

## **AC 2009-853: BUILDING RESEARCH COMMUNITIES AND COLLABORATIVE NETWORKS IN LATIN AMERICA AND THE CARIBBEAN: LACCEI VISION AND INITIATIVES**

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# **Building Research Communities and Collaborative Networks in Latin America and the Caribbean: LACCEI Vision and Initiatives**

## **Abstract**

Many engineering education organizations and agencies exist world-wide at the international, regional, national, and local levels. Some of them have specific initiatives conceived to provide capacity building. The need to identify, develop and execute activities directed to advance skills and competencies of engineers and improve process and community infrastructures is calling for engineering education organizations, industry, government and academia to share perspectives, resources, and expertise to effectively and efficiently meet these challenges. This paper aims to document the perspectives and current initiatives of the Latin American and Caribbean Consortium of Engineering Institutions, LACCEI. It also describes future initiatives that require collaborations with other organizations, with the hope that these collaborations can materialize, and progress can be made to develop global engineers for the Americas. In October 2006, LACCEI initiated an Engineering Collaboration Agreement for the Americas that has been signed by seven multinational organizations; the results obtained during the first two years and how other organizations can join the agreement is also described.

## **Introduction**

There is an awareness and growing commitment for capacity building in Latin America and the Caribbean (LAC). The region is interested in developing a competitive model by enhancing the knowledge, skills and competencies of its human capital, and by improving the use of resources and process not only to survive but also to be gung ho in the rapidly changing world. Since engineering plays a central role in building knowledge-based economies, a key factor in regions becoming and remaining globally competitive, there is a particular interest in educating engineers with a new set of skills and competencies so they can contribute to the economic and social growth of the nations on this hemisphere while they develop technology and transfer the knowledge through the region.

Changes in the global economy, especially the importance of moving to a knowledge-based economy<sup>1</sup>, have changed the role of the engineer and engineering education in the 21<sup>st</sup> century. This comes at a time when there is a shortage of engineers and a decreased interest of students to study engineering. The global market and outsourcing has changed the skills required of engineers. The engineer now has to “think globally and act locally” in order to bring global jobs to their region and be able to adapt products to the global market. Preparing these global engineers requires a shift in paradigm in their formation.

In 2006, Continental Corporation funded the first scientific global engineering study conducted by eight prestigious universities around the world<sup>2</sup>. The study resulted in four recommendations:

- (1) A key qualification of engineering graduates must be global competence;
- (2) Transnational mobility for engineering students, researchers, and professionals needs to become a priority;

- (3) Global engineering excellence critically depends on a partnerships, especially those that link engineering education to professional practice; and
- (4) Research is urgently needed on engineering in a global context.

The challenges of forming global engineers, the professors that teach them and a system that continues to build their capacity and adapt to the changes throughout their lifetime, requires collaboration, sharing resources, expertise and perspectives to build effective and sustainable initiatives. A first step in building these initiatives is to know the perspectives of existing engineering education organizations and how to interact with them. This paper describes the Latin American and Caribbean Consortium of Engineering Institutions, LACCEI. Its mission, vision, objectives, initiatives and resources are described, as well as future initiatives in which their constituents are seeking strategic partners for collaboration. In October 2006, LACCEI initiated an Engineering Collaboration Agreement for the Americas that has been signed by seven multinational organizations; the results obtained the first two year and how other organizations can join the agreement are described.

### **The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI)**

In 2002, a group of presidents and deans from twelve universities from Latin America, the Caribbean, United State of America (USA) and Spain, met to explore strategies to advance engineering education, research and practice in Latin America and the Caribbean. As a result of several meetings, it became clear that it was important to create an organization of institutions that could be used as a vehicle for advancement of engineering disciplines, and for collaboration with engineering institutions in this region. Thus, the group formed the *Latin American and Caribbean Consortium of Engineering Institutions (LACCEI)*.

The mission of LACCEI is to be the leading organization of Latin American and Caribbean Engineering Institutions that will bring innovations in engineering education and research, and emerge as a major force in this hemisphere to foster partnerships among academia, industry, government and private organizations for the benefit of the society and the nations.

The goals and objectives of LACCEI include cooperation and partnerships among member institutions in the areas of engineering education, research, and technology advancement with emphasis on:

- Faculty and student exchange
- New and/or higher level academic programs
- Dual/joint degree and certificate programs
- Distance, continuing and e-education
- Laboratory development and sharing of resources
- Curriculum development, course equivalency and accreditation support
- Faculty development, including higher degrees
- Industry internship, cooperative programs and career development
- Joint training and research programs, and solicitation of funds
- Development, commercialization and transfer of technology
- Dissemination of scholarly achievements and other accomplishments by member institutions.

LACCEI has developed some initiatives and has established collaborative agreements with other organizations with the purpose of reaching its goals and accomplish its mission. The work done and the immediate future plans are presented on this paper.

### **Homologation Agreements for Student Mobility**

An early very successful effort is the homologation of courses and programs. Homologation establishes equivalencies between courses and credits to facilitate student mobility and student exchanges. Through the discussions at Extended Governing Board meetings, Institutional Members are encouraged to partner for the purpose of exchanging students and creating dual degree programs. Memorandums of Understanding (MOUs) have been signed between Institutional Members that are active and functional because the effort to homologate and establish the equivalence between their programs in terms of content and credit hours provides a pre-agreed course/credit transfer equivalence and promotes mobility. Homologating courses with one public institution in Florida, USA, had the added effect that courses are homologated across the state since that state has a Standardized State Numbering System. This facilitates and shortens the homologation and agreements with other State Universities in Florida. This greatly increased the mobility of students from Latin America to the USA, and the number of dual degree agreements that are signed and functional. Homologation with accredited engineering programs also facilitated understanding accreditation standards and the documentation required for substantial equivalency.

