Developing an Engineering Faculty Development Model for the Americas: The LACCEI Approach

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ABSTRACT

Globally there has been an urgent call to academia from all sectors to change the paradigm for educating engineers in order to produce the Engineer of 2020, the engineer capable of addressing the Millennium Challenges and practice in a global economy. Together with this urgent call to educate the Engineer of 2020, comes the more urgent need to re-tool the Engineering faculty to enable them to meet these challenges. Engineering faculty development has been the focus of many collaborative efforts. This paper examines the models that are being used globally, and proposes a model to be used by the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) in addressing the needs for engineering faculty development in the Americas, particularly in Latin America and the Caribbean.

Keywords: faculty development, engineering pedagogy, international certification

1. INTRODUCTION

Academia is being urged by all stakeholders to produce Global Engineers[1], globally competent, locally relevant, that can co-operate, communicate and compete, and capable of addressing the United Nations Millennium Challenges. In 2007, eight prestigious universities from around the world produced the first scientific global engineering study[2], which concluded with four recommendations:

(1) Global competence needs to become a key qualification of engineering graduates;
(2) Transnational mobility for engineering students, researchers, and professionals needs to become a priority;
(3) Global engineering excellence depends critically on a mutual commitment to partnerships, especially those that link engineering education to professional practice; and
(4) Research on engineering in a global context is urgently needed.

The Engineering for the Americas (EftA)[4] initiative, an academic, industrial and government grass roots effort headquartered in the Organization of American States (OAS), aims 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 development[3]. The OAS, EftA[4], the U.S. Trade and Development Agency (USTDA) and the World Federation of Engineering Organizations (WFEO)[5] organized the Engineering for the Americas Symposium[6] at the end of 2006 in Lima, Peru. The Final Report[6] 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 Report[6] urges the academic sector to boost its collaboration with industry to develop a change in paradigm to educate the engineers of the 21st Century. They define the Engineer of the 21st Century, or global engineer, as a world class engineer, leader, visionary, and

entrepreneur, committed to the social environment and with a clear sense of the common good; an engineer who helps to create himself or herself, not look for work but create it.

In 2004 the National Academies published *The Engineer of 2020*[7], followed in 2005 by *Educating the Engineer of 2020*[8]. 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*[9], was published in 2006. In June 2006, the American Society of Engineering Education's International Division[10] met and expressed concern that "Educating the Global Engineer" was not a strategy presented in the National Academies report *Rising above the Gathering Storm.*

In Latin America, the Iberoamerican Engineering Education Association (ASIBEI, in Spanish: Asociación Iberoamericana de Instituciones de la Enseñanza de la Ingeniería) came out with a comparable description to the Engineer of 2020, named *Ingeniero Iberoamericano*[11] (in English Iberoamerican Engineer).

The Engineering for the Americas Symposium urged 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. This urgent call is coming from all sectors, and clearly requires defining and facilitating experiences that would result in the Global Engineer, and building the capacity of Engineering Faculty to meet the challenge. The National Academy of Engineering in 2009 organized the workshop "Engineering Faculty as Academic Leaders of Change" funded by the National Science Foundation to enable faculty to effectively lead curricular changes at their institutions.

In the next section we examine different efforts that have emerged globally to develop Engineering faculty to face these challenges. The model chosen by the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) is then presented. We conclude with some initial results, existing challenges and future directions.

2. GLOBAL MODELS FOR ENGINEERING FACULTY DEVELOPMENT

Models differ throughout the world on emphasis, delivery, cost, and scalability.

2.1 GLOBALY

The International Federation of Engineering Education Societies (IFEES, see http://www.ifees.net) and the European Society for Engineering Education (SEFI: Société Eurpéenne pour la Formation des Ingénieurs, see http://www.sefi.be) have partnered to offer an initiative called International Institute for Developing Engineering Academics (IIDEA, see http://www.sefi.be/iidea/). IIDEA provides a clearing house of high- caliber and world-class engineering faculty leadership training workshops, courses and seminars, helping to broker the offering of these around the world. The cost of the workshops is assumed by the host society or institution offering the workshop possibly passed on to the participants.

