

AC 2008-437: GLOBAL ENGINEERING EDUCATION IN THE AMERICAS: CHALLENGES AND OPPORTUNITIES

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Global Engineering Education in the Americas: Challenges and Opportunities

Abstract

There is an urgent call for changes in the educational model in the Americas to facilitate the formation of world class engineers for the 21 century described as a leader, visionary, and entrepreneur, committed to the social environment and with a clear sense of the common good; an engineering capable of creating new companies, being competitive in the global market, and bringing economy growth to the region. This call for a change in paradigm in engineering education to educate engineers with global competencies is coming from all sectors, and clearly requires defining and facilitating experiences that would result in the formation of world-class engineers for the Americas. This paper reports the education challenges and opportunities in forming global engineers for the Americas, as discussed in a recent workshop sponsored by the National Science Foundation (NSF) and the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), where professionals, scholars, researchers and students from the Americas met to exchange ideas and experiences, explore research opportunities, and develop international collaboration. The outcomes and recommendations from the working groups as well as the future actions suggested are discussed in this paper.

Introduction

The Engineering for the Americas (EFTA) initiative is an academic, industrial and government grass roots effort that has evolved over the past five years. Its aim is to enhance engineering and technology education in the Western Hemisphere, and to strive for mutual recognition of engineering graduates across national boundaries and cross-border trade agreements, facilitating the flow of work and human resources throughout the hemisphere to optimal locations for distributed economic development¹. The IV Summit of the Americas recognized the importance of the initiative and the Organization of American States (OAS), Engineering for the Americas (EFTA), the U.S. Trade and Development Agency (USTDA) and World Federation of Engineering Organizations (WFEO) organized the Engineering for the Americas Symposium² at the end of last year in Lima, Peru. The Symposium focused on the needs of the productive sector for engineering graduates and capacity building; quality assurance in engineering education; and national planning for financing of upgrades to engineering education. The Final Report² calls for educational reforms at the regional level that include the needs of the productive sector and preparing new engineers with attributes certified by transparent accreditation systems, which will further professional mobility, investments levels, and therefore economic development. The Final Report² urges the academic sector to boost its collaboration with industry to develop a change in paradigm to educate the engineers of the 21st Century, which they describe as world class engineers, leaders, visionaries, and entrepreneurs, committed to the social environment and with a clear sense of the common good; an engineer who helps to create himself/herself, not look for work but create it.

In 2004 the National Academies published *The Engineer of 2020*³, followed in 2005 by *Educating the Engineer of 2020*⁴ in 2005. The National Academies was asked by representatives

of the U.S. Senate and House of Representatives to formulate strategies policymakers could propose so the U.S. can successfully compete, prosper, and secure the global community of the 21st century. The resulting report, *Rising above the Gathering Storm*⁵ was published in 2006.

In June 2006, the American Society of Engineering Education International Division⁶ met and expressed concern that Educating the Global Engineer was not a strategy presented in the National Academies report *Rising above the Gathering Storm*, and will be organizing sessions at the next ASEE annual conference on this topic.

This urgent call for a change in paradigm in engineering education to create the Global Engineer, and in particular the Engineer for the Americas, is coming from all sectors, and clearly requires defining and facilitating experiences that would result in the Global Engineer. The members of the ASEE International Division⁶ have expressed concern that defining what educational experiences are needed to produce a Global Engineer was not included in the National Academies *Rising above the Gathering Storm* strategies. The Engineering for the Americas Symposium's Final Report² urges the academic sector to develop a change in paradigm to educate the Engineer of the 21st Century, and in particular to focus on this Hemisphere. The European Union has defined and facilitated multi-national educational experiences important to capacity development in their area, but this has not been done for this Hemisphere. This brings political, economic and cultural challenges that must be explored and resolved.

Therefore, this workshop brought together scholars, professionals from the private industry, representatives from government agencies, and students from the countries of the Americas to exchange ideas and experiences, explore research opportunities, develop international collaboration, and share resources with the ultimate goal of educating world class engineers for the Americas.