### **Accreditation Process Support**

LACCEI seeks to support and promote the engineering program accreditation in LAC institutions and nations. International recognition of LAC Engineering degrees affects mobility, attraction and retention of engineering industries, which is critical to creating knowledge-based economies. However, no LAC nation is represented in the Washington Accord, initially signed by accrediting agencies in 1989 to mutually recognize engineering programs they accredit (see Table 1). Neither are they represented in the Sydney Accord of 2001 (see Table 2) nor the Dublin Accord of 2002 (see Table 3) that does the same for technology programs. Recognition of accredited degrees is critical for mobility. The International Register for Professional Engineers was started in 2002 by the Engineers Mobility Forum and The Engineering Technicians Mobility Forum. This register is recognized by national engineering organizations from Australia, Canada, Hong Kong, Ireland, Japan, Korea, Malaysia, New Zealand, South Africa, United Kingdom (UK) and USA. To register requires having the equivalence to an accredited degree. An institution in a country that does not have an internationally recognized engineering program accrediting agency can ask a Washington Accord signer to evaluate their program as *Substantial Equivalent*. Looking at Table 4 it is seen those LAC institutions that have at least one engineering program that is either deemed substantially equivalent or been accredited by the American Board of Engineering and Technology, ABET. The University of the West Indies in Trinidad-Tobago has programs accredited by the Engineering Council of the United Kingdom, ECUK. Table 5 shows that two institutions in Costa Rica have engineering programs deemed substantially equivalent by the Canadian Engineering Accreditation Board, CEAB. So, in total, only 13 LAC institutions have some of their engineering programs recognized internationally! ABET after 2006 is no longer granting substantial equivalence and in Fall 2007 started non-

domestic accreditation visits to accredit engineering programs outside of the U.S. but its web site did not provide search capability to find ABET accredited programs outside of the United States.

**Table 1. Washington Accord Signers – Engineering Program Recognition**

<b>Country</b>	<b>Signers of the Washington Accord</b>
Australia	The Institution of Engineers, Australia (IEAust) Association of Professional Engineers, Scientists and Managers, Australia (APESMA)
Canada	Canadian Engineering Accreditation Board (CEAB)
Hong Kong	The Hong Kong Institution of Engineers (HKIE)
Ireland	The Institution of Engineers of Ireland (IEI)
New Zealand	The Institution of Professional Engineers, New Zealand (IPENZ)
South Africa	The Engineering Council of South Africa (ECSA)
UK	Engineering Council United Kingdom (ECUK)
USA	Engineering Credentials Evaluation International (ECEI) of the American Board of Engineering and Technology (ABET)
<i>Provisional Signatories</i>	Germany, Malaysia, Singapore, India

**Table 2. Signers of the Sydney Accord recognizing Technology Programs**

<b>Country</b>	<b>Signatories of the Sydney Accord</b>
Australia	The Institution of Engineers, Australia (IEAust)
Canada	Canadian Council of Technicians and Technologists (CCTT)
Hong Kong	The Hong Kong Institution of Engineers (HKIE)
Ireland	The Institution of Engineers of Ireland (IEI)
New Zealand	The Institution of Professional Engineers, New Zealand (IPENZ)
South Africa	The Engineering Council of South Africa (ECSA)
England	Engineering Council United Kingdom (ECUK)

**Table 3. Signers of the Dublin Accord to Recognize Engineering Technologists**

<b>Country</b>	<b>Signers of the Dublin Accord</b>
Canada	Canadian Council of Technicians and Technologists (CCTT)
Ireland	The Institution of Engineers of Ireland (IEI)
South Africa	The Engineering Council of South Africa (ECSA)
UK	Engineering Council United Kingdom (ECUK)

**Table 4. LAC Institutions with Engineering Programs Recognized by ABET (USA)**

<b>Country</b>	<b>Institution with at least one program recognized by ABET</b>
Chile	Pontificia Universidad Católica de Chile – Santiago
México	Instituto Tecnológico de Monterrey – Monterrey Instituto Tecnológico de Monterrey – Ciudad México Instituto Tecnológico de Monterrey – Estado de México Instituto Tecnológico de Monterrey – Querétaro Instituto Tecnológico de Monterrey – San Luís Potosí Universidad Autónoma de Nuevo León, San Nicolás de los Garza
Puerto Rico	Universidad de Puerto Rico – Mayagüez Universidad del Turabo - Gurabo Universidad Politécnica de Puerto Rico, San Juan

**Table 5. LAC Institutions with Engineering Programs Recognized by CEAB (Canada)**

<b>Country</b>	<b>Institution with at least one program recognized by CEAB</b>
Costa Rica	Universidad de Costa Rica – San José Instituto Tecnológico de Costa Rica - Cartago

Adding to the challenge is the diversity of traditions and programs in LAC engineering schools. Some follow the French, some the Spanish, some the German, some the USA, and some the British models. Some engineering schools have 3 year Bachelor’s degrees, while others have 4 years or 5 years degree programs. In some of the LAC countries students start the university studies after completing 11 years of primary and secondary education, while 12 years is standard in the United States and Canada. Some countries award the Ing (Engineer) designation upon completing the degree in an engineering school in their countries, while other countries require passing a board exam in the region to use the P.E. (Professional Engineer) designation, and other requires a government evaluation. In the LAC region there are 4 councils and 30 sectors that deal with accreditation. Those councils are: Consejo Andino that includes Colombia Venezuela, Peru, Ecuador, and Bolivia; Consejo Brasileño for Brazil; Consejo CAPAN for Central American and PANama; and Consejo de Acreditación de la Enseñanza de Ingeniería, CACEI, for Mexico. It is observed from the coverage of the four councils that Argentina, Chile, Paraguay, Uruguay and the Caribbean are not covered by any council. In contrast, Europe, that is comprised of 40 countries where 32 major languages are spoken and 40 different degrees are awarded to engineers (see Table 6), has created the European Accreditation of Engineering Programmes “EUR-ACE” label for the mutual recognition across the European Union. Europe has larger differences and has been able to progress in the mutual recognition of the engineering programs. Therefore, there is no compelling reason why progress cannot be made to mutually recognize LAC Engineering programs, and to move forward to be recognized by other countries already signers of international agreements as mentioned before. In the following sections two LACCEI initiatives to try to meet this challenge are described.

**Table 6. Names of Titles/Degrees Awarded to Engineers in Europe**

Akademiingeniør	Doktor-Ingenieur	Ingénieur technicien
Bachelor of Arts	Dottore in Ingegneria	Master of Arts
BEng	Engenheiro	MEng
BSc	Europa-Ingenieur	MSc
Civilingeniør	Ingenieur (grad.)	Okleveles mérnök
Civilingenjör	Ingeniør	Okleveles üzemmérnök
Diplom-Ingenieur	Insinööri	Sivilingeniør
Diplom-Ingenieur ETH	Ingénieur civil	Teknikfræðingur
Diplom-Ingenieur (FH)	Ingénieur diplômé	Teknikumingeniør
Diplomi-Insinöör	Ingénieur industriel	Verkfræðingur

