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A HYBRID INTERNATIONAL CO-TEACHING MODEL: CASE STUDY FOR BIOMEDICAL ENGINEERING DEGREE

Begonya Garcia-Zapirain, Amaia Méndez-Zorrilla, & Ana Belen Lago-Vilariño
eVIDA Lab. University of Deusto (Spain)

Abstract

Degrees in Biomedical Engineering are increasingly present among the international offer. The study plans of each of them allow to provide a certain specialization towards the different sub-areas within biomedical engineering through electives: orthopedics, microbiology, robotics, biosensors or artificial intelligence applied to clinical data. The fact of including 4 subjects of artificial intelligence is another of the particularities and/or differential elements of the curriculum. The University of Deusto offers a new degree in Biomedical Engineering of 240 ECTS where all the subjects of the "Bio" subject are taught in English, and include "master class" among other teaching methodologies. The teaching modality is hybrid, with a module of 24 ECTS dedicated to state-of-the-art frameworks in bioengineering that is entirely taught virtually and where international experts in each subject participate as online teachers. This is what we call "international co-teaching" which allows students to have a more realistic view of the use of technologies for biomedical applications but in an international framework. These teaching modules will follow a methodology that will combine synchronous videoconference sessions by international experts with an asynchronous methodology that includes the use of gamified activities for both content presentation and evaluation. Moreover, the teaching modules will be designed and developed according to a number of learning cycles that promote the development of the independent and meaningful learning of students and promotes the development of their knowledge, skills, attitudes, competences and values. Each learning cycle has five stages: experiential context, reflective observation, conceptualisation, active experimentation and assessment. These stages facilitate students' active construction of the learning content and the meaningful integration of that knowledge that will allow subsequent recovery, application and transfer.

Keywords: *Hybrid teaching, gamified learning, biomedical engineering, international co-teaching.*

1. Introduction

The Degree in Biomedical Engineering aims to train specialists in the application of new technologies in different fields of medicine. Graduates of this degree will join the labor market in response to the demand for professionals who accelerate technological innovation in the field of health to improve people's lives: minimally invasive surgery, telemedicine, 3D printing prostheses, nanotechnology, biosensors and advanced analysis of biomedical signals with the most appropriate artificial intelligence techniques to create predictive models to offer personalized medicine.

From the point of view of international trends, the best engineering schools in the USA offer studies related to biomedical engineering, bioengineering or biotechnology, with Massachusetts Institute of Technology (MIT), Stanford University, the Berkeley campus of the University of California or John Hopkins University standing out. The "US bureau of labor statistics" shows an increase of 23.1% in job offers for biomedical engineers for the period 2014-24. In Canada, the University of Waterloo or the Quebec region's commitment to engineering applied to health stand out. In Europe, ETH Zurich, Imperial College of London or DELFT Institute of Technology occupy the top rankings in these studies. The latter promotes these studies by claiming that 100% of students are placed within a maximum period of six months.

The "European Economic and Social Committee", already stated in 2015 (Lozia Edgardo M., Jarré Dirk, (2015) that the sectors of biomedical engineering and the medical and care services industry - including research and development - are among the fastest growing industrial areas, both in terms of turnover and employment. By biomedical engineering we mean the bridge between the methods of engineering, medicine and biology for diagnostic and therapeutic measures in the field of healthcare,

including, among others, biological and biopharmaceutical products, pharmaceutical drugs, various types of devices for analysis or chemical or biological processing, as well as the development of medical equipment and technologies for the cure, treatment and prevention of diseases. The combination of research and development, industrial engineering and production, and medical and care services is particularly important. Furthermore, they indicated that the establishment of a single European market combining biomedical engineering with the medical and health care services industry - in combination with information and communications technology and telemedicine - would have enormous advantages for European society, its citizens and the economic development of the European Union, especially in terms of saving resources and promoting entrepreneurial opportunities and initiatives, reducing regional disparities, overcoming national blockages in health policies, alleviating social protection systems, coordinating Research and Development (R&D) in health and care, boosting innovation, raising Europe's position in global competition, pursuing the 2020 objectives, implementing fundamental rights more effectively, establishing quality principles, promoting mobility in the labor market, etc.

In terms of the economic rationale and future of biomedical engineering, according to Michigan Tech (Michigan Technological University, 2022), medical diagnostics are tripling in market value every year, and revolutionary advances in medical imaging and medical diagnostics are changing the way medicine is practiced. New medical devices, emerging from the research laboratories of biomedical engineers around the world, have completely altered the way physicians treat disease and trauma, extending the quality and length of human life. Ultimately, the future of biomedical engineering is tied as much to the problems and obstacles we discover as it is to advances and achievements in fields such as chemistry, materials science, and biology. As in most other fields, interdisciplinarity means that innovation originates from many directions at the same time and this allows economic returns from the exploitation by companies of such services and products.

The growing demand for professionals also highlights the shortage of such professionals. One of the main reasons for this is the limited supply of training in this field. Currently, there are 19 degrees with similar characteristics offered in Spain, according to the Spanish Society of Biomedical Engineering.