Background

The establishment of new regional economic alliances beyond the frontiers of a single nation has required that engineers be prepared to work in an economy that is now best seen as essentially international in nature. Almost all major corporations now operate globally, and engineers are being challenged to design and develop, in a timely manner, new products that will impact a global market⁷. Due to this tendency, future engineers will be facing the new worldwide market where the barriers of the corporate world are disappearing. The global engineer must understand and accept diversity, be able to work in multi-national corporations, be able to work in multi-cultural teams, be able to propose solutions to problems impacting a wider and more diverse population, be able to communicate and socialize with people from different cultures, be able to use the technology to exchange ideas, solve problems and present solutions⁸. On the other hand, there is an increasing perception of the need for graduates of engineering to be creative thinkers and innovators from industry and professional associates⁹. Additionally, it is evident that technology is a predominant force in transforming underdeveloped regions into prosperous and high tech areas¹⁰. The transformation of Silicon Valley can be cited as an example, as well as the technological revolution experienced by many Asian countries such as Singapore, China, Taiwan, Korea and Japan where the investment and development in technology has transformed the economy and lifestyle of those countries. Finally, in recent years, fostering entrepreneurship

has become a topic of the highest priority in public policy throughout most industrial countries. This trend can be attributed to the growing awareness that new firms are a driving force of economic growth and job creation¹¹. As a result, the engineering entrepreneurship has become popular in many academic institutions due to the necessity of training the student to combine the technical knowledge with the business background for product conceptualization, innovation and design, technical feasibility analysis, and market research and analysis¹².

It is evident that there exists a common ground where the engineering design, the international experience, the creativity and innovation, and the engineering entrepreneurship melt together as fundamental foundations for the technology progress necessary for economic development as depicted in Fig. 1.