### LACCEI Engineering Education Capability Maturity Model

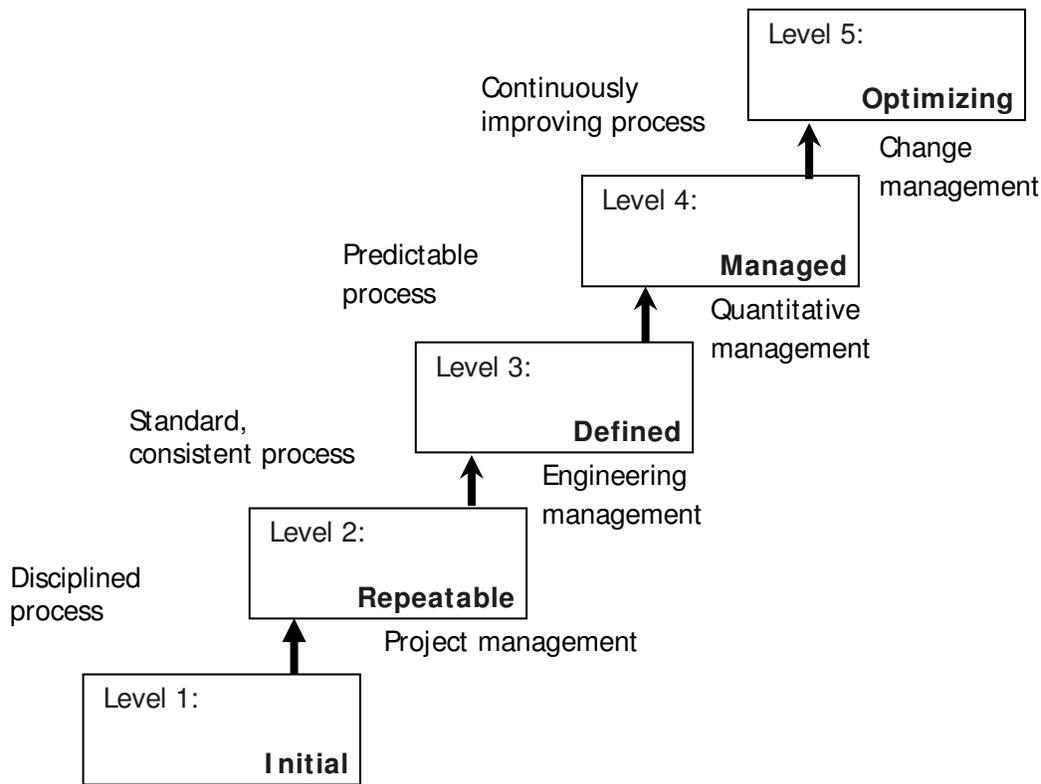
In view that

- No LAC Accrediting Agency has signed the Washington, Dublin and Sydney Accords,
- Few LAC Institutions have sought and attained Substantial Equivalence for their Engineering programs,
- Translation of documents into English is required,
- There is a concern on the part of LAC Institutions that their traditions will be respected
- There is a high cost associated with pursuing substantial equivalence, and
- There is a lack of Engineering program accreditation culture in most LAC countries, LACCEI sees its role as a venue to help
- Design, propose, evaluate a model for assessment / accreditation for LAC nations that do not have an international recognized engineering accrediting agency,
- Facilitate dialogue, homologation of courses/programs of double degree,
- Facilitate access to best practices and experts from accredited programs,
- Provide a venue for LAC organizations, agencies y councils can meet to promote and advance the number of LAC agencies that sign the Washington, Dublin and Sydney Accords and other mutual recognition agreements with recognized agencies, and
- Using the proposed multi-tier model to facilitate assessment of the maturity of the processes of the engineering program, and locating peer institutions at same level.

To this end, LACCEI proposed at the 2005 Engineering for the Americas Symposium a five level model, called Engineering Education Capability Maturity Model<sup>3</sup>, which can be used by an engineering program preparing for accreditation. This model is an extension of the Capability Maturity Model (CMM) developed at Carnegie Mellon University, shown in Figure 1. The goal of the CMM is to increase the process capability, i.e., the inherent ability of a process to produce planned results. Figure 2 shows the structure of Levels 2-5.

LACCEI's Engineering Education Capability Maturity Model (EE-CMM) applies the CMM model to engineering education and maps the activities and documentation required for ABET accreditation to the maturity level where it is appropriate to expect success in achieving the task. A program can thus move one step at a time toward accreditation, when it reaches level 5 it has

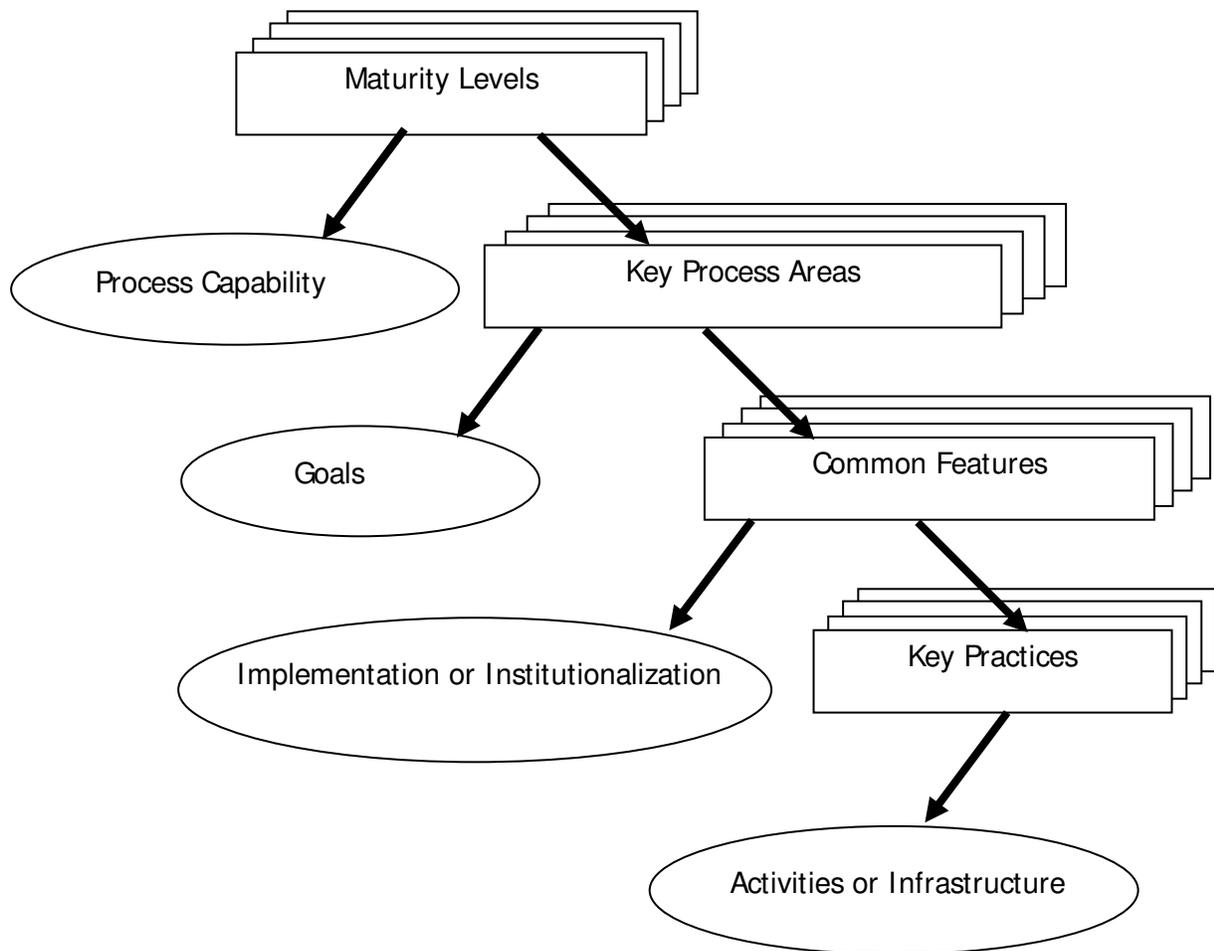
institutionalized the processes and compiled the documentation and results required to go through accreditation. By breaking it up in 5 levels, it is easier to attain “buy-in” and commitment in terms of effort and funding from the faculty and administration to advance one level at a time. LACCEI seeks collaboration to increase the level of detail of the EE-CMM model, and mapping the requirements of other accrediting agency to the EE-CMM model. This will help programs that want to pursue CEAB, ECUK, EUR-ACE or other accreditation or substantial equivalence. By mapping its requirements to the model, an accrediting agency can compare their standards to international standards, so national agencies, such as CACEI in Mexico can use the EE-CMM to map their own policies and practices and help them compare, document and attain mutual recognition of their programs.



