MOOC on Biomedical Engineering for Latin American Students – Unleashing the Potential of Virtual Learning

Ricardo L. Armentano
Translational Engineering Department
School of Engineering and Exact and Natural Sciences
Favaloro University
Buenos Aires, Argentina
E-mail: armen@ieee.org

Parag Chatterjee
Department of Computer Science
St. Xavier's College (Autonomous), Kolkata
University of Calcutta
Kolkata, India
E-mail: parag2700@gmail.com

Abstract — **Massive Open Online Courses (MOOCs) have commanded considerable public attention due to their sudden rise and disruptive potential. As a very promising area, the biomedical world offers the integration between several domains, complementing medicine with engineering topics. This work has been focused primarily over a MOOC delivered in Spanish, covering the introductory ideas of biomedical engineering and posing a holistic view of the subject. This MOOC on biomedical engineering was the first of its kind in Latin America, creating a stir in the Ibero-American community of biomedical engineering. Centering this work, a platform has been proposed which would act as a point of connection and collaboration in biomedical engineering. This would open up new possibilities of collaborative innovation besides catering the subject to the prospective students in an interesting way, so that before taking up a career in biomedical engineering, they could have an introductory and holistic view to it. The platform would also open up a common stage of partnership between universities and associations of biomedical engineering, giving the learning community an opportunity to gain from collaborative learning. Industrial partnership with the platform would shape the profile of graduated students versatile, allowing their instantaneous incorporation to the competitive market in this vast field. Pertaining to this perspective, the prospective impact of virtual learning has been explored.**

Keywords – biomedical engineering; eLearning; Latin America; learning management system; MOOC; ubiquitous; virtual learning

I. INTRODUCTION

Massive Open Online Courses (MOOCs) have taken higher education by storm. Just in few years, MOOCs have emerged as an important industry, unleashing the business perspective of this newer trend of education. Millions of students from around the globe have enrolled; thousands of courses have been offered; hundreds of universities have lined up to participate. The world has taken notice.

The MOOC modality is gaining global momentum. The MOOC phenomenon though being very recent, has created a stir in the learning atmosphere, making the stakeholders rethink upon modernizing the education paradigms [1]. A large number of users, especially in BRICS nations and other developing countries tend to be young and well-educated people who are trying to advance in their carrier. While there is tremendous hope for this educational platform, the individuals the MOOC revolution is supposed to help the most – i.e. those without access to higher education in developing countries- are conspicuously underrepresented among the early adopters [2]. MOOCs impact higher education institutions in different ways, depending on the type of institution, and its socio-economic and legal framework.

Since its very inception, Favaloro University *("Universidad Favaloro",* an Argentine private university, located in the city of Buenos Aires*)* has been characterized by a rigorous tradition of academic study that prepares its students to become key actors in a global society. As a part of the endeavor in bringing this long-standing tradition of academic excellence to a wide group of international, Favaloro University started its first MOOC in Spanish, on "Introduction to Biomedical Engineering" (*Introducción a la Ingeniería Biomédica*). The first MOOC has created an immense stir across the learning community in Ibero-America, linked to biomedical engineering. To this end, it has developed innovative cooperation with some of the most prestigious universities and associations of the world. The MOOC has opened up new possibilities for collaborative work within the concerned academic community.

The focal aim of this work is to disentangle the cross-fertilization between creativity and interoperability, designing a new curriculum, supporting the archetype that leading universities not only build with well needed and essential bricks, but also with state-of-the-art technology and virtual classrooms, making the most of the higher expertise of Favaloro University in Biomedical Engineering (BME) education. As a part of this endeavor in exploring virtual learning for biomedical engineering, a proposal for biomedical engineering MOOC platform has been put up. Different aspects of the platform have also been discussed which could connect the entire biomedical engineering

community for mutual academic and innovation exchange virtually, in a ubiquitous approach.

II. PRE-MOOC SCENARIO OF BIOMEDICAL ENGINEERING IN LATIN AMERICA

Though MOOCs have attracted considerable public attention due to their sudden rise and disruptive potential, there was no robust, published data portraying the learners' objectives and intended outcomes from the course, in a Latin American perspective for biomedical engineering. Hence it was not known precisely how transformative the MOOC phenomenon could have been. Online surveys were conducted among students enrolled in freshman course of Favaloro University to identify the main reasons for taking a MOOC. Most of the reports pointed out the need of advancement in their current job and satisfying curiosity. The students were mostly interested to take a MOOC in addition to their regular course. During the first few months of the year, the overall diagnosis was assessed through personal interviews with the leading Latin American specialists. The major concerns addressed are described in Table I.

