

# Results of Biomedical Engineering program reforms at Universidad Tecnológica Centroamericana

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**Abstract—** *Biomedical Engineering is one of the most recently recognized disciplines in the practice of engineering. In the last decades, engineers related to all forms of biomedical technology were fundamentally electronic engineers, which participated in the development of medical devices as well as maintenance of existing ones. Biomedical Engineering degree in Honduras was founded in 2007. The program originally was focused on solving the technical difficulties that are found in healthcare systems. We performed a benchmark to reform our undergraduate program, considering nine biomedical programs around the world and the courses they teach. We found many of the courses around the world are being oriented towards R&D. Taking this into consideration the reform will orient our academic program towards R&D and the local market needs.*

**Keywords—** *Academic reform, biomedical engineering, undergraduate degree.*

## I. INTRODUCTION

Biomedical Engineering is one of the most recently recognized disciplines in the practice of engineering. It's a field of practice which brings many, if not all of the classical fields of engineering together to assist in developing a better understanding of the physiology and structures of the human body. It also supports the knowledge of clinical professionals in prevention, diagnosis and treatment of diseases and modifying the anatomy of the body with new devices and clinical services [1].

In Latin America the first Biomedical Engineering academic undergraduate programs were established in the 1970s in Mexico (UAM) and in Colombia, and later in Argentina (UNER) in 1985. At the same time various graduate programs were created in Brazil, Colombia, Peru, Uruguay and Cuba [2]. In the last decades, engineers related to all forms of biomedical technology were fundamentally electronic engineers, which participated in the development of medical devices as well as maintenance of existing ones. The lack of basic skills or knowledge in anatomy and physiology, prevented this type of engineer from having a greater impact in the development of technology. Nowadays, the professional trained with a range of pertinent knowledge can propose solutions and develop suitable technologies for diagnostic, therapy, monitoring or telemetering functions [3].

One of the main challenges in developing undergraduate programs for Biomedical Engineering is the current market needs for professionals in this area of knowledge. In Latin America, Biomedical Engineering (BME) educators are still following objectives set 45 years ago, together with the pursuit of encyclopedic knowledge in medical instrumentation. There

is a fact that nowadays most job offers are of a low-salaried, technical nature [4].

Azpiroz-Leehan et. Al. [4] comment that it appears programs are aligned with the job market expectations. This can lead to low expectations and lower quality education that runs the risk of becoming highly technical in nature.

Biomedical Engineering degree in Honduras was founded in 2007 at Universidad Tecnológica Centroamericana (UNITEC) at campus Tegucigalpa. The program originally was focused on solving the technical difficulties that are found in local healthcare systems. From 2011 to 2021 a total of 169 engineers have graduated from UNITEC and are currently working in public and private hospitals as well as medical equipment distribution companies as technicians or sellers. A reform to the academic program was considered necessary due to the growth in market demand for biomedical engineers with a more specialized training.

The reform of the plan was completed in 2019 with 183 students currently in the new program. To choose the new courses in the program, a diagnostic study was carried out consulting with professional career associations, physicians, and others involved in the local healthcare industry. Also, a comparative analysis with biomedical engineering programs offered by other Latin American, United States and Europe universities was made to design a more international program.

The main goal of the reform was to change from a technical based education and promote Research and Development (R&D) projects. A technical based education in Latin America aims to manage and maintain the medical healthcare technology. However, R&D based education could improve support in the local medical devices industry. There are fewer than 10 universities in the region carrying out R&D [4]. The need to develop stronger competences in this area is evident.

One of the main challenges in reforming academic programs is the diversity of courses among universities. Several universities in the region have courses with similar structures. However, there is a great variety of contents, some covered under similar names, which has created the difficulty of homologating them [3].

To determine what courses were adequate for purposes of the reform a benchmark was performed to determine which of these were to be added to the new academic program. The courses were also chosen considering the current market needs and development of new professional areas in the country, such as biomedical devices development and research.

The role of future BMEs in the field of medical device and systems design is to act as project leaders, managers, or coordinators; rather than an engineer who is trained in all the fields of engineering that would need to be addressed during the development of a project. [4]

The following paper presents the results from the benchmark and the new courses that were added to the new Biomedical Engineering academic program at UNITEC, Honduras.

## II. METHODS

Two studies were made to select the new courses for the academic program reform. First a benchmark of academic programs among several universities was performed.

The universities considered in the study were selected from three regions: Latin America, United States and Europe. Most of the universities were chosen from Latin America due to the similarities in the local healthcare needs. Universities from the United States and Europe were chosen to promote internationality as one of UNITEC's educational model pillars. The sample size was selected as a non-probabilistic purposive sampling, due to the researcher's knowledge in the BME academic programs of specific universities.

The universities considered are the following:

- Latin America
- Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)
- Instituto Tecnológico de Buenos Aires (ITBA)
- Universidad de Valparaíso, Chile (UV)
- Universidad Don Bosco, El Salvador (UDB)
- Universidad Latina de Costa Rica (ULCR)
- United States
- Massachusetts Institute of Technology (MIT)
- Arizona State University (ASU)
- Europe
- Universidad de Grenoble Alpes (UGA)
- Universidad Politécnica de Madrid (UPM)

The selected courses were considered as standard for biomedical engineering programs worldwide. The courses were selected in such a way that they would contribute to local development, considering the opinions of employers, professors, and experts in the field of biomedical sciences and healthcare. Courses that were shared between more than 60% of the universities were considered as essential for the reforms. The second study in this investigation was a survey made to healthcare companies' spokesperson after a focal group. The purpose was to evaluate their opinion on which courses from the ones selected were most relevant for the local market. The attendance to the focal group was 17 spokespersons from multiple companies and public and private hospitals after a public call. The results of the survey were gathered considering those who attended.