**Figure 1.** Structure of the Capability Maturity Model

The EE-CMM<sup>3</sup> is briefly summarized here. The engineering program starts at the Initial Level, where few processes are defined, processes are adhoc and mostly reactive, productivity and quality vary, success depends on individual effort, current levels of quality and productivity of peers are not known. Project Management principles need to be applied to the educational process in a disciplined manner to achieve the next level. In Level 2 (Repeatable), policies and a disciplined process are being followed, and basic project management practices are used to track cost, retention, productivity and compare with peers; faculty document syllabi, goals, objectives, learning outcomes, results and feedback so successful course delivery can be repeated; the program has documented its mission, vision, goals and objectives, has identified peer programs and obtained data on their performance level. To move to the next level, the program has to maintain all practices of the previous level and add the process required to maintain the next

level. To move from Level 2 to Level 3 (Defined), processes need to be standardized and to be consistent; Engineering Management practices need to be applied; and the policies and processes need to all be defined, documented, standardized and institutionalized; a standard processes are in place for developing and maintaining degree programs and courses. To attain Level 4 (Managed), Quantitative Management practices have to be followed to attain predictable processes. At Level 4, the program seeks to quantitatively understand and control both the process and the programs, so processes are in place to collect and use detailed measures of both the program and the courses. To attain Level 5 (Optimizing), Change Management practices have to be applied to attain continuous process improvement. In Level 5, quantitative feedback from the educational process and from testing innovative ideas and technologies are used to optimize the educational program and to continually seek process improvement. Once that is achieved, the program has attained a level of educational process maturity where it is ready to pursue internationally recognized accreditation or substantial equivalence.



**Figure 2.** Structure of the Maturity Levels 2-5

Several LACCEI institutions are using the model to organize and begin their pursuit of quality assurance and accreditation (or substantial recognition). Several characteristics of the EE-CMM have been pointed out as promoting the use of the model. First, currently pursuing accreditation (or substantial equivalence) requires commitment of substantial effort and funding investments,

and result in a binary result, i.e. 0 – not accredited or 1-accredited. The EE-CMM starts the program at Level 1, not 0, this they find recognizes that their existing programs and traditions have value. Getting commitment from the faculty and administration to move from Level 1 to Level 3 is easy and organizes their efforts into activities that help them progress in an orderly manner through the maturity levels. The assessment that places them at a particular level is a self-assessment that does not require translation of documents nor justifying their traditions to foreign entities that are not familiar with their systems and language. Finding peer institutions in other countries going through the same process is simple and confidential going thru LACCEI with the common language of the five levels.

There is a LACCEI research group that is working on building more detail for the LACCEI EE-CMM Model and integrating it to the Iberoamerican Science Technology and Education Consortium (ISTEC) accreditation documentation management system called GRANA.

### *LACCEI-OAS-EftA Quality Assurance and Engineering Accreditation Workshops*

The LACCEI EE-CMM model provides a systematic approach to attain an engineering program accredited that can be mapped to the requirements of any accreditation system. LACCEI feels that, additionally to this model, there is a need for an affordable accreditation system for LAC nations that do not have a national or regional accreditation system for engineering programs that does not require translation of their documents to a foreign language. Mercosur (Mercado Común del Sur) has an experimental system called MEXA (Mercosur Experimental Accreditation Process), but very little information is available online and there is no online list of MEXA accredited Engineering programs.

LACCEI has teamed with the Organization of American States (OAS) and Engineering for the Americas (EftA) to work on improving international LAC engineering program recognition through promoting accreditation or substantial equivalency of engineering programs, and a dialogue to discuss the feasibility of creation of an accreditation system for LAC nations without an accreditation system for engineering programs, similar perhaps to EUR-ACE, that would move towards signing international mutual recognition agreements. Part of the 2005 Engineering for the Americas Symposium's action plan<sup>4</sup>, LACCEI held in 2006 a Workshop on *Advancing Strategies for Achieving Quality Assurance in Latin America and the Caribbean Engineering Education* that was co-sponsored by the OAS and brought 4 accrediting agencies, 4 organizations of LAC engineering deans, and 50 participants, who proposed recommendations published as *The Turabo Declaration*<sup>3</sup>, The main recommendation was to form an umbrella accrediting agency for the LAC region that would seek to sign the Washington Accord. The EftA is seeking funding to explore designing an accrediting system for the Caribbean and Panama.

The LACCEI accreditation workshop was repeated in 2007 and 2008, bringing together additional representatives of government, professional engineer credentialing agencies, accreditation systems, councils of deans, institutions, and chairs of departments, the resulting recommendations are being prepared for publication under the name *The Tampico Report*, basically the conclusions from the second workshop did not emphasize the creation of a new entity, as much as creating a model that would permit comparison of the different accreditation systems to help institutions decide which substantial equivalence to pursue. There is a need also

to help promote national accrediting agencies to seek international mutual recognition by signing the Washington Accord or other internationally recognized agreements.

