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Engineers in the field: accreditation of BME programs in Argentina

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Abstract—**The college diploma suffices for professional registration in Argentina and for the first time, Biomedical Engineering curricula have been included among those programs that need government and peers approval as their professional practice may affect citizen´s health, safety or state. In this paper we present the standards that must be followed by BME programs and educational institutions in order to allow their graduates registration before professional boards.**

I. Introduction

Engineering curricula are included among the programs that need government and peers approval in Argentina, to allow those graduating registration before professional boards, as the discipline practice may affect citizen´s health, safety or state.

For the last five years, and for the first time in the country, all Engineering educational programs were revised and eventually approved by CONEAU –the National Commission on University Evaluationn and Accreditation (Comision Nacional de Evaluacion y Acreditacion Universitaria) [1].

The college diploma suffices for professional registration in Argentina. Therefore, approval of a program by CONEAU combines what in other countries are two separate task, i.e. the academic accreditation of a program, such as the one performed by the American Board for Engineering and Technology (ABET) in one hand, and the evaluation of a candidate qualifications to register as Professional Engineer (PE) on the other [2].

Standards observed by colleges and universities seeking accreditation of their engineering curricula were based on preliminary documents elaborated by the Federal Council of Engineering Deans (CONFEDI) [3] and finally adopted by the Ministry of Education [4].

The assessment and accreditation process completed by mid 2005 ranked engineering curricula in almost every traditional field: civil, mechanical, electrical, electronics, chemical, nuclear, among others. Biomedical Engineering as a discipline was omitted.

Only recently, a set of standards was formulated by the government specifically for Biomedical Engineering [5]. This represents a landmark, as the requirement for accreditation, similar to other engineering disciplines, indicates a formal recognition of Biomedical Engineering as a profession.

The listing of BME as an independent engineering discipline will allow BME graduates from accredited institutions to becoming professional engineers in their field of expertise.

Currently, six universities in Argentina are under the accreditation process of their Biomedical Engineering programs. Four of these universities are supported by the federal government: Tucuman, Cordoba, Entre Rios and San Juan. The other two are run by private foundations, the Favaloro University in Buenos Aires and the University of Mendoza [6] [7] [8] [9] [10] [11].

In the next sections we present the main issues of the accreditation process: the core Biomedical Engineering curriculum and the accreditation standards for both BME programs and educational institutions.

II. Biomedical Engineering Curriculum

The broad scope of Biomedical Engineering requires careful planning when designing educational programs which must prepare students for a successful professional performance in a constantly changing field [12].

A Biomedical Engineering graduate must be prepared to work in industries, hospitals, educational institutions, in particular in the overlapping areas of health and technology fields. BME professional competence also includes, among others, designing biomedical instrumentation and setting the rules for its manufacture, verifying biological safety standards.

Biology and engineering backgrounds allow a BM engineer the understanding of the physical and chemical properties of materials of biomedical interest and their biocompatibility in one hand, and familiarity with the structure and dynamics of varied complexity hospitals on the other.

A BM engineer must exhibit, in addition to Biology, strong knowledge of Mathematics, Physics, Electronics and Computer Sciences as any other civil, electrical, mechanical or chemical engineer.

The requirements for BME curricula have been delineated by the Argentine government. These requirements, which include a minimum of 3750 classroom hours over a period of five years, are grouped into five categories: basic topics, minimum duration, practical education criteria, accreditation process and professional activities.

A. Basic Topics

It is generally accepted that most medical advances in the second half of the 20th century are due to technological dvelopments incorporating Physics, Computer Sciences and Electronics.

The core BME curriculum is aimed to provide a common background for all engineering students. Basic topics are grouped in Basic Sciences, Basic Technologies, Applied Technologies and Complementary Studies.

1) Basic Sciences: This group includes a minimum of 900 hours in courses which prepare students with solid basic concepts needed to understand future scientific and technological developments.

At least 400 hours must be dedicated to teaching Math courses: algebra, geometry, calculus, statistics. Courses in Physics for 225 hours should include mechanics, electricity, magnetism, optics and thermometry. For chemistry, 50 hours to studying the structure of matter, chemical equilibrium, metals, non metals and basic kinetics will fulfill the requirement.

Among Basic Sciences, a minimum of 150 hours of Biology comprises Cellular and Molecular Biology, Anatomy, Physiology, Biophysics and Pathology. Computer Programming fundamentals (75 hours) are also included in this basic sciences group.

2) Basic Technologies: These technologies represent engineering application of basic sciences, and they prepare students to undertake further studies. Courses in Computer Science include algorithms, low and high-level programming, numerical analysis and data bases.

Courses on Circuit Analysis and Electronics should cover dc and ac circuits, electronic devices, analog and digital circuits, microprocessors and microcontrollers.