It is to be expected that the demand for a specific degree with these characteristics will be high. The official degrees that have so far served to cover the biomedical engineer profile have been mainly computer engineers, electronic engineers and telecommunications engineers.

3. Methods

3.1. General context of the pedagogical framework, Deusto strategy

Spanish universities offer study programs in three cycles of study, bachelor's, master's, and doctorate degrees according to Bologna Process (Elias, 2011). Bachelor's degree is the first cycle and its main aim is the general education of students in one or more disciplines, aimed at preparing for the exercise of professional activities. The study plan or curriculum is divided into various modules that contain different types of subjects: core, obligatory, elective subjects or final project. These have a concrete syllabus with specific objectives, which must be reached within a specific period called semester and an academic year has two semesters. Each subject has been allocated a number of ECTS Credits (European Union's Credit Transfer and Accumulation System) (European Commission, 2017) which measure the total workload required to complete the subject, including the time spent on theoretical and practical classes, the time dedicated to studying and preparing and carrying out assessments. In ECTS, 60 credits represent the workload of a year of study; normally 30 credits are given for a semester. An ECTS credit is equivalent to 25 working hours. At the University of Deusto, the student work distribution for bachelor's degree programs is typically based on 6 ECTS subjects, which means 150 working hours.

In this context, the University of Deusto offers a new bachelor's degree in Biomedical Engineering, which takes four years to complete, with a total of 240 ECTS credits (60 credits per year). Unlike other existing degrees, this degree combines online and face-to-face learning modality and in online subjects is used "international co-teaching" (Svobodová, Z., 2020), where several international experts in each subject participate as online teachers. This degree contains a module of 24 ECTS credits with four 6 ECTS credits subjects focused on state-of-the-art frameworks in bioengineering distributed in different semesters.

3.2. Pedagogical techniques

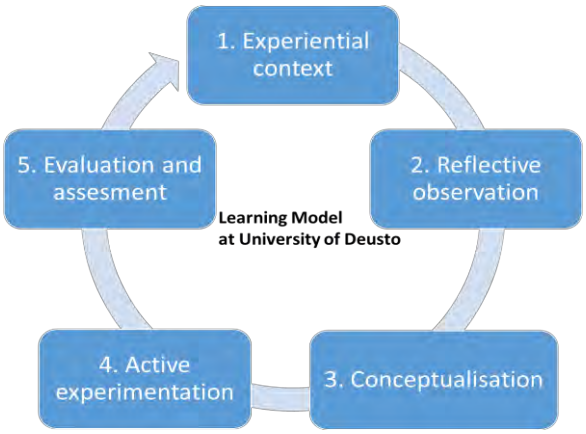
The University of Deusto has developed its own pedagogical framework, known as "MAUD" by its abbreviation in Spanish (University of Deusto's learning model) (Universidad de Deusto, 2001). It was developed by the university itself with the University of Gröningen (Holland) within the framework of the Tuning Project (Tuning Educational Structures in Europe, 2003). The pedagogical framework has served as a guide for many other universities, both nationally and internationally. From 2003 to the present day,

the University of Deusto has advised more than 70 Spanish universities, and more than 100 universities from countries around the world.

MAUD is based in autonomous and meaningful learning and centred in students' skills and competences development as advocated in the European Higher Education Area (Bezanilla, Garcia & Poblete, 2019) (Bezanilla, Arranz & Aguilar, 2014). MAUD aims to develop student's ability to think for themselves and to be autonomous and free-thinking individuals.

Inspired by the model of Kolb (Kolb, 1999) and "Ignatian pedagogy" (Gil, 1999), MAUD defines a structured learning cycle organized in five stages, as shown in Figure 1.

Figure 1. University of Deusto's Learning Model.



Experiential context stage aims to motivate students through their experience and context to come close to the idea of topic or issue under study. This phase requires contextualizing different methodologies and strategies, working on future expectations of students and common perceptions, and linking to other contexts and experiences.

Reflective observation stage consists of opening students' eyes to perceive the reality that surrounds us and to question, through reflection, the considerations of what this observation really means. The main objective is to achieve meaningful learning.

Conceptualisation stage includes acquiring knowledge about theoretical concepts in the subject area in the greatest depth possible. In this stage, students develop comprehensive competences, analytical-synthetic, critical and lateral thinking, enabling integrated and meaningful learning.

In the fourth learning stage, active experimentation seeks to apply the concepts, theories and models for problem solving or to design or implement a model or strategy. It is an appropriate stage for collaborative work, learning to cooperate and develop social and interpersonal skills.

In the last stage, the learning evaluation is carried out from three perspectives. In the personal perspective, students reflect on their own learning experience (self-assessment). In the formative perspective, students receive feedback as a key element for their progress. Finally, in the summative perspective, each student's work performance is evaluated.