In 2009, LACCEI is expanding the OAS workshop to have also a Forum for Accrediting Agencies, and an Accreditation Evaluators Training Workshop. LACCEI in 2008 took part in the Accreditation Forum in Panama organized by ACAAI (Central American Association for Accreditation of Architecture and Engineering).

### **Development of Regional Engineering Dean's Councils**

In 2007, the International Federation of Engineering Education Societies (IFEES) launched an initiative to create a Global Engineering Deans and Rectors Council (GEDC). In 2008, in a meeting in Paris, the GEDC was founded and published the Paris Declaration. Concerned that all regions of Latin America and the Caribbean did not have national engineering dean's councils, LACCEI is creating umbrella regional councils in 2009 for the underrepresented regions, beginning with Central America and also the Caribbean. ASIBEI (Asociación Iberoamericana de Instituciones de la Enseñanza de Ingeniería), is the Iberoamerican Association of Dean's Councils, and has expressed concerns that not all nations are represented. LACCEI will be paying membership fees within ASIBEI for the regional councils, thus giving the regions a voice and vote, building a database of deans/rectors, providing a meeting venue and infrastructure and disseminating information from the GEDC and ASIBEI.

### **Dual Degree Program Agreements**

Different types of dual degrees have been arranged by following up on discussions initiated at the LACCEI Extended Governing Board Meetings. These are called 2+2, for four year BS degrees where the first 2 years are completed in one institution and the final 2 in another, but completing the graduation requirements for both institutions; similarly 3+1 dual degree programs have been arranged through homologation. Many Latin American and Caribbean (LAC) engineering programs require 5 years or more, where the last year the student writes a Senior Thesis. Similar 3+2 and 4+1 programs have been arranged. Also 4+2 programs have been arranged that result in an undergraduate degree from the LAC institution, and a Masters Degree from the US.

### **Faculty Development, Graduate Scholarships and Exchanges**

To help LAC institutions increase the proportions of their faculty with PhD degrees, several Institutional Members have developed special faculty development programs for other LACCEI Institutional Members. These programs are aimed at establishing a long-term relationship between the two LACCEI Institutions in all areas of education, research and technology development (see <http://www.laccei.org/Scholarships.htm>).

An example of one such program is offered by Florida International University (FIU) (see Some of the coursework can be delivered at the LAC Institution via Distance Learning and six graduate credits from LAC institutions can be transferred into the program (this is especially beneficial for LAC institutions developing their graduate programs). The faculty participants stay at FIU 3-4

semesters, including a Summer, and during that time must take and pass a qualifying exam, identify the dissertation advisor and dissertation committee members, and develop (and hopefully successfully defend) a dissertation proposal before the faculty returns to the LAC home institution to complete the dissertation. Each subsequent semester the student enrolls in a minimum of three credits of dissertation credit and must visit FIU at least once every semester to meet with the dissertation advisor and dissertation committee to present progress. The dissertation advisor visits the sponsoring LAC institution at least once every year. Support from the faculty member comes from two sources: the sponsoring LAC institution that continues paying the faculty salary throughout their studies, and while in the USA, FIU offers tuition waivers and, during fall and spring semesters, competitive assistantships to teach a course. The University of South Florida has a similar program which has resulted in more than 40 LAC PhD degrees being awarded.

One barrier that prevents more LAC faculty from seeking graduate degrees in the USA is the GRE (Graduate Record Examination) and TOEFL (Test of English as a Foreign Language) examinations requirement for admission, in other words their English proficiency is lacking but their technical expertise is not. Florida Atlantic University (FAU) offers a special program for LAC faculty from LACCEI Institutions to prepare for both exams while advancing their research. The LAC faculty comes to FAU as a Visiting Researcher, which allows a stay of three months to three years; the LAC faculty is paired with a bilingual researcher from FAU so they can participate in a research investigation and have access to research laboratories and library facilities. The LAC faculty enrolls in an Intensive English Institute course especially tailored for passing the TOEFL exam. Additionally, they are allowed to “sit” in a live graduate engineering course that is being recorded, and are given access to recorded CDs or online video files. Taking notes in the live class and reviewing the recordings improves their aural comprehension and their technical vocabulary and knowledge. To improve their oral and written communications, bilingual tutors who are experienced language instructors are available at low costs for 1-1 sessions for improving conversation, minimizing accents, and individually reviewing for the TOEFL. This allows the LAC faculty to advance their research while mastering the English language to pass the TOEFL and GRE. After passing the TOEFL and GRE, the LAC faculty can apply for graduate admissions. If they choose to start their engineering graduate studies at FAU, they are awarded an FAU-LACCEI Scholarship that reduces their tuition to in-state resident level (a reduction of \$16,000 a year in out-of-state tuition costs, which is reflected also in the amount required to be documented in bank letters for the issuance of the visa). They have been better able to compete for research- and teaching-assistantships. The FAU-LACCEI Scholarship is open to any LAC graduate student, not just LAC faculty, and can be continued as long as they are full-time students (summers are optional) through completion of the master, MS, and the doctorate, PhD, degrees. Currently there are 20 of these FAU-LACCEI Scholarships – all current participants have not only attained the scholarships but all have successfully attained additional research- or teaching- assistantships which provides tuition waivers plus from \$7,500 to \$20,000 per year in assistantships. Additionally, there are a small number of FAU-LACCEI PhD Scholarships that includes tuition waivers plus a \$15,000 - \$20,000 per year assistantship for up to 3 years.

In the 2008 Board Meeting of LACCEI the need for Certification Programs for Engineering Faculty Development and Academic Administration was identified and an initiative is being

developed with a desire to partner with IGIP (International Society for Engineering Education), and ASIBEI to create a certification program that could serve Latin American and Caribbean faculty. In 2008, the Executive Director of LACCEI traveled to India and to Washington DC to participate in the Indo-USA Collaboration for Engineering Education (IUCEE) which created a Summer Faculty Leadership Institute in India that trained almost 600 Indian Engineering faculty and administrators, and is being continued in 2009. The IUCEE model is being studied for possible adaptation to Latin America and the Caribbean.