The survey gathered the following information:

- Satisfaction with the new BME program
- Needs for the local market

- Possibility to hire a professional graduated under the new program.
- Comments to improve BME education.

## III. RESULTS AND DISCUSSION

The results from the benchmarking are shown on Table I and Table II. As it's shown from the benchmarking, six out of nine selected courses meet the criteria (the courses are shared by more than 60% of the universities). All these courses were considered essential for the internationality of the program.

The six selected courses that have met the criteria are: Medical informatics, bioinstrumentation, biomechanics, biomedical signal processing, clinical engineering, and sanitary regulations.

When analyzing Central American universities, we observe that UDB from El Salvador is already teaching the considered courses, and that ULCR from Costa Rica still has not included these to their academic programs. Considering this information, including these subjects in the academic program brings opportunities for academic exchanges with UDB university and demonstrates a need for more specialized courses in the academic programs in the region.

TABLE I  
BENCHMARK RESULTS FROM UNIVERSITIES IN LATIN AMERICA

Selected Courses	Universities					Percentage shared
	Latin America					
	UDB	ULCR	ITESM	ITBA	UV	
	Central America		Rest of Latin America			
Medical Informatics	X	-	X	X	X	80%
Bioinstrumentation	X	X	X	X	X	100%
Biomechanics	X	-	X	X	-	60%
Biomedical signal processing	X	-	X	X	X	80%
Clinical Engineering	X	X	X	X	X	100%
Sanitary Regulations	X	-	X	X	X	80%
Medical Devices Analysis	X	-	X	-	-	40%
Clinical Seminars	-	-	-	-	X	20%
Medical Imaging Systems	X	X	-	-	X	60%

When analyzing the results from universities in the United States and Europe we find that courses such as medical informatics and biomedical signal processing could be standardized in international programs. This may be due to the strong R&D environment experienced in those countries.

United States universities include courses in sanitary regulations, but European universities do not include them. In comparison with Latin American universities Sanitary regulation is present in 80% of the universities in this region.

TABLE II  
BENCHMARK RESULTS FROM UNIVERSITIES IN UNITED STATES AND EUROPE

Selected Courses	Universities				Percentage shared
	United States		Europe		
	MIT	ASU	UGA	UPM	
Medical Informatics	X	X	X	X	100%
Bioinstrumentation	-	X	-	X	50%
Biomechanics	-	X	X	X	75%
Biomedical signal processing	X	X	X	X	100%
Clinical Engineering	-	-	-	X	25%
Sanitary Regulations	X	X	-	-	50%
Medical Devices Analysis	X	X	-	X	75%
Clinical Seminars	X	-	X	-	50%
Medical Imaging Systems	X	-	-	X	50%

Courses such as clinical engineering are common among all Latin American universities. United States and European Universities, besides UPM, don't teach this subject. This may be because these universities are orienting their academic programs towards R&D, in contrast with Latin America where the investment in R&D is low. In Latin America R&D represents an average of 0.7% of the GDP and over 90% of the regional investments are concentrated in Brazil, Argentina, Chile, and Mexico [5]. Universities like ITBA, ITESM and UV all teach courses like Medical Informatics and Biomedical Signal Processing, which are essential for R&D of medical devices.

From the benchmarking we observe that UDB from El Salvador has already adopted many of the considered courses and has oriented their program towards R&D. This is important since as a region we must work together towards developing new technologies.

According to the results of the focal group, the program should provide more skills in management, knowledge in medical device analysis and communication skills with medical professionals. Another relevant comment made by the spokesperson was to provide programming skills focused on biomedical applications, such as signal and imaging processing. Through the survey we also gathered information about what the local market needs for a BME. Most of the spokesperson agreed to add:

- The course of medical informatics due to the need of analysing medical data.
- A course to make students come closer to national healthcare reality to contribute to society.
- Reinforcement of management skills.

Courses such as clinical seminars, medical imaging systems and medical device analysis were left as part of the reform since they are an essential part of what employers require from undergraduate students. Clinical seminars were considered essential so students can develop better communication skills with the medical staff. Other courses that complete the

academic program remain from the original one such as Anatomy and Physiology and the courses of electric, electronic, math and physics.

Overall, we observe that Biomedical Engineering academic programs are shifting towards a more R&D oriented education, but it must be balanced with the local market demand.

According to the results of the survey 94% of the spokesperson will hire a graduate from the new program. Some of the reasons being: local healthcare system requires updated content in BME programs, new knowledge in medical technologies and the competences of the new courses are aligned to the market needs.

#### IV. CONCLUSION

We implemented a reform in 2019 for the Biomedical Engineering academic program considering the importance of promoting an R&D environment in the region and the demands of the local market. The reform included the courses evaluated in the benchmarking and those considered by local healthcare employers as important knowledge for the country's needs.

The courses selected for the reform were: medical informatics, bioinstrumentation, biomechanics, biomedical signal processing, clinical engineering, sanitary regulation, medical device analysis, clinical seminars, and medical imaging systems. Currently 183 students are registered in the new program and the first graduates are expected for 2023.

We have considered the need for internationality and standards so that our students can share contents and quality of education with others around the world.

Although the benchmarking was made considering just a small number of universities, the information provided was important to guide our selection of courses. We will continue performing this analysis in the future considering more universities for the next reform, which must happen in five years. We will also continue to consider the local market needs according to companies' and hospitals' spokesperson. This to keep our academic program on the same tracks as other programs around the world and contribute to Honduran healthcare system.

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