TABLE I. CONCERNS ADDRESSED IN PRE-MOOC SURVEYS

Issue	Description
Limited dissemination	Limited dissemination of biomedical engineering among pre-university and university students, opinion-makers and the general public.
Subject biasedness	A common biasedness toward Clinical engineering.
Lack of international exposure	Lack of representation of the R9 in high-impact scientific journals, especially in IEEE journals
Language bar	Most of the literature being in English, students with Spanish as First Language faced issues in studying literature. Also a significant number of Spanish speaking research contributors could not disseminate the work in English, because of the number of students proficient in English has been few in the community concerned.

However, the intent to take a MOOC on biomedical engineering has been profuse among the concerned student community in Favaloro University. Most of the MOOCs on biomedical engineering in popular platforms like edX, Coursera etc. being delivered in English, keep away these students from taking those courses. The primary target was to fill up this void with a MOOC delivered in Spanish, mostly putting light on the basic aspects of Biomedical Engineering.

Besides MOOCs, the need of a common network between the Spanish-speaking Ibero-American biomedical engineering communities for mutual sharing of research and innovation has also been identified. Hence the intended MOOC was thought to be designed in such a manner that it could serve as the primary step toward connecting them through a common platform.

III. USE OF MOOC FOR BIOMEDICAL ENGINEERING

Favaloro University's "Open Learning Initiative" has offered a first attempt to disseminate the EMB (Engineering in Medicine and Biology) endeavors throughout Latin America, unrestricted and free of charge. The preliminary step was starting a MOOC in Spanish, discussing mostly about the applications of engineering in medicine and biology. Despite the first MOOC being designed mostly over the introductory areas of biomedical engineering, the focal aim was to have an impact across Ibero-American biomedical engineering community.

A few salient features of the MOOC have been presented below.

A. Registration

The MOOC was open for all and any person could register for taking the course. However, the registration data has been stored in the database for future analytics purpose.

B. Courseware

The courseware consisted of primarily video lectures having an average duration of 5 minutes. There were 5 such primary lectures, delivered by the course instructor. However, a substantial amount of additional resources have also been embedded within the MOOC, including PowerPoint presentations and notes. The focal point though being an introductory idea to biomedical engineering, another important goal of the MOOC was to explore the potentials of pursuing a career in biomedical engineering. The details of an academic career in biomedical engineering and its potential exposure in the industry have also been explained in the courseware. A trivial scenario explaining and distinguishing the roles of biomedical engineer and eHealth IT engineer has also been portrayed in the course (Table II). Taking the field of eHealth into concern and discussing in the context of biomedical engineering have been one of the important aspects of this MOOC.

TABLE II. CONCERNS ADDRESSED IN PRE-MOOC SURVEYS

Biomedical Engineer	E-Health IT Engineer
Design, construct and put in use equipment, which is specifically designed for a purpose in medicine including all relevant aspects of hardware and software.	Contribute to biomedical research, in particular to areas where the computer is used as a major tool
Participate in the construction, sale and marketing of biomedical equipment	Be attractive as future employees to companies focusing on the development and production of medical equipment, like imaging workstations, patient monitoring and assessment equipment, pacemakers; or of medical software, such as clinical information systems and

Biomedical Engineer	E-Health IT Engineer
	decision-support systems
Train medical, paramedical and technical personnel in the use of biomedical equipment.	Develop a sufficient foundation to usefully contribute to information technology issues of healthcare management.
Carry out maintenance and repair of equipment used in the hospital environment and in human beings.	Contribute to the scientific world of computer models and simulation, signal and imaging processing and telemetric applications
Verify standards of security (biological, microbiological, mechanical, electrical radiations).	Verify the technical standards of the IT equipment and systems used for healthcare services
Serve as an interface between medical staff and hospital physicists.	Act as the interface between IT sector and the medical field

Another important aspect of the courseware is that, there were several videos where experts from the field of biomedical engineering discussed their views on a given track. The experts' discussions added a new dimension to the MOOC by drawing diversified and practical aspects of the course. The tracks of the discussion are pointed out in Table III.

