Building Common Spaces in Engineering Education: A Review From ICECE05

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Invited Paper

Editor-in-Chief's Introduction: The leadership of the IEEE Education Society desires that its members understand both the opportunities and challenges facing the disciplines that comprise the Society. With 53% of the Society's membership living outside of the United States, the Society is attempting to increase member knowledge of international education events that relate to the discipline.

Each year, the International Conference on Engineering and Computer Education (ICECE) is one of the conferences that addresses topics that are relevant to the interests of the Education Society. Because of the role played by ICECE in keeping Society members informed, Edmundo Tovar and Manuel Castro were asked to summarize 2005 conference presentations to provide Society members not in attendance at the conference with an overview of the major presentations at the conference. The following Invited Paper is their response.

***Abstract*—The creation of Common Spaces for Higher Education means facing different challenges. This paper reviews the main contributions to three of these key aspects: namely, the main competencies of practicing engineers, the position of the main Education Societies in building these spaces for education, and the particularities for standards in Engineering accreditation. These ideas were debated in the last Conference on Engineering and Computer Education (ICECE05) with the technical cosponsorship of the IEEE Education Society.**

***Index Terms*—Accreditation, common space, competencies, engineering education.**

I. Introduction

THE construction of the "Knowledge Society" is now widely recognized as an unparalleled factor in human and social progress. This development is capable of giving its citizens the competencies they need to face new challenges and of contributing toward making them aware of the importance of shared values and membership in a common social and cultural space. This mission is only accomplished through strengthening cooperation in educational terms. The creation of Common Spaces for Higher Education in different international geographical areas demonstrates this mission.

The International Conference on Engineering and Computer Education (ICECE) was held in Madrid, Spain, from November 14 to November 16, 2005, with IEEE Educational Society (IEEE-ES) technical cosponsorship. Madrid, an attractive European tourist and cultural center accustomed to serving as a forum for the exchange of opinions and ideas, was an ideal place for educators to discuss all issues related to the lemma of the conference based on the quality of the papers submitted. One hundred forty-five papers were received, and ninety-nine were finally selected by the reviewers.

II. Origins

The American Society for Engineering Education (ASEE) and the Institute of Electrical and Electronics Engineers Education Society (IEEE-ES) each hold an annual conference, the Annual ASEE Conference and the Frontiers in Education Conference (FIE), respectively. In 2006, ASEE held its 113th Annual Conference, and the IEEE-ES its 36th Frontiers in Education Conference. These conferences have normally been held in North America with some exceptions. In 1974, the London Chapter of the IEEE Education Society and University College of the University of London hosted the FIE. Later, in the 1990 conference, the second time in Europe, the conference was held in Vienna and Budapest, under the auspices of the IGIP, the Internationale Gesellschaft für Ingenieurpädagogik. Both of these offered an opportunity to meet and learn from engineering educators across Europe [1].

In 1997, the ASEE and the IEEE endorsed the creation of an International Conference on Engineering Education (ICEE). The ICEE held its first conference in Chicago, IL, and its second in Brazil, in 1998. These conferences were attended by a great number of participants not only from the Americas and Europe but from all five continents. The ICEE has had conferences successively in Ostrava (1999), Taiwan (2000), Oslo (2001), Manchester (2002), and on up until the present time.

Progress and technological advances in computer science and the need for a venue for international discussion of its role in education, prompted the ASEE and IEEE-ES together

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with IGIP and Société Européenne pour la Formation give Ingénieurs (SEFI) to support the creation of the International Conference on Engineering and Computer Education (ICECE).

During the last International Conference on Engineering and Computer Education (ICECE) held in Santos, Brazil, the General Chairman, Professor Doctor Claudio da Rocha Brito, agreed that the next conference should be hosted by Madrid, Spain, thus continuing the international momentum. The changes happening now in Europe have resulted in a greater interest in the development of a Common European Higher Education Space. These changes can be counted on to foster interest in additional discussion of educational issues in an international forum. This factor was the decisive reason for holding the 2005 conference in Madrid, Spain, to be hosted by the Universidad Politécnica de Madrid with the participation of the Spanish Chapter of the IEEE-ES.