The area of Biomaterials and Biomechanics introduces the fundamentals of biomaterials and biocompatibility, and it also includes biomechanics of soft and hard tissues and mechanics of the human body.

Modeling, Simulation and Control cover system modeling, analysis and design.

Signal and Image Processing includes the study of signals and noise, filters, and time-frequency analysis.

3) Applied Technologies: The group of applied technologies is intended to developing students creativity and to preparing them for solving major Biomedical Engineering problems through the use of different design methodologies.

Applied technologies include Clinical Engineering, -dedicated to the integral study, design and operation of health care centers-, Rehabilitation Engineering, and Medical Imaging.

Topics on sensors, and the measurements of physical, chemical and biological variables are included on Biomedical Instrumentation. The area of Radiation and Radioprotection takes into account the study of nuclear physics and medicine, ionizing and non ionizing radiation and radiotherapy.

4) Complementary Studies: Knowledge of social sciences, humanities and foreign languages are essential to modern engineering education.

Courses on Economics (cost-benefit analysis, finances, project design and assessment), Industrial Organization (structure and planning), Legislation (professional responsibilities, commercial laws, patents) and Environment Protection are included in this group of Complementary Studies.

B. Minimum Duration

Of the 3750 classroom hours that a program granting a Biomedical Engineer professional degree should minimally include, 2225 hours must be dedicated to the 4 groups mentioned in the previous section as follows: Basic Sciences 900 hours, Basic Technologies 575 hours, Applied Technologies 575 hours and 175 hours for Complementary Studies.

C. Practical Education Criteria

In order to develop practical professional skills, a minimun of 750 hours must be devoted by students to four major activities: basic sciences experiments, engineering problem solving, projects and design activities and supervised trainingship.

For experiments, 200 hours of laboratory or fieldwork are oriented toward practical training for the operation of equipment, experiment design and data processing.

Concerning problem solving, 150 hours are dedicated to identifying engineering problems and to seeking solutions in both real and hypothetical situations.

Project development and design activities must be emphasized by all Biomedical Engineering programs, to provide students with significant experience, leading to the development of a system or process, directed to satisfy a certain need and to optimize the use of available resources.

A supervised trainingship represents practical operations in the field, that is outside the academic setting. This fieldwork is key for students to gaining practical experience through firsthand observation. The supervised trainingship constitutes the essence of the government controlled professional practice of Biomedical Engineering graduates.

D. Accreditation Process

The accreditation process as ruled by the government in Argentina, involves the evaluation of both the Biomedical Engineering study program and the educational institution implementing it. The set of standards for these assessments are presented in section III.

E. Professional Activities

For the formal recognition of the Biomedical Engineering profession, a set of specific activities have been listed by the government. Such listing embraces all those activities that could be legally performed by any practicing biomedical engineer who graduated from an accredited institution.

It must be noted that most of these activities refer to biomedical engineers involvement in health care systems, medical instrumentation manufacturing or regulatory agencies, as it could be expected for public professional practice. Although to a much lesser degree, entailment in the academic setting is also listed.

III. Accreditation Standards

Fifty-one standards have been formulated by CONEAU, which comprehend and delineate five axis for the evaluation process of both the study program and the academic institution.

The first axis relates to the institutional context. A total of 10 standards describe the conditions that must be met for those educational institutions interested in granting Biomedical Engineering professional degrees. Teaching and research policies, inter-institutional cooperation, mid and long term goals, academic and administrative organization, data processing and storage, are among some of the issues of the institutional setting to be assessed during the accreditation process.

Another set of standards involve the Biomedical Engineering Program itself and its relation to other engineering programs of the same school. Detailed content of the core BME curriculum was presented in Section II. The standards for the BME program orient toward a continuous evaluation and eventual updating of courses and syllabuses.

Integration of the academic staff deserves a group of 8 standards ecompassing the required profile of teachers and researchers, their backgrounds and career achievements, their ability to attracting students and grants, and their experience in the field.

The accreditation procedure also involves students and recent graduates evaluation. Every college should guarantee an acceptable quality in education, which is measured in terms of the available physical and human resources for teaching. Student must be encouraged to join research and development teams, and to pursue activities for life long learning.

The last group of standards details the minimal conditions and characteristics for library and laboratory facilities and equipment. Institutional plans for instrumentation upgrading as well as space and resources use are of interest to all educational actors.

IV. Conclusion

Biomedical Engineering consolidates the concept of modern engineering which must take into account the social, economical and political context of professional practice. Engineers currently engage in a wider range of activities and Biomedical Engineering, far from being the exemption, stands as a clear and almost unique example of strong multidisciplinary integration [13].

Following its formal recognition, the accreditation of BME programs and institutions represents the occasion for strengthening the discipline in the region allowing at the same time the registration of professional practitioners. It must be noted, however, that some standards defining the scope of the BME profession must be revised in the mid term, to include new and emerging activities of our constantly changing discipline.

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