The International Society for Engineering Education (IGIP, International Gesellschaft für Ingenieurpädagogik – see www.igip.org), founded in 1972 at the University of Klagenfurt in Austria. The university founded the Klagenfurt School of Engineering Pedagogy. IGIP has created an international register of engineering educators, who have gone through an IGIP-approved curriculum and who have received the International Engineering Educator Certification or Diploma (ING PAED IGIP, see http://www.igip.org/pages/aboutigip/ing-paed.html). IGIP has members in 72 countries and consults for UNESCO and UNIDO. The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI, see http://www.laccei.org) and the Brazilian Science and Education Research Council (COPEC, Conselho de Pesquisas em Educação e Ciências, see http://www.copec.org.br/) have been approved to offer courses that count toward the International Engineering Educator Certification in the Americas.

2.2 INDIA

The Indo-U.S. Collaboration for Engineering Education (IUCEE, see http://www.iucee.org) partnered with the U.S. National Academies of Engineering, InfoSys Corporation, and donors to develop the Summer Faculty Institutes for India, where U.S. engineering education and accreditation experts present courses to Indian faculty who take a one-week course in effective modern pedagogy practices, and a 3-5 day course on teaching within a content area. After three years IUCEE is now producing the seminars as webinars and delivering weekly webinars on different topics to 200-300 faculty participants at a time. The IUCEE has opened Regional Training Centers at 100 Engineering Institutions using trained Indian faculty to scale up nationally.

In their Summer Institutes and webinars, the IUCEE is also addressing the needs to train administrators and faculty in engineering educational management and accreditation.

2.3 UNITED STATES

The American Society of Engineering Education (ASEE, see http://www.asee.org) partners with the National Effective Teaching Institute (NETI, seehttp://www4.ncsu.edu/unity/lockers/users/f/felder/public/NETI.htm) to deliver a 3 day Workshop as a pre-conference activity as part of their annual conference, sponsored by the ASEE and funded by registration fees of $950 for up to 50 participants.

There are a growing number of universities who are offering Engineering Education Certificates (Virginia Tech) and PhD degrees (Arizona State University, Carnegie Mellon University, University of Michigan, Ohio State University, Purdue University https://engineering.purdue.edu/ENE/Academics/Graduate/, Stony Brook University, Tufts University http://ase.tufts.edu/education/programs/research/MSTE.asp, Utah State University, University of Washington, and Virginia Tech University, http://www.enge.vt.edu/Graduate/grad.html).

2.4 BRAZIL

The Brazilian Engineering Education Society (ABENGE) is working with IUCEE to design a similar model for Brazil, as part of an initiative by the International Federation of Engineering Education Societies (IFEES, see http://www.ifees.net).

2.5 IBEROAMERICA

ASIBEI has published many books[11,12,13,14] (see http://www.asibei.org/interior.php?CdPb=PUB-0000016&CdIdioma=ESP). The Colombian Engineering Education Association (ACOFI, Asociación Colombiana de Facultades de Ingeniería, see http://www.acofi.edu.co/portal/index.php) is well known for its advanced faculty development programs.

3. UNESCO'S PROGRAMME FOR EDUCATION

A central topic addressed by the international scientific community during the International Year of Physics 2005 at the World Conference on Physics and Sustainable Development held then in Durban. South Africa was the relevance of physics education as a catalyzing agent for sustainable development.

During 2008-2009, UNESCO (United Nations Educational, Scientific and Cultural Organization) organized four landmark international education conferences to address inclusive quality education, education for sustainable development, adult learning, and higher education. Following the recommendations formulated at these conferences, the UNESCO's Programme for Education 2010-2011, under the motto "Education for All" , centers on providing global and regional leadership and guidance to transform education systems in a globalizing world.

According to this priority, the program of the Education Sector of UNESCO includes the creation of effective education systems at all levels, from K-12 to high education.

The UNESCO's Office for Basic and Engineering Sciences calls for "international actions to promote science education so that every citizen can lead a meaningful life in increasingly knowledge-based societies. Capacity building in the basic sciences, their interconnection with the needs of society, and equal access for women and men to scientific and engineering education are essential components of a science-based response to national, regional and global challenges." The Office is implementing the Global Microscience Experiments Project in promotion of science education, part of whose objectives are (i) to improve science curricula by inclusion of hands-on experimentation for a better understanding of science, (ii) to increase the interest of young people in science so as to promote gender equality, scientific literacy, and the choice of a scientific career, and (iii) to promote capacity building for science education and enhance development of scientific thinking and experimentation for pupils

The same objectives led to the development by UNESCO of the Active Learning in Optics and Photonics (ALOP) Project, an earlier project of the same office, which has reached maturity, has earned wide international recognition and awards, and is at the stage of being widely disseminated worldwide.