III. Key Issues in Building Common Spaces in Engineering Education

Because Europe is currently intensely experiencing the construction of a Higher Education Common Space, the topics of the Conference covered those issues that promote the development of this type of environment. Therefore, the ICECE05 focused on three areas.

- competencies of practicing engineers;
- the position of education societies in building Common Spaces for Higher Education;
- engineering accreditation.

Coverage of the invited speakers and information on and proceedings of the Conference are available in summarized form in [2].

A. Competencies of Practice Engineers

"Enhancing the competencies of manufacturing engineers through society of manufacturing engineers–academia–industry partnerships," Professor Khalil Taraman, Chair of Manufacturing Engineering and Director, Lawrence Technological University [3]

Training of engineers should not be limited exclusively to that received in the classrooms. Like doctors, engineers must also be familiar with the surroundings encountered in the exercise of their profession, such as factories, or companies.

To progress in the process of education in engineering, one needs bring the world of the company into the educational process. Part of a strategic plan must be formed with specially assigned resources and standards. Resources can be provided by the companies. To control how investments are made, standards are needed to measure the quality of this education. Success cannot be measured only in economic terms. Success or failure in the educational process is measured through the set of competencies that the students must acquire. Professor Taraman explained his positive experience in establishing periodic meetings with the industry to establish the aforementioned competencies and to create managerial groups to subsidize this education. Societies, such as the Society of Manufacturing Engineers, have improved the profitability of the investments from the companies' subsidies.

"Competencies of engineers," Professor Richard Newrock, Dean of Engineering, University of Cincinnati, OH [4]

Issues in addition to technical competencies or Obvious Engineering Competencies, the so-called "soft-skills" issues of concern to employers, were considered by Richard Newrock, Dean of College of Applied Science (Cincinnati University). These competencies are referred to the needs of the marketplace and can be obtained only by constantly questioning industry leaders in what their employers want students to be competent.

The major problems at this university, which are beginning to be detected elsewhere as well, not only in the United States, were as follows.

- Deterioration of all technical students' oral and written communication skills over the past twenty years. All students take "Technical Writing," in which they must create written and oral presentations; students have to write up a project, make an oral presentation intended to "sell" the project to management, create posters to explain the project during the annual Technical Exposition, (adding e-portfolios, writing essays into the portfolio reflecting their class experiences and what they have learned, summarize the material and evaluate and assess where they are for each quarter and market) and use the e-portfolio to sell themselves to prospective employers.
- Developing a sense of business ethics and ethical competence, an important issue to avoid cases such as WorldCom, Enron, and Arthur Andersen. As a solution, universities should create a habit of critical reflection on the moral code, focusing on general moral issues, moral questions arising either in the student's professional training or in his/her future professional employment. Future professionals require competence in identifying, analyzing, and evaluating arguments.
- Incivility in the workplace, characterized by a lack of consideration for others, growing to critical proportions. The business community can no longer ignore the problem which is getting too costly. Individuals may choose how they want to behave outside the business world, but businesses cannot allow them the same choice in the workplace. Dr. Newrock finds the following explanation for this situation: parents feel guilty about not forming part of their children's lives, thus they fail to punish bad behavior, and children are taught that they are special (self-esteem) but not that everyone else is as well. Parents have relinquished the teaching of civility to universities and to the schools, but schools see this teaching as a "soft" skill, less important than teaching technology. Higher education must provide students with social skills (social codes and protocols, respect for one's fellow human beings, and respect for oneself) to take them to the top of their field, to help them practice their technical skills in any social situation, and to teach them about civility.

In brief, to achieve real success in the business community, engineers and technologists need more than excellent technical skills. They need to be able to communicate their ideas; they need to understand what ethical corporate and personal behavior is; they need to develop social skills and manners; and they need to learn how to respect others, i.e., be civil.