TABLE III. TRACKS OF EXPERTS' DISCUSSION IN THE BME MOOC

Questions answered in the discussion
What were the greatest achievements of biomedical engineering in the last 15 years?
What are the greatest challenges of biomedical engineering in the next 15 years?
How to arrange and utilize a grant of $1000000 to improve biomedical engineering in Latin America?
What are the 5 devices created by bioengineers who changed her life to humanity?
What is your idea on bioengineering paradigm?
How to improve teaching degree in Engineering applied to medicine and biology?
How to improve the teaching of postgrad Engineering applied to medicine and biology?
What would be the flagship of the Bioengineering to help develop Latin America?
What would be the greatest threats and weaknesses of Bioengineering at present and in the near future?
Share your experience in Bioengineering

C. *Assessments and Evaluation*

After almost every lesson, a set of objective-type questions have been asked to the learners. Answering them correctly to some extent, they were allowed to proceed for the next lesson. Evaluation has been done automatically and instantly the test scores were made available to the learner. It was really helpful for a learner to immediately assess herself and retake that course segment if the scores fall below the required passing marks.

D. *Discussion Boards*

Since a MOOC lacks the face-to-face interaction available in a typical classroom scenario, the discussion board was used to let the learners post comments, ask questions and interact with the peer learners or the course team members.

E. *Platform and Technologies used*

The Open edX platform was used for delivering and managing the MOOC on biomedical engineering. It was hosted using a subdomain of Favaloro University. However, the traffic was typically less to moderate, so no load issues were faced during the process.

IV. IMPACT OF THE MOOC ON BIOMEDICAL ENGINEERING

For the first time, "An Introduction to Biomedical Engineering" MOOC in Spanish was delivered targeting the Ibero-American community; it has represented a unique occasion to connect the Spanish speaking students and colleagues from around the world. Most of the instructors in the MOOC were officers of Biomechanics societies, EMBS representatives and linked to the national societies of biomedical engineering affiliated with CORAL. An Ibero-American regional aspect has worked towards the success of the MOOC.

The biomedical engineering MOOC has emphasized reaching the general public, opinion-makers, pre-university, and university students for setting up an online and remote mentoring eLearning network in order to increase the interest in biomedical engineering education and to connect people interested in biomedical engineering topics. As the effect in Latin America, in general, the members of IEEE of any given country know each other quite well; yet in many cases the members of large societies (i.e. Computers, Communications, Power), or even in smaller ones (i.e., Social Implications of Technology) are unaware on how their work may relate to biomedical engineering. The design of forums and discussion boards has represented a place for biomedical engineering aspirants to "meet and learn"; also it has given an opportunity to all communities to introduce the new technologies and applications in the field. Supportive literature and PowerPoint presentations were made available in both Spanish and English (and Portuguese, in near future) which helped getting a deeper insight into the subject.

The MOOC analytics have immensely helped the course team in understanding the student behavior in the MOOC environment; also the chief issues could be better addressed for the future MOOCs. Few analytics (from the commencement on 2nd July 2015 till 9th September 2015) obtained from the learning management system have been showcased below (Table IV).

TABLE IV. MOOC ANALYTICS

Attribute	Description		
Number of enrollees	Total: 283		
	Male: 152	Female: 105	Didn't specify: 26
Enrollees'	Primary School	1	

Attribute	Description	
Level of Education	Junior Secondary Junior High Middle School	10
	High School	91
	Bachelor Degree	41
	Associate Degree	36
	Master/Professional Degree	47
	PhD	9
	Didn't specify	48
Grade cutoffs	A: 0.75	B: 0.50

The analytics more or less complied with the targets and objectives set up by the MOOC team before commencement the MOOC. The primary target audience was the high school students about to start their undergraduate courses; they contributed maximum number of enrollees. Also a significant number of graduate students have also opted for the MOOC, mostly to have a clear view of biomedical engineering prospects.

Another interesting aspect of the analytics (Fig. 1) is the age of the learners. Though the MOOC was open for all, most of the learners were from the age group of 20-25. This endorses the fact that the learners were taking the course to get a notion about biomedical engineering either to pursue a biomedical engineering career or to connect with the Ibero-American biomedical engineering community.