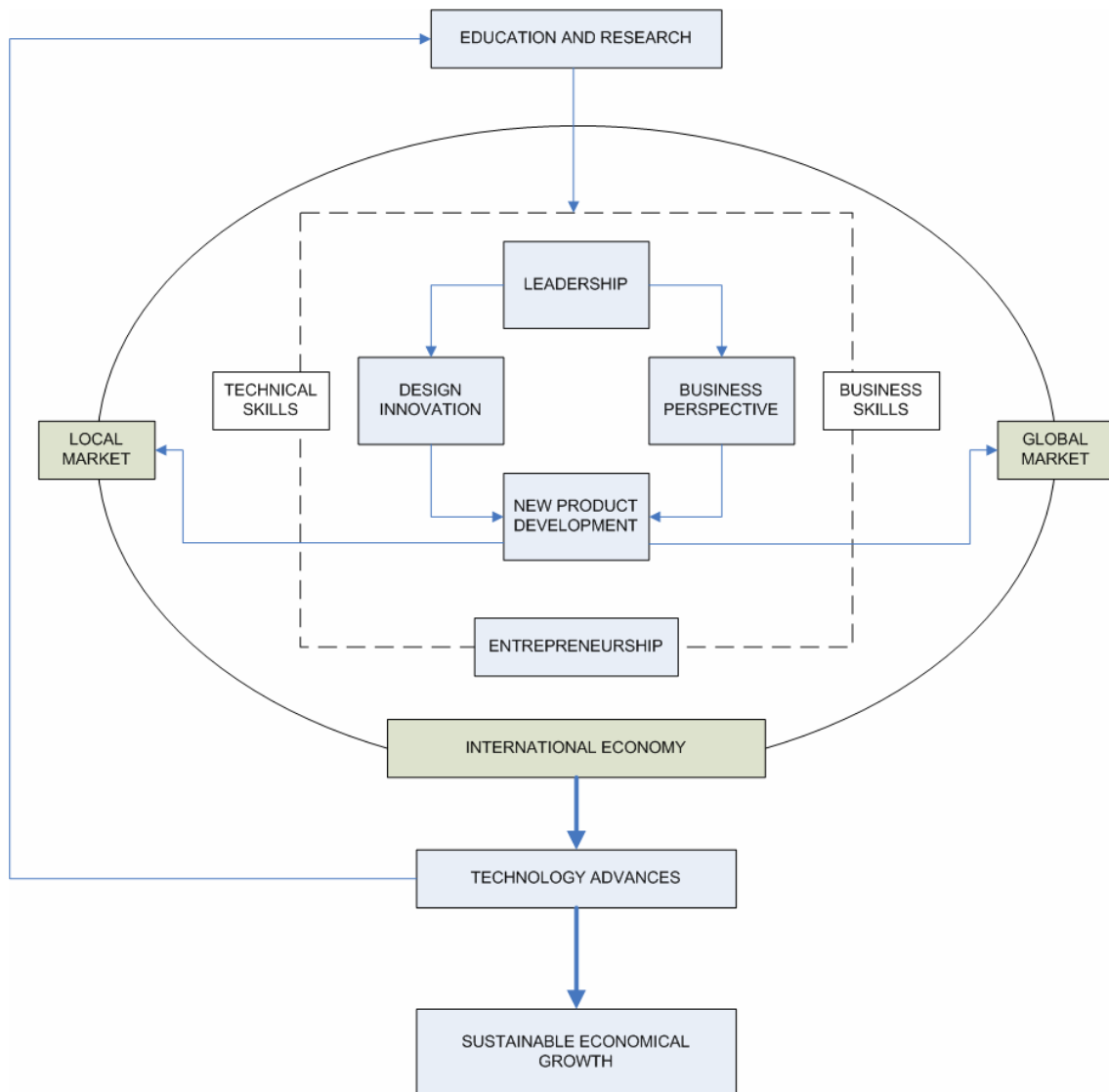


Figure 1. Model of IDEAL (Innovation, Design, Entrepreneurship, And Leadership) education integrated with a global perspective

New financial models, where free trade agreements are being established in different regions, demand the formation of engineers with solid technical formation capable of working in cross-disciplinary and multinational teams. The new engineers for the Americas should be aware of the global nature of their profession, be versatile, creative and effective leaders to make the individual nations competitive and the new economic blocks sustainable and strong. This has been recognized in many developed countries and a great effort is being made to provide that formation for the new generation of engineers. Technology development is obtained mainly by investing in education and research to recruit and prepare the future engineers for discovering and implementing new advances in science and engineering. However, it has been observed that while universities in developed countries are teaching global design, engineering entrepreneurship, and forming alliances and consortiums to establish international collaborations, most of the educational institutions in Latin America and the Caribbean are behind in this type of initiative, with practically no engineering design and entrepreneurship courses, and few international projects. This lack of formation of Latin American and Caribbean engineers in the critical issues affecting the global market makes it difficult to generate a technology revolution in these countries, placing the whole region at a disadvantage compared to other regions.

Therefore, recognizing the importance of technology in the progress of underdeveloped regions, and understanding the role of the future engineers in the advancement of technology, it was suggested to offer a workshop as a forum for exchanging best practices, creating networks for international engineering educational experiences involving the Americas (research project collaboration, design projects collaboration, entrepreneurial project collaboration, and international internships) and sharing resources for promoting engineering design, innovation and entrepreneurship in the engineering institutions of the Americas.

Workshop Program

The NSF sponsored workshop entitled The Global Engineering Education Challenge for the Americas was held in Tampico, Mexico May 29 – June 1, 2007 co-located with the 5th LACCEI Conference on Latin American and Caribbean Conference for Engineering and Technology. The aim of the workshop was to explore paradigms for building capacity in global engineering for the Americas. The long term goal is to provide an enduring mechanism to promote education, research and practice in global engineering design, innovation, and entrepreneurship for the formation of engineers in the Americas.

Since the workshop was co-located with the 5th Latin America and Caribbean Conference for Engineering and Technology held from May 29, to June 1 2007, the first day was devoted exclusively to the pre-conference workshop whose agenda is presented in Table 1. The topics covered in the pre-conference meeting were identified by the thematic team as critical subjects in developing the competencies and skills necessities for the future engineers in the Americas. The conference that followed had specific tracks related to the objectives established for the workshop. Participants were encouraged to participate actively not only the first day but also during the other activities and sessions offered in the conference. The overall program for the conference is summarized in Table 2.