3.3. UNESCO'S SCIENCE AND EDUCATION OFFICE FOR LATIN AMERICA AND THE CARIBBEAN

UNESCO's office in Montevideo is UNESCO's Regional Office for Science for Latin America and the Caribbean. The office is in charge of the UNESCO Regional Project in Education for Latin America and the Caribbean (EPT/PRELAC 2007). The Education Ministries of the region have affirmed in the PRELAC [17] that education is the key for the construction of a more just world and have committed to promote changes in the education policies and practices through the transformation of the existent paradigm and assuring the quality of learning and the human development of all people in the region. Two of the focus points of the project are to promote a change of education contents and practices and the training of teachers as agents of that change.

3.4 ACTIVE LEARNING WORKSHOPS

Active learning strategies for physics were presented by David Sokoloff (University of Oregon), Priscilla Laws (Dickinson College), and Ronald Thornton (Tuffs University) in a workshop held in Australia in January 1999 for the Asian Physics Education Network (ASPEN). Many international active learning activities have been supported by UNESCO since then. The original topics were mechanics, heat and thermodynamics, and electricity. The goal of UNESCO in Latin America and the Caribbean is to develop through its regional offices and education networks a large group of local trainers to run regional active learning workshops.

3.5 ACTIVE LEARNING IN OPTICS AND PHOTONICS

The Active Learning in Optics and Photonics (ALOP) project was conceived in 2003. Dr. Minella Alarcon, Programme Specialist responsible for physics and mathematics at the UNESCO office for Basic and Engineering Science, pioneered the establishment of the project, intended to provide university physics lecturers with novelty education methodologies in order to build capacity for research and advanced training based on a real understanding of the physical concepts at the foundations of modern technologies.

Through centuries optics has provided physics and other sciences with extremely accurate experimental techniques for research and discovery. During the last half century, since the invention of the laser, optics and photonics stood out as an enabling science and revolutionized the world of technology for communications, health, image display, environmental sensors, and others. With the support of the Abdus Salam International Centre for Theoretical Physics (ICTP) and the International Society for Optics and Photonics (SPIE), Dr. Alarcon gathered a team of highly reputed researchers on science education and developed one of the most successful of UNESCO's programs on science education: the Workshop on Active Learning on Optics and Photonics, a

trainers' training activity promoting innovative approaches to teaching and learning, and in particular the so-called hands-on activities and other activity-based methods intended to engage students in their learning process[18]. The ALOP workshop is designed to train high school and university professors of math, science or electrical engineering in active learning techniques and provide them with exciting hands-on modules to put in practice with their students. It consists of five modules carefully designed to lead the student from the observation of basic optical phenomena to the conceptual understanding of fiber optic telecommunications, including wavelength division multiplexing. It also includes activities on the basics aspects of human vision and atmospheric optics.

The members of the core group of trainers are David R. Sokoloff, Zohra Ben Lakhdar, Ivan B. Culaba, Vasudevan Lakshminarayanan, Joel. T. Maquiling, and Alex Mazzolini, who developed the structure of the Workshop and the Manual in English. Their strategy to further disseminate the method had been to train two regional teams of trainers, a French-speaking team for Africa and a Spanish speaking team for Latin America. The regional teams have completed the translation of the Workshop Manual into their respective languages. The coordinator of the Spanish speaking team of trainers is Angela M. Guzmán (USA and Colombia), and the team comprises David Sokoloff (USA), Vasudevan Lakshminarayanan (Canada), Miguel Torres Cisneros (Mexico), Cesar E. Mora (Mexico), Graciela Punte (Argentina), Julio Benegas (Argentina), and Omar Ormachea (Bolivia).

The profile sought for active learning trainers is that of a highly experienced teacher, with good background in optics and interested in innovative education methodologies and affiliated with a supportive local University. This has been the case of the Universidad Nacional de Colombia, whose General Vice Rector supported the creation of a local team of trainers, composed of professors with research experience in the area of optics, several of them already awarded with medals for the excellence of their teaching, who attended international ALOP Workshop, served as assistant trainers for the Latin American team, and finally built all of the equipment required for the workshop and held a workshop for teachers and instructors from all of its 7 sites throughout the country (ALOP-SPN, Bogotá, Dec. 2010, see http://alop-spn.blogspot.com/). The challenge they faced was the redesign of all lab circuits --- originally designed with Australian standards --- with components easily found in the Americas (see contributed paper by Inti Poveda et al. in the LACCEI Conference) .