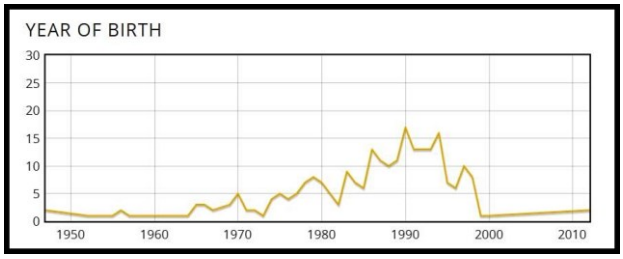

Figure 1. Number of Learners vs Year of Birth in the BME MOOC.

V. FUTURE SCOPE OF THE MOOC

The first MOOC though focused on introductory ideas of biomedical engineering, it was the foundation of the future MOOCs using the same platform and paradigms. However there has been future plans to extend the MOOC to different other subjects. On one hand it would address several aspects of biomedical engineering; on the other hand it would serve as the linking factor with eHealth technologies. Some objectives to carry on this endeavor of virtual learning to other sectors have also been discussed briefly.

A. Numeric Simulation

In this area, the main objectives would be simulating differential equations to find the flow movement in rigid and non-rigid tubes solution. Different advanced techniques, including finite elements algorithms could also be designed to fulfill the computational requirements, making use of peer learning and virtual assignments allotted to peer-learner groups.

B. Computational Fluid Dynamics

Software is being used to model stent patency after surgical instrumentation in coronary patients. Online simulation could be implemented in the MOOC for a better understanding of the learners.

C. Digital Signal Processing and Ubiquitous Computing

The main objective of the course would be developing equipment involving digital signal processing, including signal acquisition, signal conditioning, software development, and microcontrollers (PIC, Motorola series) programming, real time signal processing using digital signal processor (DSP) and Field Programmable Gate Array (FPGA, Altera MAX+PLUS), Signal communication USB, RS232 and Digital Filters implementation. Transforming the coursework into a MOOC environment would involve online laboratory platforms which would enable the learners to create their design and test it online. Collaborative work would also escalate the process of designing.

D. Image Processing

The main concerns being focused in echography related images, the task could be outsourced as assignments through the MOOC.

E. Cardiovascular modeling

The main interest in this field is to develop new models that describe the cardiovascular system, including arterial mechanics, ventricular coupling, and pulmonary/systemic circulation studies under pathological states as hypertension. In a MOOC perspective, multidisciplinary teams (consisting of instructors and group of learners with common goal) could integrate the physiologic concepts with the most advanced mathematical algorithms.

F. Bioinformatics

The epidemiologic study of great populations deserves a special statistical analysis. The patients' database and its associated software are designed and customize to study precisely cardiovascular pathologies and diseases in our hospital. This group concentrates the database design and the networks interconnection between different sections in the university, the hospital and the research center. Different PACS have been planned to be designed and installed in the near future to unify the patient clinic history. It would give the learners a flavor of Internet of Things in eHealth technologies.

VI. CONCLUSION – IMMENSE POTENTIAL OF VIRTUAL LEARNING

The paper has been centered on two focal themes. The first one is a MOOC approach to improve the quality of biomedical engineering education. Concrete implementation of this approach in the form of an introductory course aims at

introducing the students to biomedical engineering knowledge and to challenge and motivate them in fostering their creative and innovative abilities.

The second one is proposing the extension of the MOOC initiative toward a connecting platform which would connect the entire Ibero-American community of biomedical engineering for collaborative research and partnership.

By analyzing the current boundary between secondary education and university in Latin America, the harsh reality could be observed. A large number of students have a vague idea of the scope and implications of the careers they choose, to such an extent that the enrolment to technical-scientific careers has been decreasing. Furthermore, many of them experience existential crisis during their first undergraduate years, thinking that it was not their true calling, when they cannot really know it, since there are overwhelmed with the training in basic sciences and biology rather than being exposed to a holistic approach. The traditional structure of engineering programs has certain characteristics that encourage dropping out. Firstly, all subjects are taught in isolation, in completely independent courses, which hinders any future multidisciplinary work. On the other hand, students do not have a real objective, since they are unclear about the usefulness of the basic knowledge they acquire, and ignorant of the tools and working methods of their future profession.

All the above sums up the need to emulate the current paradigm of engineering during a first introductory course, where projects rather than disciplines mold each area of expertise, blurring the boundaries between science and engineering, and defying the educational practice of separating fundaments from applications. Consequently, biomedical engineering becomes a *Profession of Everything*, where no bounds are set regarding its scope, and technology turns into science, art and management, pushing the limits of its mission statement.