B. The Position of the Education Societies in Building Common Spaces for Higher Education

"The role of SEFI, European Society for Engineering Education," Alfredo Soeiro, Former President [5]

SEFI's mission is closely related to the building of a common space in European higher education because it aims at serving as an international forum representing the European Engineering Education Community, promoting the European Dimension in Engineering Education. In particular, its position can be summarized by the following points.

- SEFI shares the opinion of the European Ministers of Education concerning the need for a system of easily readable and comparable degrees, through a Diploma Supplement or otherwise.
- SEFI supports a wider use of the ECTS system as a proper means of promoting student mobility, as a workload measure/planning tool, taking into account many factors such as program design, teaching methods, student abilities, and motivation. Disciplines are planned in terms of learning outcomes.
- SEFI is convinced of the importance of increased mobility for students, teachers, researchers, and administrative staff.
- SEFI shares the opinion of the European Ministers concerning the importance of European cooperation in quality assurance and accreditation.
- SEFI is already committed to the idea of developing the European dimension in education.

In Professor Newrock's opinion, the construction of any reform of the structure of European Engineering Education must take the particular conditions of this field of education into account. The existing integrated five-year European curricula in engineering are compatible with the idea of a European education area: longer integrated curricula leading straight to a Master's degree in Engineering should be maintained, possibly in parallel with a two-tier Bachelor/Master's system.

SEFI promotes the creation of a common space in a global sense as a result of the involvement of the different actors in the process, distinguishing types of members: institutional (Institutions of a high level that offer a complete curriculum leading to an academic engineering degree), individual members (typically teachers of science or engineering or science, industrial members (any industrial company, public administration, or other organization having an interest in supporting European Engineering Education), Associate members and Professional societies, or other organizations interested in initial or continuing education of engineers, and student organizations. All contributions are produced through working groups, such as the EUR-ACE Project, an engineering standard for Quality Assurance and Accreditation.

"The role of INTERTECH, Interamerican Council on Engineering and Technology Education," Muthar Al-Ubaidi, President [6]

Dr. Al-Ubaidi introduced INTERTECH as an effect of the new trends on the globalization of the world economy: an increased need for businesses who wish to compete in the global economy, the need to employ a professional staff with an international perspective, and the realization that Engineering is one of the most likely professions to encounter an international assignment during a typical career. Therefore, Engineering education interaction across national boundaries becomes important. INTERTECH was born in the 1989 ASEE Annual Conference as an invitation to sponsor an inter-American conference in the Americas. In the western hemisphere, the common space is of extreme importance because there are only four languages in the Americas, and many individuals who assume leadership position in universities and official research agencies have been educated in the U.S. Therefore, some similarities exist among educational systems.

Areas identified by this society which have had an impact on engineering education since the nineties are college curricula, with an emphasis on languages and global studies to build linguistic competence and to develop the student's technical vocabularies; international students, who broaden the outlook of native students and provide them with valuable perspectives regarding global concepts; and intellectual exchanges of students and faculty. No single formula for a successful exchange program can be provided; only full cooperation in the western hemisphere requires the existence of a broad-based organization with a strong focus on engineering and technology education and educators, solving problems such as the rigid lock-step sequence of required courses, academic recognition, or coordination of marks/grades.

"The role of IGIP," Professor Claudio da Rocha Brito and Melany Ciampi on behalf of Federico Flueckiger, President of IGIP, Chairs of Working Group: International Aspects of Engineering Education in IGIP [7]

IGIP, founded in 1972, in Klagenfurt, Austria, has about 500 members, institutional and individual members, in 72 countries, and enjoys a consultative status with UNESCO and UNIDO. IGIP contributes to the creation of a common area supporting engineering education in developing countries, facilitating the exchange of ideas and experiences internationally, and supporting the networking of experts in various fields of technical teaching with the creation of working groups on curriculum development in engineering and technology international aspects of engineering education. One of the main features of IGIP is its work on the certification of the qualifications and competences of engineering and technology teachers. IGIP confers the title of 'International Engineering Educator ING-PAED IGIP' on technical teachers fulfilling the requirements, some 750 ING-PAED IGIP from 28 countries, with one National Monitoring Committee in many countries, and only one International Monitoring Committee. IGIP is extending its boundaries, going overseas across the Atlantic, as an example of a common global area.