Table 1: Workshop program

TIME	Tuesday May 29	
8:00a – 8:30a	Registration	
8:30a – 8:45a		Introduction
8:45a – 10:15a	Session 1	World Class Engineers for the Americas: Competencies, Challenges, and Opportunities
10:15a – 10:30a		Break
10:30a – 12:00n	Session 2	Entrepreneurship in Engineering Education
12:00n -1:00p		Networking Lunch
1:00p – 2:30p	Session 3	Engineering Leadership Education
2:30p – 2:45p		Break
2:45p – 4:15p	Session 4	Global Service Learning in Engineering
4:15p – 4:30p		Break
4:30 – 5:45p	Session 5	Focus Groups: Curriculum Development, Research and International Collaboration Opportunities in the Americas

Table 2: LACCEI Conference program

TIME	Wednesday May 30	Thursday May 31	Friday June 1
8:30-9:0	Welcome - Opening Ceremony	Plenary Keynote Speaker: Engineering Entrepreneurship Education	Plenary Panel: Sustainable Growth Initiatives & Service Learning
9:00-9:30	Plenary Keynote Speaker: Global Engineering & Economic Development	Plenary Panel: Small Business & PYME Profile of Engineer for Small Businesses	
930-945	Plenary Panel: Global Initiatives from LAC Engineering Education Organizations. Engineering for the Americas	Break	Break
9:45-10:45		Parallel Sessions: Technical Papers	Parallel Sessions: Technical Papers
10:45-11:00	Break	Break	Parallel Sessions: Technical Papers
11:00-12:30	Parallel Sessions: Technical Papers	Parallel Sessions: Technical Papers	
12:30-13:45	Networking Lunch	Networking Lunch	Closing Ceremony
13:45-14:15	Plenary Speaker: LACCEI Meeting the Funding Capacity Challenge for Global Engineering Collaboration	Plenary Keynote Speaker: Accreditation and Quality Assurance	Post Conference Tutorials

14:15-15:15	Plenary Panel: LA GRID Researchers and Scholars Summit	Parallel Sessions: Technical Papers	Plenary Panel: Accreditation Initiatives
15:15-15:30	Break		
15:30-17:00	Parallel Sessions: Technical Papers	Break	
		Parallel Sessions: Technical Papers	Panel: Curriculum Revision to Competencies / Outcomes
17:00-17:15	Break		
17:15-18:00	LACCEI Focus Groups	LACCEI Focus Group	
18:00-19:30	Poster Session. Exhibit and University Fair Opening and Industry Reception	Award & Gala Dinner	
20:00-22:30			

This workshop was developed with broad participation of administrators and faculty from several universities in the US and Latin America, and the involvement of industry and government partners, all of whom have a mutual interest in identifying, defining, and facilitating educational experiences for developing global competences important to educate world-class engineers for the sustainable growth of the Americas. This meeting brought together researchers, instructors, students, professionals and administrators from academic institutions, and industry located primarily in the U.S., Latin America and the Caribbean.

In total 71 participants attended the workshop coming from Antigua and Barbados, Argentina, Brazil, Colombia, Dominican Republic, Ecuador, Honduras, Mexico, Peru, Puerto Rico, Spain, Trinidad and Tobago, USA, and Venezuela. Table 3 summarizes the demographic distribution of the total number of participants in the workshop distributed in country of residency, title, gender, and ethnicity. The diversity shown in Table 3 greatly contributed to the discussion of the issues of interest for the Americas and brought different perspective into the focus groups organized during the workshop. The outcomes from these working groups are presented in another section of this paper.

Table 3: Demographic distribution of the total number of participants in the workshop

Country of Origin		Title		Ethnicity		Gender	
USA	36	Students	13	Hispanics	51	Male	55
Dominican Republic	3	Instructors	3	Caucasian	14	Female	16
Antigua and Barbados	1	Assistant Professors	8	Asian	4		
Colombia	9	Associate Professors	5	African-American	2		
Venezuela	3	Full Professors	30				
Mexico	6	Deans & Administrators	7				

Trinidad and Tobago	3	Researchers	1		
Puerto Rico	2	Professionals	4		
Brazil	2				
Ecuador	2				
Peru	1				
Spain	1				
Argentina	1				
Honduras	1				
Total	71		71	71	71

Challenges and Opportunities

The focus groups were created during the workshop as an important tool for acquiring feedback about the topics and initiatives discussed in the presentations, and also as an important source of new information to identify challenges, opportunities and define future activities and actions. The groups formed were asked to target different topics according to the particular interest of their members, and the challenges and opportunities identified by the group are summarized in this section. Their recommendations are presented in the next section.

