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Present and Future Challenges in Educating Biomedical Engineers Part2: New approaches to Curricular Design

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Abstract— **Undergraduate programs in Biomedical Engineering have been around for a long time. However, change in the curricular structure has been slow and uneven. This Session will discuss the challenges worldwide to modernize the hundreds of programs that are being offered, in light of the new biological developments revolutionizing health care.**

I. Introduction

The start of Biomedical Engineering (BME) Education at the undergraduate level dates from the 1970s. Founders of these pioneering BME programs state that at the beginning, these were developed from modifications to classical Electrical Engineering curricula by adding more subjects in biology and medicine to the structure in addition to proposing projects and laboratory work dealing with the measurement of physiological phenomena. Nowadays, these ideas make up but a very small section of what we consider to be the field of the BME discipline. This field is so wide that the IEEE Engineering in Medicine and Biology Society divides its conference into 12 different themes as diverse as health informatics, signal and image processing, and cell, molecular & tissue engineering.

The purpose of this special session is to discuss new approaches to curricular design that address the ever-changing landscapes of the medical & biological disciplines and their relationships to engineering. This includes the questions on the program structures, the core competencies, and even the relationship that the BME program should have with its traditional Electrical Engineering origin.

II. Background

There have been many analyses published about the state of BME education, starting around 1975 up to now [1-5]. In the U.S. there have been three initiatives that have shaped the way the curricula are structured: the VaNTH initiative, the Whitaker Foundation programs and the ABET requirements. In the rest of the world, curricula have been established with the aim of solving specific problems in Engineering in Medicine. For example, dealing with the practical problem of the maintenance of medical devices. Several studies have been published on the different approaches in different institutions worldwide [4,6]. Many institutions offer programs that are strongly traditional and thus offer pyramidal structures where BME subjects are taught only after two years of classical engineering. In light of the new approaches to health care and therapies, it is imperative that we examine current programs with the aim to propose updating the curricula so they are in line with contemporary and future directions in health care technology. One approach that is still useful is the bridge model described by Katona [3], where in the 60s-80s, BME was applying engineering techniques to solving problems in the life sciences (a slender bridge); in the 80-90s with the biological revolution, the bridge was greatly widened and BME education included a broader knowledge of life sciences, and now, the challenge is to provide an integrative approach that is still poorly understood which requires both the inclusion of Both Breadth And Depth in Engineering and Life sciences.

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III. Discussion & Conclusion

The questions to address lie in several axes:
a) Breadth v depth (partly answered above).
b) A pyramidal structure with wide bases in basic science and engineering v a Design Core running all along the 4-year curriculum and
c) A rebalancing of required courses between electrical engineering, cell & molecular biology and quantitative physiology.
Other questions regarding the need for specializations or even a different degree for more work in the field as medical technicians of Clinical Engineers will have to be discussed.

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Perspectives of the Biomedical Engineering Program at UASLP after ten years of experience.

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The Biomedical Engineering (BME) bachelor program of the Faculty of Sciences in the Universidad Autónoma de San Luis Potosí was created in June of 2010, with the aim to train professionals with an integral perspective in the field of engineering by considering a multidisciplinary approach to develop and apply technology in areas of medicine and biology.

After 10 years, our BME program has achieved national recognition. Despite of being a recently created program, this achievement has been obtained by the consolidation of our academic staff, the outstanding participation of our students in national and international academic events, and the historical graduation results. In our evaluation, we report an overall terminal efficiency of 67% and a graduation efficiency of 44%, where these values are above the average for an engineering program in our institution. Additionally, the BME program provides students with solid skills and background to carry out research activities, which has resulted in a considerable number of alumni (38) pursuing graduate studies, or have already completed one,

Our results show that 88% of our former students are working after graduation, but only 45% work in the field of biomedical engineering, since the regional labor market starts to saturate given the fact that, at present, students from six generations have completed our BME bachelor program. Because of this, we have found that few graduates are able to visualize the wide spectrum of job options where a biomedical engineer can have an impact due to their distinctive comprehensive and multidisciplinary training.

Therefore, it is necessary to propose new curricular design strategies to provide our students with an academic training that allows them to enter a globalized world, where there is an even greater spectrum of engineering possibilities related to the fields of medicine and biology, in line with current trends. At this moment, our academic staff is working on a curricular adjustment to be implemented in a near future.

Clinical Engineering Education Opportunities in Latin America

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***Abstract*— Clinical Engineering (CE) face diverse challenges in their education. From the rapid changes and trends in medical devices to a more prevalent and essential role in the global health community. An analysis of the Latin American social, economic, and educational context and the academic opportunities for CE is presented to draw the challenges for clinical engineering education.**

INTRODUCTION

Biomedical engineering education was an answer to a series of challenges that healthcare has been facing regarding finding better ways to provide acute diagnosis, effective treatment, and, more recently, play a prominent role in dealing with global health issues. But health-related problems have been present long before. For example, we may locate the antecedents of physiological signal measurements, like clinical sphygmomanometry, from the Egyptian culture or, most recently, in the eighteenth century with Stephen Hales' experiments, the nineteenth century with the Poiseuille's mercury manometer or Vierordt non-invasive version [1].

Over the past half-century, there has been a growing concern about the lack of knowledge of key stakeholders, including government agencies, towards clinical engineers' work and their impact on healthcare [2]. Taking medical technology as a basis, recent activities aimed to increase awareness of clinical engineers on medical devices' assessment have impacted the biomedical engineering community and other related fields like policymaking and regulation [3]. CE academic and professional programs should follow, or even be ahead of, the global changes and trends in health care medical devices. However, evidence shows that few changes are implemented, and many bureaucratic delays don't allow them to be effectively implemented and evaluated.

II. METHODS

Although most of the academic programs in Latin America show an alignment with the job market expectations, those are more focused on a practical technical solving problem profile [4]. This leads to a considerable problem at providing many different topics in a time line of, at most five years, including general science and electrical engineering courses. Some of the proposed solutions are the design of optional specific topic courses or professional practices at hospitals. The amount of knowledge, skills, and capabilities that the future clinical engineers has to learn needs to be managed by the student, ideally with academic advisor support. Unfortunately, there are not enough professors who can take the role due to their heavy workload at universities and other institutions.

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III. RESULTS

After considering the geographical, social, and cultural similarities among Latin American countries, strategies that aim to share theoretical frameworks and practical knowledge may find a good place in a regional educational program that benefits clinical engineers, biomedical technicians, and other related professions. This can be done by organizing webinars, massive open online courses, and workshops on clinical engineering topics. One of the most important steps is to carefully select the main subject and the specific topics so that academic and pedagogic goals are met. Others should address aspects like content quality, relevance for the region's context, technical and managerial solving problems, or diffusion. The creation of groups of professors and/or experts by subject can provide a high-level academic experience to the student and conform a network of professionals in CE.

IV. DISCUSSION & CONCLUSION

The CE division of the International Federation for Medical and Biological Engineering has led some primary global efforts to form a CE education network. Still, the imbalance between supply and demand leads to the development of regional strategies to address this need.

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