"The role of IEEE-ES, Education Society of the IEEE," Ted Batchman on behalf of Professor Daniel Litynski, President of IEEE-ES [8]

The Institute of Electrical and Electronics Engineers Inc. (IEEE) Education Society (ES) is by nature a global professional society that promotes a global education with strong

operating principles. The Constitution and Bylaws describe the organization and procedures for the management of the society, and the Strategic Plan analyzes the essence of the organization. This plan is for the implementation of the Education Society is vision and mission, namely, the advancement of the theory and practice of electrical and computer engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members and affiliates, within the field of interest. The field includes Educational Methods, Educational Technology, Instructional Materials, History of Science and Technology, and Educational and Professional Development Programs within Electrical Engineering, Computer Engineering, and allied disciplines.

The IEEE ES has the following strengths.

- A voice of the engineering education community: The ES is for many the forum for education in the fields of electrical, computer, computing, electronics, and information technology (IT).
- Leaders in their profession: Members of the ES are active in the IEEE in many areas including accreditation, educational innovation, and conference organization.
- IEEE TRANSACTIONS ON EDUCATION: This journal has become a recognized and valued peer review forum for those wanting to publish in the field of engineering education research.
- Frontiers in Education Conference: This Conference was founder and now cosponsor of the FIE that has become a leading international conference for Education.
- Excellent international reputation: The ES is actively pursued by other engineering societies and individuals to cooperate in international activities.
- Governance of the society: This feature is innovative, stable, and dedicated. The Administration Committee (AdCom) is active and excellent.

Some facts show the globalization efforts that the Society is making: international membership is the fastest growing segment, with more than 365 000 members in over 150 countries, almost 40% of whom are from outside the United States; administrative committee global membership; and cooperation with international societies in meetings and Conferences, such as ICECE05. Finally, six international agreements govern mutual recognition of engineering qualifications and professional competence.

1. Agreements for tertiary (postsecondary) engineering qualifications.
   a) The Washington Accord, signed in 1989, recognizes substantial equivalence in the accreditation of qualifications in professional engineering, normally for a four-year duration.
   b) The Sydney Accord, which began in 2001, recognizes substantial equivalence in the accreditation of qualifications in engineering technology, normally for a three-year duration.
   c) The Dublin Accord, which began in 2002, agrees to substantial equivalence in the accreditation of tertiary qualifications in technician engineering, normally for a two-year duration.
2. Agreements covering competence standards for practicing engineers.
   a) The Asia-Pacific Economic Cooperation (APEC) Engineer agreement from 1999 with government support in the participating APEC economies.
   b) The Engineers Mobility Forum agreement, initiated in 2001, uses the same competence standard as the APEC Engineer agreement but which any country/economy may join.
   c) The Engineering Technologist Mobility Forum agreement of 2003 where parties to the agreement to begin establishing a mutual recognition scheme for engineering technologists.

C. Engineering Accreditation

"Accreditation Practices in Engineering Education in France," René Paul Martin, C.T.I. Commission des Titres d'Ingénieur, France [9]

The Commission des Titres d'Ingénieur (CTI), in a talk introduced by René Paul Martin from the French Engineering Degree Accreditation Board, acts on behalf of the Higher Education Minister and has its mission in a statement given by the law of 1934 to accredit and to assess periodically new and existing engineering degrees in the French engineering education system (one cycle of five years of higher education with entry in the engineering profession directly after the engineering degree is recognized by the "Conventions collectives." Currently in 2004, CTI has accredited 227 engineering institutions, 728 programs with 30 000 degrees, and 65 apprenticeship and continuing education engineering programs.