Challenges:

- Lack of integration of universities across Latin America and the Caribbean.
- Lack of an accreditation system in the region for quality assurance in education that will facilitate students and professionals mobility, technology transfer and economic development.
- Decreasing number of student enrollments in engineering and technology programs specially in the US.
- Lack of service learning projects in Latin America and the Caribbean.
- Lack of funds for research Latin America and the Caribbean.
- Cost of student mobility and government issues such as visa problems.
- Lack of engineering design, entrepreneurship and leadership courses in the engineering curriculum.
- Lack of promotion of creative skills in the engineering curriculum in the Americas since most emphasis is placed in analytical skills.
- Have academia, industry, and governments working together in Latin America and the Caribbean for technology development.
- Become competitive in the global market and participate actively in addressing the new engineering challenge such as alternative sources of energy.

Opportunities

- Talented students and professors in Latin America and the Caribbean: talented people eager of opportunities.
- An increasing awareness of the importance of integration and internationalization of programs in the academic institutions in this hemisphere.

- Extensive quantity of technical and natural resources available in the region which are sub-utilized.
- Increasing efforts to develop accreditation initiatives in different countries or regions in Latin America and the Caribbean.
- Well established international programs and offices in many institutions in the region.

Recommendations

The recommendations and comments from the focus groups are summarized below. They were grouped according to different themes covered in the meeting and targeted by each team as follows:

Integration and Collaboration

- Promote more integration of universities across Latin America and the Caribbean by sharing resources and exchanging programs, faculty, and students
- Follow up on the creation of the International Engineering Student Leadership Initiative for the Americas.
- Foster International collaboration
 - Identify US professors in engineering or other Science, Technology, Engineering and Mathematics (STEM) fields who are interested in collaborating on international research projects
 - Identify Latin American and Caribbean STEM professors interested in collaborating on international research projects
 - Identify equivalent courses at these universities which could be counted for student exchange program between the two institutions collaborating on a research project
 - Facilitate the collaboration among instructors in different locations
 - Set up international exchange programs in engineering entrepreneurship; helps cross-cultural understanding and how entrepreneurship is viewed in countries other than your own
- Make better use of existing resources in other countries: share courses, provide examples of successful infrastructure
- Use R&D parks as a starting point for government and academic collaborations

Entrepreneurship

- Use entrepreneurship teaching and activities to generate alternative forms of generating companies, jobs, and resources to improve the quality of life
- Develop new solutions for engineering challenges and promote and facilitate the creation of new companies by moving students ideas into startup ventures
 - Foster collaboration among different departments/schools within the university, so that the students get credit for work performed to help in starting the business (law schools, schools of medicine, business, engineering, etc.)
 - Focus on company creation, not business plan development.
 - Emphasis on providing or finding sources of funds for the companies that can demonstrate merits. For example, all students provide some funds when they register each semester to support entrepreneurship efforts. These funds are matched by the dean of the college, and each year they are distributed to support the most promising projects.

- Provide a protocol to deal with legal issues with the universities, including use of university resources (labs, office space, computers, etc.), and potential participation or ownership.
- Establish an entrepreneurship model for students-professors flexible enough so that it can be implemented easily at any university in the U.S. or Latin America. A team should be formed, and some funds should be allocated to design, develop, and test the proposed model for assessment and recommendations (the team should be composed by students, professors and representatives from the industry).
- Present success stories (new startups) during future workshops
- Encourage the development of entrepreneurial skills and attributes such as:
 - Ability to calculate, manage and mitigate risk
 - Ability to collaborate across distance (multi-national teams)
 - Ability to use newest cyber-tools for data analysis and visualization
 - Ability to communication
 - Ability to work in multidisciplinary, multi-national teams (teamwork and leadership)
- Facilitate the development of entrepreneurial skills by:
 - Offering games or do-it activities and projects so students can plan, cost, manage, prototype and sell a product or service. Example: student teams designed, prototyped a new infant incubator with product costs ~ 10% of current models to make this a possible product in developing world
 - Providing case studies with entrepreneurial and engineering flavor
 - Having a course for engineering students on business planning
 - Getting law students to help with patent and intellectual property issues for the entrepreneurship team
 - Defining a way for students doing entrepreneurial tasks or projects to get credit
 - Running a contest ideas based on different topics such as creativity/problem solving, technology-appropriate product for a specific need, or product-redesign contest to meet local or national needs
 - Impressing on students two ideas:
 - Entrepreneurs are not made – they are discovered
 - Entrepreneurs do more than transfer wealth – they create jobs and new wealth