The Physics department of the Universidad Nacional also adopted the ALOP Workshop as part of a regular course in the Master in Education Academic Program. Members of the Latin American Team have been supporting this effort and attending the activities organized by the Universidad Nacional as advisors offering positive feedback to the Colombian team.

UNESCO'S STRATEGY FOR ALOP WORKSHOPS & LACCEI ROLE

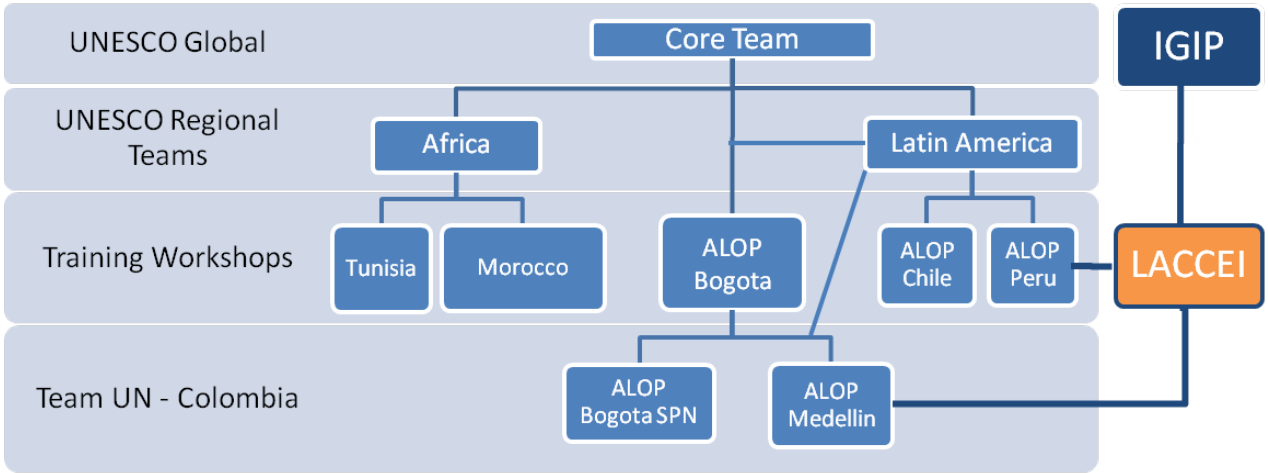

Figure 1. UNESCO strategy to develop a large group of ALOP trainers in Latin America and role of LACCEI as supporting organization.

The UNESCO strategy has been sketched in Figure 1. The Core group of trainers has trained regional teams in Africa and Latin America. In 2009 the core team, with the Latin American team acting as assistant trainers, held ALOP Bogota which motivated the commitment of the Universidad Nacional de Colombia to the ALOP program. Members of the Latin American team translated the ALOP manual into Spanish and held the first ALOP Workshop in Spanish in Chile in January 2010.

The first ALOP Workshop co-located with a LACCEI annual conference took place in parallel with the LACCEI 2010 Conference at the Universidad Católica de Santa María, Arequipa, Peru, facilitated by the Latin American team of facilitators, The workshop was delivered in a bilingual format, free of charge to 40 participants. Thirty-eight completed successfully and received certificates for the module (see http://www.laccei.org/index.php/events/alop-peru). Ten of them received free laboratory kits to take to their home institution; all received the manual in their choice language (English or Spanish) and a CD with all materials in English and Spanish and schematics and descriptions to reproduce all laboratories. In 2010, the LACCEI Annual Conference and the UNESCO's Workshop on Active Learning in Optics and Photonics were held together in Arequipa, Peru.

4. PROPOSED LACCEI FACULTY DEVELOPMENT PLAN

LACCEI after studying the different models[15] and considering the cost, scalability, language, and other factors has decided to pursue a model of faculty development that results in an international recognized certification. It decided the oldest and most comprehensive model was offered by IGIP with its ING PAED IGIP International Engineering Educator certification. IGIP accredits training centers that adhere to its standards and curriculum. In the Americas, LACCEI and COPEC (in Brazil) have been accredited. The IGIP curriculum[16] for the certification is composed of modules, shown in Table 1 and Figure 2.