The method applied by the CTI involves a self-evaluation of the organization, awareness and partnerships, student recruitment, education and training, employment and continuous improvement. The accreditation criteria for new curricula includes objectives, recruitment procedure, pedagogic and personal outcomes (balance between scientific, technical, economic, and human resources programs), research activities, faculty mix (academic–industrial), educational self-education, premises, equipments, library, etc., quality management system, and costs. Lately, every six years a compulsory, periodical accreditation takes place whose purposes are: to make sure that educational programs are still in line with the industrial environment, to give advice to institution management for the improvement and updating of curricula, to encourage company involvement in training programs, and to reinforce synergies among engineering institutions.

The international activities of CTI aim at overseeing the development and operation of accreditation, developing mutual recognition agreements with other countries [ABET-CCI (ABET-Conseil Canadien des Ingenieurs, Canada), BEM (Board of Engineers Malaysia), etc.], assessing foreign engineering degrees on their request (Germany, Switzerland, Luxemburg, Bulgaria, Vietnam, etc.), or taking part in the rationalization of higher education systems [European Consortium for Accreditation (ECA), European Association for Quality Assurance in Higher Education (ENQA), European Accredited Engineering (EUR-ACE)] in cooperation with national agencies, and organizing its own self-evaluation and external review.

In conclusion, CTI has a long history of experience in evaluating and accrediting programs and institutions, and it searches the convergence of views, analyses, and decisions for the integration in Europe and other regions.

"Advantages and challenges which the accreditation process with ABET offers to Engineering and Computer Science Programs. Perspective of the Engineering College," Professor Ted Batchman, Dean, College of Engineering, University of Nevada, Reno [10]

Professor Batchman provided the perspective of an engineering college with ABET accreditation. ABET, the foremost organization responsible for monitoring, evaluating, and certifying the quality of engineering, engineering technology, computing, and applied science education, is a federation of 30 technical and professional societies recognized by the Council of Higher Education Accreditation. Degrees, Basic Level or Advanced Level, and all paths of study, must be accreditable.

Engineering accreditation criteria before 2000 focused on the specific number of course credits required in mathematics, basic sciences, engineering sciences, engineering design, humanities, and social science. Criteria since 2000 have focused on the assessment of outcomes based on the consideration: Are graduates able to do what you say they can do? Programs can be defined flexibly in order to meet specific requirements. The general criteria for Basic Level are: Students, Program Educational Objectives, Program Outcomes and Assessment, Professional Component, Faculty, Facilities, Institutional Support and Financial Resources, and Specific Program Criteria.

Program accreditation ensures quality, makes the transfer of credits easier between institutions and, in the case of the USA, is necessary for licensing as professional engineers.

The accreditation process begins with program development to meet criteria: 1) after the requested accreditation visit; 2) then the submitting of self-study documents to ABET; 3) the team visit to the institution; 4) the exit interview; 5) the indication of the outcome of the visit; 6) the preparation of the draft report; and 7) the final statement after a period of process response.

The accreditation takes a global view, in Dean Batchman's opinion. Global engineering teams design products for use worldwide, using common design skills and tools or maintaining common standards necessary to promote the mobility of the engineering work force, so that graduates can work in any country and have legal liability. The knowledge society has made the world flat, leveling the opportunities, with a global engineering work force. Engineering education has changed. To maintain minimum standards, accreditation has become necessary.

"Accreditation in Engineering," Professor Benjamin Suarez, Coordinator of the European Convergence Program of the National Agency for Quality Assessment and Accreditation, ANECA [11]

Accreditation is seen as a type of control to ensure that higher education conforms to the needs of the students and social agents, and to other international institutions of reference. Covering the qualities of the teacher, the contents that the teacher presents, and the material the student learns is essential.

