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Virtual Learning Approach Toward Introductory Biological Engineering Course in Uruguay During COVID-19

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Abstract

INTRODUCTION: Global education has seen a paradigm shift in the recent years; especially in life sciences, specializations have started sharing common space in applied research and development. Extending the transdisciplinary approach to undergraduate programs, a case study on the introductory course of Biological Engineering program at University of the Republic *(Universidad de la República)* Uruguay is presented.
OBJECTIVES: The COVID-19 pandemic has led to shifting the biological engineering course to virtual modality, changing the pedagogical dynamics. This study aims at analyzing the adaptation to the new model of virtual learning.
METHODS: Different course metrics over time has been analyzed along with surveys on students and professors of the course.
RESULTS: Despite several new challenges posed by the virtual modality, the overall student-performance didn't decline.
CONCLUSION: The biological engineering course presents interesting contents especially in its course design and student engagements, remodeled especially during its virtual mode.

Keywords: Education, Creativity, Innovation, Biological engineering, Peer-learning, COVID-19, Pandemic, Virtual Learning.

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1. Introduction

The status of education has always been one of the primary factors of development in defining academic capital, human resource and vision of development [1,12]. In the digital era, one of the crucial areas which needs to embrace newer technologies and cutting-edge paradigms is education. During the transition from high school to university-level education in Science, Technology, Engineering, and Mathematics (STEM), it has been observed that a significant number of students lack clarity regarding the scope and applications of the career or study program they choose [11], which often reduces their commitment to their chosen career. Especially in the domain of life sciences, the uncertainty among the students especially with respect to the future scope of their career is caused by several factors, including inadequate exposure to the state-of-the-art in the field, or limited access to professional development in parallel to the university courses, or unsatisfactory communication with referents and leaders in the field. These issues, observed over a span of several years in the Department of Biological Engineering of University of the Republic *(Universidad de la República)*, Uruguay, led to the development of a new course from the ground up, totally redefining the approach toward the introduction of course topics as well as the teaching and learning paradigms. The objective of cross-fertilization between creativity and interoperability in a transdisciplinary environment was central to this, fusing

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measured, following which they present a written report. Throughout the entire course, special attention is taken in introducing the students to the state-of-the-art in the field. Every class consists of a specific segment where students are introduced to a trending topic in the field, mostly through online talks and papers, which later pose as a platform for open discussion between peers and the professors.

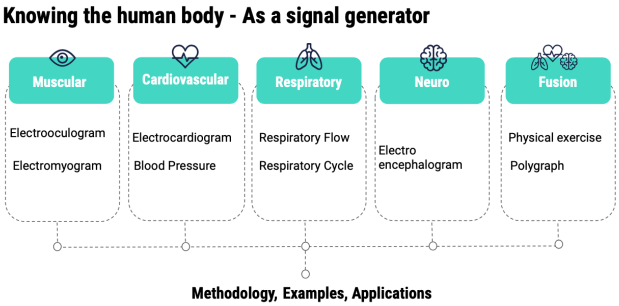

Figure 3. Thematic modules for theoretical and practical classes (Biological Engineering Workshop 1) at the University of the Republic *(Universidad de la República)*, Uruguay

The course was designed with the objective of twinning the theoretical and practical modules in an applied way, which will facilitate the students to immediately apply the concepts learnt into a real-world scenario. A major part of this involved non-invasive acquisition of signals from the human body and analyzing these thoroughly (Table 2).

Table 2. Key objectives of the new course in Biological Engineering

Muscular Physiology Module	Electromyogram	**Theory:** Fundamentals of anatomy of the muscular system, base of muscular contraction, action potential, electromyogram, applications, recording equipment, innovative projects in signal registration. **Practical:** Manipulation of instruments in the recording of the electromyography signal, recording of skeletal muscle tone at baseline levels of electrical activity, recording of maximum activation of muscle fibers in contraction, analysis of acquired data.
	Electrooculogram	**Theory:** Fundamentals of the anatomy of the eye, physiology of the eye movement, physical bases of the electrooculogram, recording of the electrooculogram, innovative projects in the registration and processing of the signal. **Practical:** Handling of instruments, tools and data, familiarization with the electrooculogram signal, analysis of the records, application of the register in the movement of objects
Cardiovascular Physiology module	Electrocardiogram	**Theory:** Fundamentals of heart anatomy, pulmonary and systemic circulation, cardionector system, action potential, cardiac cycle, electrocardiogram, innovative projects in signal acquisition. **Practical:** Familiarization with electrocardiogram measurement, recognition and manipulation of instruments, evaluation of electrical events of the heart and their association with mechanical events in the cardiac cycle, evaluation of changes in signal frequency under certain conditions
	Blood pressure	**Theory:** Relevance of the topic, fundamentals of blood vessel anatomy, arterial flow dynamics, systolic and diastolic blood pressure, regulation mechanisms, invasive and non-invasive

		measurement techniques, innovative projects in signal acquisition. **Practical:** Familiarization with different methods of measuring blood pressure and with the information provided by the data, taking measurements with different methodologies and tools, recording and comparing methodologies.
Respiratory Physiology module	Respiratory cycle	**Theory:** Fundamentals of respiratory system anatomy, pulmonary ventilation, ventilatory mechanics, static properties of the lung, gas exchange, breathing control, respiratory cycle measurement, innovations in measurement systems. **Practical:** Measurement and recording of pulmonary ventilation using pneumography and air and temperature transducer, relationship between theory and the phenomena observed in the signals.
	Respiratory flow	**Theory:** Fundamentals of respiratory physiology, air flow, resistance to air flow, breathing air flows, measurement of respiratory air flow, spirometry of flow, obstructive and restrictive pathologies of the respiratory system, calculation of flow and volume. **Practical:** Manipulation of instruments, tools and data analysis, familiarization with airflows in the airway, evaluation of volumes and capacities of the respiratory system
Neuro-Physiology module	Electroencephalogram	**Theory:** Fundamentals of anatomy of the nervous system, neurophysiological bases of the electroencephalogram, technological bases of electroencephalographic records, measurement recording devices. **Practical:** Data acquisition, derivations and assemblies, processing of recorded signals, pattern recognition in electroencephalogram signals
Integrating module	Physical exercise	**Theory:** General concepts, physiological responses and adaptations in physical exercise at the level of energy metabolism, cardiovascular system and ventilation, diffusion and transport of gases. **Practical:** Record and compare changes in lung flow, heart rate, and skin temperature before, during and after moderate exercise in different periods of duration.
	Polygraph	**Theory:** Physiological bases of the autonomic nervous system, physiological signals recorded in polygraph, evasion forms, false positive factors, signal recording equipment, application. **Practical:** Recording of pulmonary ventilation signals, electrocardiogram and electrodermal activity, observation and recording of changes in the signals associated with different types of stimuli, analysis