### **In Class Multinational Collaborative Design Projects**

In the 2<sup>nd</sup> LACCEI conference in 2004 in Miami, Florida, a group of professors from the USA, Colombia and Brazil started discussing the need of collaboration in the area of teaching design through multinational design projects. In the 3<sup>rd</sup> LACCEI conference in 2005 Cartagena, Colombia, the effort of the first collaboration<sup>5</sup> emphasized the importance of global design projects in the engineering curriculum in Latin America and the Caribbean institutions. The global design projects collaboration started in Spring 2005 and by the end of 2008 more than 300 students from eleven different universities in seven countries (USA, Brazil, Colombia, Dominican Republic, Ecuador, Peru, and Honduras,) have participated in this initiative. The number of teams, campuses and countries that have participated are summarized in Table 7.

The multinational design projects were adopted by these institutions because it has been shown that they are one of the most effective ways to incorporate international experience in the curriculum<sup>6,7,8</sup>. This type of projects allows the students to work in diverse teams that are geographically dispersed while they are solving a real engineering problem. The multi-team projects are of short duration, running as part of a course that usually lasts for seven weeks. The project is assigned to the students in the different countries simultaneously. Pairs of collaboration are formed among the institutions participating so each team has a corresponding partner in a foreign institution. Participating students discuss the design methodology and the project at a local level first and then they are asked to discuss the problem and share information with their international partners to enrich the final solution of the problem using web conferencing tools and e-mail. Some of the students have presented their designs in poster sessions at the LACCEI conferences, expanding the global educational experience, and have requested that more of these types of projects be incorporated in the curriculum.

**Table 7 Participation in the global design projects initiative**

<b>Period</b>	<b>No. of Teams</b>	<b>No. of Campuses</b>	<b>Countries</b>
Spring 2005	18	4	USA, Brazil, Colombia
Fall 2005	24	7	USA, Colombia, Honduras, Peru
Spring 2006	10	4	USA, Colombia, Dominican Republic
Fall 2006	13	5	USA, Colombia, Peru, Dominican Republic
Spring 2007	11	5	USA, Brazil, Colombia, Dominican Republic
Fall 2007	12	6	USA, Colombia, Dominican Republic, Ecuador, Peru
Spring 2008	12	4	USA, Colombia, Dominican Republic
Fall 2008	32	7	USA, Colombia, Dominican Republic, Ecuador
Spring 2009	16	4	USA, Colombia, Dominican Republic

### **Forming the Global Engineer for the Americas**

The National Science Foundation funded a 2007 LACCEI Workshop on *The Global Engineering Challenge for the Americas*<sup>9</sup>. This effort was designed to explore existing and potential projects that involve or could involve Latin America and the Caribbean. More than 80 faculty and students participated. The Workshop Manual was created by experts sharing best practices in a variety of global education experiences organized into five Sessions:

1. World Class Engineers for the Americas: Competencies, Challenges and Opportunities
2. Entrepreneurship in Engineering Education
3. Engineering Leadership Education
4. Global Service Learning in Engineering
5. Curriculum Development, Research and International Collaboration Opportunities in the Americas

The group also had a thread of sessions that was woven into the 3 day conference and met in birds-of-a-feather focus groups each day to continue networking and “matching” projects to interested institutions.

The 146 page Workshop Proceedings<sup>10</sup> of all the presentations and material distributed at the workshop is available online at <http://www.engr.de.psu.edu/Ivan/NSFWorkshop.pdf>. The results

of the working groups as well as the conclusions presented during the workshop were disseminated in the 2008 ASEE annual conference in Pittsburgh and in the 2008 LACCEI conference in Tegucigalpa, Honduras. They are also expected to be presented in the 2008 ASEE (American Society for Engineering Education) Global Colloquium in Cape Town, South Africa.

Another workshop is planned for 2010 to assess the value or importance of global engineering experiences to generate characteristics, skills, or behaviors that are desired in Global Engineers.

There are two other initiatives of interest for LACCEI in preparing global engineers who will contribute to the economic and social growth of the region. These initiatives are presented later under future direction in LACCEI collaborative initiatives.

### **Engineering Collaboration for the Americas**

This organization has served as the meeting place where institutions can work together to join and align efforts to promote best practices to develop well qualified engineers for the Americas with global competencies. In October 2006, LACCEI organized the signing of the *Engineering Collaboration for the Americas*, a memorandum of understanding signed by seven multi-national organizations representing more than 1200 engineering institutions of the Americas at the celebration of the fifth ASEE Global Colloquium on Engineering Education in Rio de Janeiro, Brazil. This accord will facilitate the integration of goals and strategies to improve the quality of the engineering programs responding to the challenges of the global market. The signers of the accord are: Asociación Ibero-Americana de Instituciones de Enseñanza de la Ingeniería (ASIBEI), American Society of Engineering Education (ASEE), Engineering for the Americas (EftA), Ibero American Science and Technology Education Consortium (ISTEC), International Federation of Engineering Education Societies (IFEES), Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), and the Organization of American States (OAS).

These multi-national engineering education organization and governmental agency agreed to the following:

- To promote professional, educational, & research development of world class engineers
- To enhance engineering education and to support engineering academia under global quality assurance and program accreditation processes
- To promote and develop continuing education programs, extension services, and lifelong learning activities to support lifelong productivity enhancement to strengthen enterprise competitiveness,
- To work toward meeting world demand for global engineers committed to solving problems of society,
- To build bridges for networking and resource sharing between industry, professionals, and governments, academia and the civil society to meet the challenges for developing global engineers to impact worldwide economic development,
- To promote the sustainability values and proactive actions on behalf of forthcoming generations,
- To envision and carry out collaborative efforts and activities for the benefits of all,

- To help enhance social, political and professional equity, justice, and welfare and provide opportunities for those underrepresented in the global engineering community
- To promote job creation and alleviate poverty
- To jointly seek funding to support all activities related to engineering and
- To broadly disseminate worldwide this agreement and attract other interested partners into this partnership.

LACCEI seeks to expand this agreement to other multinational organizations. Interested organizations can request to add their signature to the agreement by contacting the Executive Vice President of LACCEI, Maria Larrondo Petrie, [petrie@fau.edu](mailto:petrie@fau.edu).

### **Results of the Collaboration**

As a first step in collaboration, LACCEI included the partners in planning the LACCEI Annual *Latin American and Caribbean Conference on Engineering and Technology*. All the signing societies were invited to participate as Strategic Partners in the LACCEI Extended Governing Board meeting. The OAS and EftA co-organized and sponsored the Pre-Conference Workshop on *Strategies to Advance Engineering Program Accreditation in Latin America and the Caribbean*, and they also joined efforts to sponsor a Latin American student to present at the LACCEI conference. EftA, ISTECS and ASIBEI each sent speakers to contribute to conference sessions on Entrepreneurship, and Accreditation. All sent a representative to report in a Plenary Panel that featured their initiatives and disseminated this information to the LAC engineering education community. This interaction permitted the four LAC multinational organizations: ASIBEI, EftA, ISTECS, and LACCEI to plan co-authored papers that would disseminate their initiatives outside of the LAC community, and three manuscripts have resulted from this collaboration<sup>9,10,11</sup>.