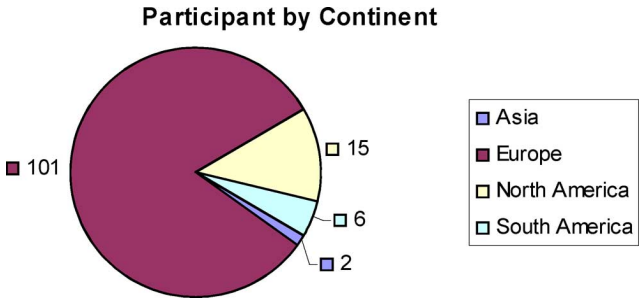

Fig. 1. Distribution of participants by continent.

TABLE I
DISTRIBUTION OF PARTICIPANTS BY COUNTRIES

Country	Participants
Austria	1
Brazil	5
Colombia	1
Czech Republic	3
China	1
Estonia	1
Finland	1
France	4
Germany	1
Greece	1
Ireland	1
Mexico	2
Poland	1
Portugal	2
Spain	84
Taiwan	1
USA	13

A failure in accreditation might bring about a temporary suspension of the program. Professor Suarez questions whether a failure of this type should also affect the professors, academic administrators, or politicians.

IV. The Results in Numbers and Final Dissemination

The ideas presented here and explained by the keynote speakers at ICECE05 were complemented by the presentation of 100 papers organized under the following topics: competencies, curricula, teaching-learning process, courses, resources, and quality. The distribution of the participants is illustrated in Fig. 1 and Table I.

The materials produced have been edited and distributed to the participants as follows:

- a book of abstracts in four languages: English, Portuguese, French, and Russian [12];
- the Proceedings in CD format [13];
- a DVD with the video recording of the Plenary lectures and submitted to the participants [2].

All these materials can be accessed online at http://web3.fi.upm.es/icece05.

V. Conclusion

The construction of Higher Education Common Spaces is an emerging challenge in different geographical areas of the world. This paper compiles the opinions of relevant keynote speakers in Engineering Education from Universities and Education Societies. Their opinions are organized according to the main areas

of the conference, in which they argued their positions: Competencies of practicing engineers, the position of Education Societies in building Common Spaces for Higher Education, and Engineering Accreditation:

- *Competencies of engineers*. Professor Taraman and Professor Newrock agree that competencies must be referred to marketplace needs. These may be obtained by questioning, asking industry leaders or establishment of periodic meetings with the industry, and creation of managerial groups to subsidize education. Success or failure in the education process is obtained through the set of competencies that the students must obtain.
- *The position of the Education Societies in building Common Spaces for Higher Education*. This presentation gives opportunity to contrast the view of four different societies, two European (SEFI and IGIP) and two American (IEEE ES and INTERTECH). All of them share the same interest in facilitating the exchange of ideas and experiences internationally and supporting the networking of experts in various fields of technical teaching. SEFI's mission is closely related to the building of a common space in European Higher Education in a global sense as a result of the involvement of the different actors in the process. IGIP contributes to the creation of a common area with the creation of working groups on Curriculum Development in Engineering and Technology, International Aspects of Engineering Education. IEEE-ES makes an effort at Globalization and has reached six international agreements governing mutual recognition of engineering qualifications and professional competence for tertiary (postsecondary) engineering qualifications. INTERTECH requires the existence of a broad-based organization with a strong focus on engineering and technology education and educators, solving problems such as the rigid lock-step sequence of required courses, academic recognition, or coordination of marks/grades.
- *Engineering Accreditation*. Examples of accreditation were explained, European and American (CTI and ABET). In spite of having its own criteria and process, each aims at overseeing development and operation of accreditation, developing mutual recognition agreements with other countries, assessing foreign engineering degrees upon request, or taking part in the rationalization of higher education systems in cooperation with national agencies. Ted Batchman represented the IEEE Education Society at ICECE and reported to the IEEE Education Society AdCOM on substantial interest in accreditation.

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