Table 1. The IGIP Curriculum for International Engineering Educator Certification[16]

Module Description	Credits at least
Core Modules	**8**
Engineering education science in theory and practice	6
Laboratory methodology	2
Theory Modules	**4**
Psychology and Sociology	3
Ethics (1 credit) or Intercultural competencies (1 credit)	1
Practice Modules	**6**
Oral communication skills, scientific writing	3
Working with projects	1
Media, e-learning, computer aided technologies	2
Elective Credit Points	**2**
Electives	2
In Total	**20**

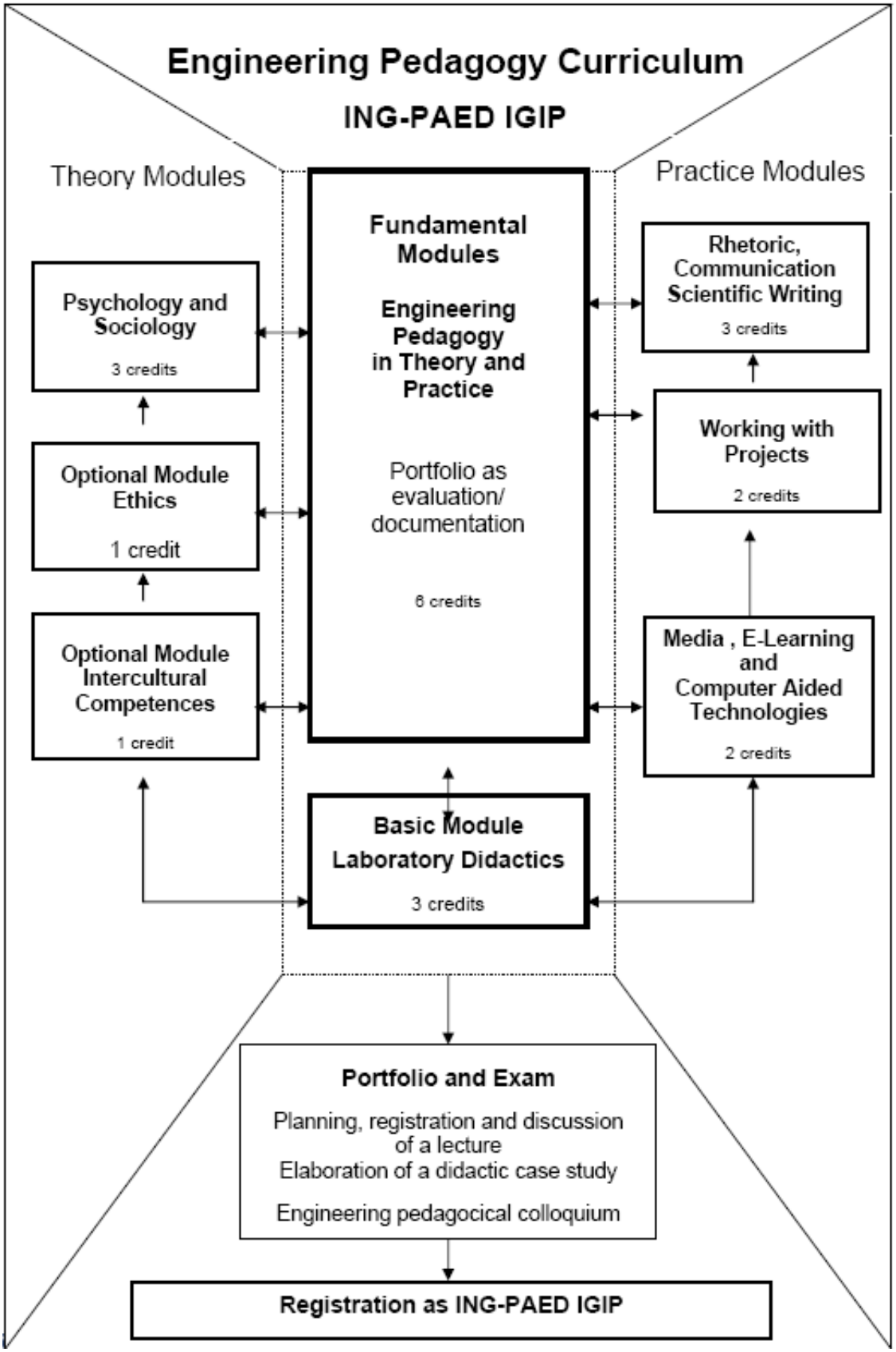

Figure 2. The IGIP Curriculum[16]

The ING-PAED IGIP certification is open to teachers and professors who have taught for at least one year in an engineering program, including those that teach sciences, mathematics and technology in support of the program, and who complete the required modules in institutions accredited by IGIP.