A LACCEI officer has been elected to the IFEES Executive Committee and served as co-chair of the first IFEES *Global Engineering Education Summit* and also on the IFEES Strategic Planning Committee, and participated in a forum at the National Academies in Washington DC on the IFEES initiative: *Indo US Collaboration for Engineering Education – IUCEE*<sup>12</sup> that is seeking to form an Indo-US Institute for Engineering Education. This gives Latin America and the Caribbean visibility and participation in the international engineering education arena. ASIBEI also invited a LACCEI officer to participate in their assemblies and conferences to continue discussing collaboration. ISTECS also invited a LACCEI officer to its board meeting. This cross participation of signers in each others board meetings has created an environment of trust to share information, efforts and resources.

LACCEI had signed an agreement with the ASEE to provide the *Journal of Engineering Education* (JEE) for a deeply discounted fee to its members, and free to each institution that is a member of LACCEI as part of its membership. The JEE has agreed to design Engineering Education Research Workshops to help form a cluster of pedagogical researchers within LACCEI that collaborates in hemispheric and global engineering education research projects with the goal of improving the quality of the research, data and publication from the region. The ASEE has agreed to consider LACCEI a Partner Society and collaborate in other areas, such as inviting LACCEI papers for the ASEE Global Colloquium.

LACCEI also took the opportunity of the NSF-funded pre-conference workshop on *The Global Engineering Education Challenge for the Americas* to bring experts to the Annual Conference. It was able to fund participation of Latin American Grid student scholars<sup>13</sup>. LA Grid is a network of IBM and academic researchers and student scholars who are collaborating with Latin American researchers in important research topics: such as Hurricane Mitigation, and Bird Flu Epidemic Counterstrategies. LA Grid also sent representative researchers to present at the LACCEI conference<sup>14</sup> and will be invited to sign the Collaboration Agreement.

The newest LAC engineering education organization, the Cartagena Network of Engineers, RCI - Red Cartagena de Ingeniería<sup>15</sup>, invited LACCEI to join their network and has requested to sign the Collaboration Agreement. Additionally LACCEI and other international engineering education organizations were invited to present at the first International Conference on Engineering Education (ICONEED). This has promoted even tighter collaboration, which will be pursued through joint participation in the RCI General Assembly this year where a proposal for an International Institute for Engineering Education will be written to be proposed as an IFEES initiative with the collaboration and leadership of RCI and LACCEI.

### **Future Directions in LACCEI Collaborative Initiatives**

Two LACCEI Institutions: Florida International University and Florida Atlantic University jointly submitted a grant proposal to the National Science Foundation PIRE (Partnership for International Research and Education) program which was funded at US\$2.3M to foster research collaborations by funding LA Grid scholars to travel for extended research collaborations (6 wks to a full semester) with other LA Grid researchers in Spain, Argentina, India, China, Mexico, France, and Japan or at IBM Research Centers in India and Spain. Since both institutions offer LACCEI Scholarships and promote double degree programs, it is anticipated that many LACCEI scholars will also become LA Grid Scholars, and will positively impact the number of student exchanges.

Europe has a Dual-Degree Masters program, called *Erasmus Mundus*<sup>16</sup>, funded by the European Commission that fosters mobility of students/faculty. From 3-5 universities propose a common Master's program in an area of strategic importance or critical need. The universities are in different countries, students start in one institution in the group and change to a different one. They require that the student learn a second language and each university where the student studies issues a degree, so it is possible for a student to obtain up to 3 degree diplomas in the program. There are scholarships to encourage students, particularly from Latin America to participate in Erasmus Mundus. There is also funding for faculty exchanges to teach and research in these programs for shorter periods. One idea that has been presented at LACCEI to create a version of the program in Latin America and the Caribbean, the name *Erasmus Nuevo Mundus*, has been proposed. Because there is no funding source similar to the European Commission, perhaps starting with a Global Engineering Education Certificate that promotes student mobility across LACCEI Institutions. Strategic areas where courses can be developed jointly by LACCEI Institutions need to be determined. Blended learning can be used, together with multinational design/project teams. A short 1-3 week intensive seminar/workshop in Latin America or the Caribbean can be more easily funded than an entire Masters program. This workshop could be in

sites of premier caliber, such as for controls or transportation – the City of Knowledge in Panama can be used; for energy – the Orinoco Hydroelectric Power Plants in Venezuela can be used; for civil engineering – Machu Pichu in Peru can be used. The study abroad can be paired with a for credit course that can be team taught and offered at a number of LACCEI Institutions; this would also eliminate the problem of TOEFL requirement for taking the course from a US institution, and the problem of costs as the student could pay the lower tuition cost at a less expensive LACCEI school. Further collaboration and planning are needed.

### *Centers of Excellence*

An agreement signed between two LACCEI institutions: Universidad Sergio Arboleda in Colombia, and Florida Atlantic University in USA, has led to a proposal to LACCEI to endorse and promote Centers of Excellence that:

1. Involve 2 or more LACCEI institutions
2. Are multinational
3. Are multidisciplinary
4. Involve capacity building, research, and global internships
5. Have economic or social impact
6. Involve government, industry, academia, private sector and student collaboration
7. Have a sustainability plan

The center that is being proposed by the two universities is to support the proposed Free Trade Agreement between their countries that is considered by Congress, and involves the Colleges of Engineering & Computer Science, Arts & Letters, and Business of their perspective universities. FAUs Arts & Letters is providing capacity building in teaching English -and Spanish- as-A-Second-Language to the Sergio Arboleda's Language and Linguistic professors, who are creating specialized Spanish and English classes to be delivered to importers, exporters, investors, and engineers. The Colleges of Business are developing courses for the importers, exporters and investors regarding rules, regulations, culture and tradition of doing business in the respective countries. The Colleges of Engineering are developing Port Management, Engineering and Security courses, and exploring possibilities of including internships or projects that involve students working on design or analysis projects involving the ports that are near both universities. Universidad Sergio Arboleda Santa Marta Campus is near the Ports of Santa Marta, Barranquilla and Cartagena; and FAU is near Port Everglades, Port of Miami and the Port of Palm Beach.