Virtual Community

- Develop an internet site to be used as a networking tool for the educational and research community in the Americas where information can be centralized. The information portal should be used for:
 - Education: share courses, material, and practices.
 - Research: identify research areas and interest, disseminate results, share resources.
 - Projects and Initiatives: provide information about previous, current, and future projects including a quick synopsis of the project and some general information about it, as well as a point of contact.
 - Interconnectivity: allow for collaboration among institutions inter/intra-nationally
 - Funding: provide information about funding agencies and opportunities
 - Activities: promote activities in the region and those of interest for the constituents

Education

- Develop curricula to prepare students with global competencies to be competitive in the worldwide market and to face problems that do not exist yet
- Share courses and best practices across the region.
- Develop joint courses or programs in collaboration with other institutions in the region targeting specific areas of interest
- Incorporate design, leadership, and entrepreneurship topics in the engineering curriculum as fundamental concepts to be competitive in the global market and generate wealth in the region through the creation of new companies
- Follow up on the challenges of educating engineers with a global conscious and environmentally-friendly awareness as part of the Global Engineering Education Challenge for Latin America and the Caribbean.
- Outreach by US universities to Latinos to encourage participation in STEM fields
- Develop continuing education programs for instructors in engineering and technology to facilitate the changes in the educational model and stay current in the new trends in those fields
- The creation of coursework that would enable the student to become more internationally-minded (like our current European counterparts) is essential.

Research

- Collaboration on engineering research between US and Latin American universities
 - Collaboration between professors on projects
 - Research experiences and international study opportunities for students
- Promote the development of sustainable projects for R&D

Quality Assurance

- Develop an internationally accepted accreditation system for Latin American and Caribbean engineering programs
- Promote accreditation and education quality assurance to facilitate human mobility in the Americas and dual degrees programs

Initiative Theme

- Identify and have emphasis in the problems the local and global community are and will be facing in the future such as:
 - Alternative sources of energy
 - Population growth and food distribution
 - Healthcare

Funding

- Identify funding sources for international initiatives: grants, donations, friends & family, angels, private equity
- Identify local funding agencies and counterpart agencies in corresponding countries for the development of joint proposals for international projects
- Offer workshop on writing research funding proposals

Future Action Plans

Based on the issues discussed during the workshop and the co-locate conference, and the feedback received from the participants and the workgroups in the workshop, a task force has been created to plan and execute futures activities. The most significant activities identified and been planned are:

- Search for funds for the planning phase that includes:
 - Forming the leadership team
 - Identify, and understand the opportunities
 - Gather information and identify strategic partners abroad
 - Define thematic areas: goal and specific objectives
 - Develop steering team for initiatives
 - Identify initial funding sources: industry partners, government agencies
 - Develop sustainable projects
- Some of the initiatives to be explored in more details are:
 - Develop and deliver follow up workshops in the following areas:
 - Increasing the awareness in global engineering education initiatives
 - Evaluating the effectiveness of international initiatives in developing global competencies
 - Working with funding agencies and developing sustainable initiatives
 - Design and run a website to be used as an ongoing mechanism to create a community of scholars, researchers and practitioners interested in international collaboration and initiatives for exchanging ideas, disseminating information, and facilitating cooperation. This site will be developed in the languages spoken in the Americas.
 - Promote the formation of the International Engineering Student Leadership Initiative for the Americas.
 - Establish an international center to promote multinational collaboration in engineering education and research for capacity building in the Americas. This center will serve as a hub for initiatives in:
 - Education
 - Research
 - Virtual community
 - Collaborative projects

Conclusions

It is important that the academia, industry and government join and align efforts for educating world-class engineers. There must be a continuous exchange of information and resources to maximize the implementation of the best practice and minimize the use and impact of weak practices. This joint effort implies changes in the foreign policy and the budget allocations of the governments, in the curriculum and teaching methodology, in the research and development, and internship policy of the industry, and the mental attitude of the students. It is clear that the changes have to be conciliated with the idiosyncrasy and culture of the individual countries.

There should be a common purpose of building capacity in the western hemisphere for global competitiveness. This ultimate goal can be facilitated through collaboration among institutions, faculty, students, government agencies and industry in the region to foster excellence in engineering education and research for the formation of global engineers with innovative, leadership and entrepreneurship skills not only to be competitive in the worldwide market but also to create jobs and wealth in the Americas.

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