U.S. institutions/curricula vs. non-U.S. systems.

8.2.4. Development of Model Curricula

NSF should consider sponsoring a workshop to develop model curricula and components (new courses/modules) for such a curricula.

8.2.5. Making ECE Programs More Attractive

NSF should consider sponsoring a workshop to address the question of how to make ECE programs more attractive and more fun to potential students, including K-12 students.

8.3. Action Items and follow-up activities by ECEDHA

8.3.1. Invited Sessions at the 2006 and 2007 National ECEDHA Meetings

It was recommended through the outcomes of the workshop that progress toward implementing the recommended actions should be reported at the annual ECEDHA meetings. Consequently at the Annual ECEDHA meeting in March 2006 a special session was organized entitled "Panel Session I – Globalization" in which results of the 2005 ECEDHA/NSF Globalization Workshop were reviewed for the benefit of the entire ECEDHA membership. This panel was moderated by Ken Jenkins (Pennsylvania State University) and the panel consisted of Ken Connor (Rensselaer Polytechnic Institute), Steve Goodnick (Arizona State University), David Lowther (McGill University), Ed Schlesinger (Carnegie Mellon University), and Steve Phillips (Arizona State University). The next follow-up occurred at the Annual ECEDHA meeting in March 2007 when a second special session was organized entitled "Plenary Panel IV - International Strategies - What are They Doing in Europe, Asia, and The Americas?" This second panel session was once again moderated by Ken Jenkins (Pennsylvania State University) and the panel consisted of Lester Gerhardt (Rensselaer Polytechnic Institute), Gary May (Georgia Institute of Technology), Victor Debrunner (Florida State University), and Magdy Bayoumi (University of Louisiana at Lafayette). The purpose of this second panel session was to develop a perspective of how globalization was being handled by institutions outside of the United States. The panelists were selected to participate in this session because each of them had extensive international experiences with institutions in different parts of the world.

8.3.2. Second ECEDHA/NSF Workshop on Globalization: Implementation

The 2005 ECEDHA/NSF workshop on globalization began with collecting a considerable amount of background information and then digesting this information in breakout sessions. Since some things have changed since the first workshop the second workshop will start with an update session to determine where things currently stand with regard to globalization of the ECE profession. Tom Friedman has updated his book and we are now in a position to gather more information on how companies are doing with outsourcing. Updated information on the current ECE job market will also be gathered.

The second area of concentration will be to hear from working engineers as to what their present jobs are like under the influence of globalization. During the first workshop we heard from managers, but in the second we will hear more from people with on-the-job engineering experiences. We will attempt to accumulate information about whether or not ECE dominated companies are good places to work and what daily life is like for engineers working to develop small start-up companies.

Outreach will be a third topic to be highlighted in the next workshop. There will be an attempt to accumulate information about the types of outreach activities in which ECE Department are currently engaged. This activity can build on the ECEDHA-related web site that is now maintained at Oregon State University. The second workshop will also build on the NAE themes that resonate with prospective students and their parents. (e.g. Engineering is essential to our health, happiness and safety).

The forth topic that the second ECEDHA/NSF workshop will dwell on is how to enhance the total ECE educational experience. The question of how the ECE educational experience can be improved to attract and retain the best student body will be central to these discussions.

Finally, a fifth area of emphasis will be an effort to better understand the forces that are luring students away from ECE and toward Mechanical, Biomedical and Civil and Environmental programs. An effort will be made to better understand the factors that lead students in these directions and new strategies will be developed to attract more students to enroll in Electrical and Computer Engineering programs.

9. References

[1] Thomas L. Friedman, *The World is Flat*, Farrar, Straus and Giroux Publishers, 2005.

[2] Thomas L. Friedman, *The World is Flat*, Farrar, Straus and Giroux Publishers, 2006 (updated and expanded edition).

[3] *Engineering Research and America's Future* (NAE 2005): Committee to Assess the Capacity of the U.S. Engineering Enterprise.

[4] *The Engineer of 2020*, the National Academy of Engineering Press*, 2004*.

[5] *Educating the Engineer of 2020,* the National Academy of Engineering Press*, 2005.*

[6] *Rising Above the Gathering Storm*: Energizing and Employing America for a Brighter future (NRC/COSEPUP, 2005)

10. Workshop Agenda

Globalization Effects on ECE Education for the Engineering Profession Workshop
November 13, 14, 15, 2005

<u>Sunday, November 13, 2005</u>
Sheraton Premiere Tyson's Corner
8661 Leesburg Pike, Vienna, VA

5:30 pm – 7:00 pm
Registration and Welcome and Reception

<u>Monday, November 14, 2005</u>

National Academy of Engineering
2101 Constitution Avenue NW

All Sessions in Room NAS 150

7:30 am *Continental Breakfast*

8:15 am *Welcome*
Kenneth Jenkins, The Pennsylvania State University

8:30 am – 9:15 am *Keynote Address*
William Wulf, National Academy of Engineering

9:15 am – 9:45 am *Plenary Address*
Linda Sanford, IBM

9:45 am – 10:00 am *Break*

10:00 am – 11:30 am *Industry Panel*
Chair: Kenneth Connor, Rensselaer Polytechnic Institute
Panelists: Ahmad Bahai, National Semiconductor
Steve Mezak, Accelerance
Galen Ho, BAE Systems

11:30 am – Noon *Plenary Address*
Richard Buckius, National Science Foundation

Noon – 1:15 pm *Lunch*

1:15 pm – 1:45 pm *Plenary Address*
Lester Gerhardt, Rensselaer Polytechnic Inst.

1:45 pm – 2:30 pm *Plenary Addresses*
Gary Gabriele, National Science Foundation
Usha Varshney, National Science Foundation

2:30 pm – 3:00 pm *Break*

3:00 pm – 4:30 pm *Academic Panel*
Chair: Joseph Bordogna, University of Pennsylvania
Panelists: Sherra Kerns, Olin College of Engineering
Lester Gerhardt, Rensselaer Polytechnic Ins.

Karen Kelsky, University of Illinois
Pradeep Khosla, Carnegie Mellon University
William Aspray, Indiana University

4:30 pm – 5:00 pm *Wrap up*

6:30 pm *Reception, Dinner & Plenary Address*
Sheraton Premiere Tyson's Corner
Eugene DeLoatch, Morgan State University

Tuesday, November 15, 2005
National Academy of Engineering

7:30 am *Continental Breakfast*

8:15 am – 8:45 am *ACM Report on Globalization and the Offshoring of Software Services*
Room NAS 150
William Aspray, Indiana University

8:45 am – 9:00 am *Breakout Session Instructions*

9:00 am – 10:30 am *3 – Breakout Sessions*

A. *Global Awareness*
   Room NAS 150

B. *Technical Skills for Global Environment*
   Room NAS 142

C. **Recruitment and Retention of Students and Faculty in the face of Globalization**
   Room NAS 146

10:30 am - 10:45 am *Break*

10:45 am – 12:15pm *Breakout reports*
Room NAS 150

12:15pm – 1:30 pm *Lunch*

1:30 pm – 3:00 pm *Report preparation*
Room NAS 150

3:00 pm – Adjourn