LACCEI considered UNESCO's ALOP to be an outstanding course to submit for approval as an IGIP module in Laboratory Methodology. LACCEI presented all required information to IGIP and the workshop was approved by IGIP with 3 credits.

LACCEI also offers a good nesting opportunity for the UNESCO program in Latin America and the Caribbean, since the annual LACCEI conference gather engineers from all countries in the region. LACCEI will promote the Workshop in the region and recommend to all member institutions to send at least two faculty members to attend a workshop, be trained in active learning methodology, and go back to their institution to train other faculty. LACCEI will put stronger emphasis on the participation of faculty from the prospective host institution for the next LACCEI annual conference. LACCEI is also working on the creation of a repository for parts for the circuits and equipment required for the Workshop in the Americas, and has also contacted student organizations interested on assembling the circuits to be provided for the realization of future Workshops.

LACCEI efforts as a supporting organization will help spreading the Colombian experience throughout the region, and will serve its members with a high quality component for their faculty development. LACCEI has also invited the UNESCO's director of the ALOP Workshop, Joseph Niemela, the director of ICTP, Fernando Quevedo, and the director of the UNESCO's regional office in Montevideo, Jorge Grandi, to attend a Panel on Engineering Pedagogy within the LACCEI Annual Conference.

The UNESCO ALOP workshop will be again offered parallel to LACCEI 2011 Conference in Medellin, Colombia. The Colombian faculty from the Universidad Nacional de Colombia who had been trained in previous UNESCO ALOP workshops ran workshops, where trained earlier in 2011 to deliver the workshop at their university, thus increasing the national team of trainers to disseminate the ALOP workshop. The ALOP-Medellín workshop will utilize the team of Colombian trainers assisted by international facilitators offering the workshop to international participants (see http://www.laccei.org/index.php/events/alop-medellin) in Spanish, with the Manual in English and Spanish. It is expected that the Colombian trainers will benefit as well as the participants, and will be able to disseminate the active learning practice throughout their institutions and throughout other Colombian Engineering faculties. LACCEI, UNESCO, ICTP and ISO are collaborating to deliver the ALOP to Latin America through LACCEI.

The Colombian team has documented their experiences in transitioning from participant, to practitioners, to trainers in papers also submitted to the LACCEI 2011 conference, as well as the improved schematics and parts lists utilizing components available in the Americas and instructions to build the required circuits. It is hoped that this documentation being made available in both Spanish and English, and the process of train-the-trainers and follow up support, can propagate best practice in a manner that is low cost and high quality, and has high scalability.

5. CONCLUSIONS

LACCEI has proposed a model for Engineering Faculty Development for the Americas through partnership with other global organizations to provide courses and workshops that result in certificates that can accumulate to attain an internationally recognized credential of ING PAED IGIP – International Engineering Educator. The program differs from other models in that it is very low cost to participants and institutions; it is offered multilingual (Spanish and English) and the experiences are well documented. The first course has been successfully offered, and will be continued and expanded. A special issue of the LACCEI Journal is planned on this topic. Other high quality courses that are developed that can be adapted to the IGIP and LACCEI curriculum standards are being explored, such as the material in Visual Analytics developed under a National Science

Foundation grant, and the world-class workshops under the IIDEA and IUCEE initiatives. A taskforce is being formed to seek funding to design a new Active Learning program with modules focused in other topics, such as energy and sustainability. It is hoped that this effort, together with others planned in training LACCEI Pares Amigos in Engineering accreditation, training Engineering Deans and training engineering student leaders, will result in enabling the Engineering Faculty in the Americas effectively produce Engineers for the 21st Century.

The ALOP Workshop will continue as an independent activity supported by UNESCO through the Abdus Salam International Centre for Theoretical Physics (ICTP) and by the International Society for Optics and Photonics (SPIE), but will be offered as a parallel event to the LACCEI Annual Conferences when possible. Participants will receive credit from IGIP for the Workshop as a module for Laboratory Methodology within the Engineering Pedagogy Curriculum. LACCEI is also working on the creation of a repository for parts meeting American standards, to be used to replicate the circuits all over the Americas.

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