Center for Innovation, Design, Entrepreneurship and Leadership for the Americas (C-IDEAL for the Americas). This is a multidisciplinary initiative that will promote capacity building in the Western Hemisphere by building an international network of collaboration in engineering education, research and practice among students, educators, practitioners and researchers in the Americas to foster excellence in innovative designs, entrepreneurial enterprises, and global leadership to enhance the competitiveness of the region. The idea is to have a multidisciplinary center with a broad scope under which many particular themes with different backgrounds could

be treated. The mission of the center is based on five fundamental pillars which are: education, research, collaborative projects, outreach and online community.

Another program that is being developed in collaboration with ISTECH is called Sustainability, Environment and Energy for Latin America and the Caribbean (SEELAC). This effort is directed to advance engineering education and research in the area of green designs and alternative energies, and how to comply with the principles of preserving the environment. Both initiatives, C-IDEAL and SEELAC will require strong partnership among academia, industry, government and private organizations.

A proposal for an International Institute for Engineering Education is in preparation for submission for approval as an IFEES initiative with the collaboration and leadership of RCI, LACCEI and industry leaders. IFEES also is promoting joint regional conferences, and discussions have started on collaborating to co-locate multi-conferences to host the IFEES LAC Regional Conference and promote further collaboration.

## **Conclusions**

Engineering and engineering education are key for economic development. The urgent call for a change in paradigm in engineering education to create the Global Engineer, and in particular the Global Engineer for the Americas, is coming from all sectors. This initiative is progressing, key issues are building capacity, new long-term leadership, scalable and sustainable efforts, mobility, culture of quality in education and businesses (accreditation and certification), and entrepreneurship. Latin America and the Caribbean must strive for integration and the development of models where the Region can be considered as a global participant and partner. Collaboration and partnerships between all sectors – academia, industry, government and non-governmental organizations – are essential to achieve goals and objectives of developing knowledge based economies in all of the Americas. LACCEI seeks strategic partnerships to advance initiatives, seek funding, share expertise, best practice and resources; expand venues of dissemination, and co-locate joint multi-conferences. LACCEI is promoting initiatives that form Global Engineers for the Americas that have social conscience, are economic aware, have multicultural experiences and sensitivities, and promote fluency in multi-languages. Moving LAC nations to knowledge-based economies requires close collaboration between all engineering education organizations and stakeholders to promote government investment and policy building and access to best practices and resources to support quality engineering education; and foremost, a spirit of inclusion to expand the pool of engineers with global competencies in this region.

## **Bibliography**

1. “Knowledge for development.” The World Bank Institute, 1998. [www.worldbank.org/eca/knowledgeeconomyreference](http://www.worldbank.org/eca/knowledgeeconomyreference)
2. In Search of Global Engineering Excellence: Educating the next generation of engineers for the global workplace. Technische Universität Darmstadt, Germany; Eidgenössische Technische Hochschule Zürich, Switzerland; Georgia Institute of Technology, USA; Massachusetts Institute of Technology, USA; Shanghai Jiao Tong University, China; Tsinghua University, China; Universidade de São Paulo, Brazil; University of Tokyo, Japan; Continental AG, Germany, 2007. <http://www.global-engineering-excellence.org>

3. Larrondo-Petrie, M.M., Sankat, C., Loran, R. "The Turabo Declaration and the Engineering Education Capability Maturity Model: LACCEI initiatives to improve Latin America and Caribbean Engineering Program Accreditation and Recognition". In *Proceedings of the 114<sup>th</sup> Annual American Society for Engineering Education Conference and Exposition (ASEE2007)*, Honolulu, Hawaii, USA, 24-27 June 2007.
4. Final Report, Engineering for the Americas Symposium: Capacity building for job creation and hemispheric competitiveness, Lima, Peru, 29 Nov. – 2 Dec. 2005.  
[http://www.oest.oas.org/engineering/espanol/documentos/Informe\\_Final\\_ENG.pdf](http://www.oest.oas.org/engineering/espanol/documentos/Informe_Final_ENG.pdf)
5. Esparragoza, I.E. and Devon, R. 2005. Developing the global design curriculum in Latin America and the Caribbean through multi-national projects. *Proceedings of the 3rd Latin American and Caribbean Conference for Engineering and Technology*, Cartagena, Colombia, 8-10 June 2005.
6. Ion, W.J., Woldenhouse, A., Juster, N., Grierson, H., and Stone, A. 2004. Educating the Global Designer", in *Perspectives from Europe and Asia on Engineering Design and Manufacture*, Jiang, Y.X.T., and Juster, N., Eds., Kluwer, 2004, pp. 225-336.
7. Pollar, J.D., Devon, R., McKay, A., and Bilen, S.G. 2002. Teaching Design Through International Collaborations", *Proceedings Int. Conference on Engineering Education*, Manchester, England, August 18-21, 2002.
8. Devon, R., Sathianathan, D., Saintive, D., Nowe, M., and Lessene, J. 1998. Alliance by Design: International Student Design Teams, *Proceedings of the 1998 ASEE Annual Conference & Exposition*, Session 2544, Seattle, WA, June 28-July 1, 1998.
9. National Science Foundation Grant NSF04-035\_OISE\_0715273: Global Engineering Education Challenge for the Americas. Investigators: Ivan Esparragoza, Pennsylvania State University, USA; Maria M. Larrondo Petrie, Florida Atlantic University, USA; and Dhushy Sathianathan, Pennsylvania State University, USA; 2007.
10. *Proceedings of the LACCEI-NSF Workshop on the Global Engineering Education Challenge for the Americas*, I. E. Esparragoza, M. M. Larrondo Petrie, D. Sathianathan (eds.), Tampico, Tamaulipas, Mexico, Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), 29 May 2007.  
<http://www.engr.de.psu.edu/Ivan/NSFWorkshop.pdf>
11. Esparragoza, I. E., Larrondo-Petrie, M. M., Sathianathan, D. "Global Engineering Education in the Americas: Challenges and Opportunities Developing Assessment Tools for International Experiences in Engineering Education,"
12. Indo US Collaboration for Engineering Education, <http://www.iucee.org/>
13. LA Grid Latin American Grid Projects. <http://www.latinamericangrid.org/projects.php>
14. Morales, George M., Martinez, Pete, and Larrondo-Petrie, Maria M. "Opportunities for students for global engineering research and leadership: LA Grid Scholars", in *Proceedings of the 5<sup>th</sup> Latin American and Caribbean Conference for Engineering and Technology*, Tampico, Tamaulipas, Mexico, Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), 29 May to 1 June 2007.
15. Red Cartagena de Ingenieria. <http://carthagene.enim.fr/spip.php?rubrique11&lang=es>
16. The Socrates-Erasmus Programme. <http://www.erasmus.ac.uk/index.html>