This work has been developed reaching the framework of a Degree in Biomedical Engineering, a new training program with a strong focus on biological processes and life sciences, in order to produce professionals capable of performing in an industrial environment and of developing the necessary equipment for the biomedical industries. Delivering a MOOC would be helpful for learners (especially the high school and summer school students who would take up a career in biomedical engineering) to get a holistic view of the subject (as introduction) and a deeper insight through collaborative and active learning. On a different note, the MOOCs could be analyzed well to understand the focal areas of interest among the learners in a course. Accordingly the quality of teaching could be improved besides introducing more engaging contents in the courseware [3]. In a blended learning scenario, the MOOC-analytics could help gearing up the classroom-based study also, making the most out of the blended model.

Also another important aspect of MOOC is partnering with other institutions for disseminating enriched and diversified content. With incremental growth of members in the network, the platform could become a wholesome entity for all concerned teachers, learners and researchers to learn, communicate and collaborate [4]. There has always been a gap between the industry and the academia especially at the university-level study. This platform could also be helpful in connecting the biomedical industry with the academia; it would be immensely helpful for especially the students, who would get a concrete academic support and an industry exposure too, all at the same platform. Good functioning of the platform would definitely shape the biomedical engineering scenario in Ibero-America in a new approach.

Favaloro University *(Universidad Favaloro)* is one of the leading Latin-American universities for biomedical sciences, offering undergraduate, Master and PhD degrees. Its mission is to educate open-minded individuals who can understand the world and make a profound impact upon it. René Geronimo Favaloro (July 12, 1923 – July 29, 2000) was an Argentinean cardiovascular surgeon who revolutionized the field with his pioneering contributions, among which the most remarkable is the standardization of the coronary artery bypass surgery, performed for the first time in 1967. He developed a university in Argentina (Favaloro University) that is committed to putting scientific research. Origin of the institution is thus based on a research center.

The university hospital and the university follow a natural development to complement and integrate several areas in the biomedical spectrum. The collaboration between the university and its hospital holds an excellent potential for MOOCs, where students would be able to get in touch with real life examples of biomedical engineering. The research assignments related to the hospital could also be outsourced through the MOOC, opening the possibilities of collaborative work including healthcare technologies.

Transitioning from a classic school course to a MOOC platform allows democratizing technology, generating an Ibero-American network, disclosing information on many levels, to put their high-end technologies at the service of medical humanism, as embraced by Dr. Favaloro. This Biomedical Engineering Network could transfer technology to business and healthcare institutions across Latin America in general and Ibero-America in particular.

The team for MOOC has worked hard to make the MOOC on “Introduction to Biomedical Engineering” a success. The MOOC served as opening the window to biomedical engineering and introducing the subject in an interesting manner so that prospective students could have a holistic view of biomedical engineering. Also it has been noticed that the interesting presentation of the subject has drawn a large number of prospective students who were immensely interested. From the university perspective, the MOOC venture has opened the possibilities of connecting with talented and motivated personalities, along with a large number of students taking the MOOC.

MOOCs have transformed the formal way of teaching-learning to a new dimension. The MOOC on biomedical

engineering was first of its kind in Latin America. Massive expansions of the scheme to a platform for collaboration and virtual learning would benefit the entire biomedical engineering community. Thus, a new horizon of ubiquitous learning and collaboration would be open up, taking the platform to second screens and mobile devices.

REFERENCES

[1] Chatterjee, P.; Nath, A., "Massive open online courses (MOOCs) in education — A case study in Indian context and vision to ubiquitous learning," in *MOOC, Innovation and Technology in Education (MITE), 2014 IEEE International Conference on* , vol., no., pp.36-41, 19-20 Dec. 2014 doi: 10.1109/MITE.2014.7020237

[2] Armentano, R.L., ""Biomechanics and mechanobiology", a proposal for an iberoamerican MOOC platform," in *MOOC, Innovation and Technology in Education (MITE), 2014 IEEE International Conference on* , vol., no., pp.175-178, 19-20 Dec. 2014 doi: 10.1109/MITE.2014.7020265

[3] "The Internet of Everything: Fuelling Educational Innovation," Cisco, 2014.

[4] Chatterjee, P.; Nath, A., "Massive open online courses (MOOCs) in higher education — Unleashing the potential in India," in *MOOC, Innovation and Technology in Education (MITE), 2014 IEEE International Conference on* , vol., no., pp.256-260, 19-20 Dec. 2014 doi: 10.1109/MITE.2014.7020283