3.3 Proposed syllabus and methodology

3.3.1 Details about the syllabus. The curriculum of the Bachelor's Degree in Biomedical Engineering is structured in seven modules, as described below:

- **Module 1. Basic training.** 60 ECTS credits (FB). Module aimed at the acquisition by the student of the basic training competences.
- **Module 2. Biomedical Engineering.** 84 ECTS credits (OB). Module aimed at the acquisition by the student of the competences related to the technologies necessary for the design and development of biomedical products and services, as well as their application on biological, physiological and cellular systems, the competences of which will also be acquired in this module.
- **Module 3. Data Science and Artificial Intelligence.** 24 ECTS credits (OB). Module aimed at the acquisition of skills related to technologies that allow the representation of knowledge in a computable way, as well as the subsequent inference (reasoning) in order to perform or optimize a process automatically.
- **Module 4. Industrial Technologies.** 12 ECTS credits (OB). Module aimed at the acquisition of competences related to technologies related to electronics and prototyping and mechanics.

- **Module 5. Ethical, human and personal options training.** 18 ECTS credits (OB). This module is compulsory in all the degrees of the University of Deusto.
- **Module 6. Elective training.** 30 ECTS credits (OP). This module consists of two electives and the student must select one of the two: 30 ECTS credits to be chosen en bloc by means of an international stay in the fourth year or 30 ECTS credits to be chosen in optional subjects in the fourth year to complete their professional profile, one of them being an internship in a company.
- **Module 7. Final Degree Project.** 12 ECTS credits (FDP). The student develops in the last semester a project in the subject "Final Degree Project".

3.3.2 Proposed methodology: hybrid Learning Model with international co-teaching

The class delivery model is hybrid, combining face-to-face classes with faculty from the team contracted to work on the Spanish campus, with online classes in which professors from other countries will participate in the category of international co-teaching online (both synchronous and asynchronous way) (Aldabas, R. A, 2018). The following is a summary of the credits that will be taught virtually:

- 24 ECTS credits of the subject Frameworks in Bioengineering will be taught in virtual mode (Chizhik, E. W.,et al, 2020). This subject belongs to the Biomedical Engineering module which is formed by 2 face-to-face subjects (Biomedicine and Biomedical Technologies) where students will work the competences that require the use of hardware, microscopes, instrumentation and equipment...etc. through face-to-face practices in the laboratory, and a virtual subject called Frameworks in Bioengineering, where the technological tools that students will work with will be remote access software (Del Val, et al, 2010).
- 6 of the 18 ECTS credits of the subject Ethical, human and personal options training will be taught in virtual mode.

In total, 30 ECTS credits will be taught in this modality, which will represent 12.5% of virtual credits of the entire degree (Brendle, J., 2017). The teacher of each subject, following the learning model of the University of Deusto and the teaching methodology already defined, must select the appropriate strategy and activities for the teaching of his subject in the virtual modality.

The tools offered from the virtual learning platform, own of the ALUD platform, and other complementary technologies to which it also gives access as the videoconferencing tool, simulation software, processing and modeling, remote laboratories, the mural tool for collaboration between students and the anti-plagiarism system among others, enable the development of the following training activities: Videoconference classes, consultation, viewing and reading of didactic material, debate through the course forum, individual activities and exercises of application and immediate feedback, individual/group activities, practical software simulation exercises, individual or group tutorials and international expert lectures "Master Class" on a specific subject.

4. Discussion and Conclusions

When designing a degree program, it is important to take into account the study of the impact on the ecosystem where the studies will be taught (Barron, T., et al, 2021). In our case, this involves taking into account companies in the bio and technology fields, hospitals, patient associations, students and their families. This 360-degree study, carried out through face-to-face or telephone interviews, has allowed us to identify important elements in the design of the degree:

- The differentiation with traditional degrees through the international dimension given to this degree has been very attractive to potential students.
- Companies value positively the return of talent from abroad of students who will spend the fourth year abroad, through the Erasmus+ semester, to which is added a semester of online classes that will allow them to continue abroad.
- Families see a promising future for their children with a long international stay (one year).

Limitations are posed at the economic level, given the cost that may be involved for families with average economies to finance international stays. The Erasmus grants are a small incentive, but we are aware that it will not sufficiently cover the required cost.

Looking to the future, annual reviews of the impact and perception of the regional ecosystem that nurtures students of this degree at the University of Deusto will be included, in order to guarantee an adequate offer for the situation. Additionally, an offer of double degrees will be proposed where each student, over 5 years, can obtain two graduate degrees in industrial engineering plus biomedical engineering

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References

Aldabas, R. A. (2018). Co-teaching in classrooms: Literature review of teachers' perspective, readiness, and knowledge. Journal of Education and Practice, 9(9), 156–161.

Barron, T., Friend, M., Dieker, L., & Kohnke, S. (2021). Co-Teaching in Uncertain Times: Using Technology to Improve Student Learning and Manage Today's Complex Educational Landscape. Journal of Special Education Technology, 1-8.

Beninghof, A. M. (2020). Co-teaching that works: Structures and strategies for maximizing student learning. John Wiley & Sons.

Bezanilla, M., Arranz, S., Rayon, A., Rubio, I., Menchaca, I., Guenaga, M. & Aguilar, E. (2014). A proposal for generic competence assessment in a serious game. Journal of New Approaches in Educational Research (NAER Journal), 3(1), 42-51.

Bezanilla, M., García, A., Paños, J. & Poblete, M. (2019). A Model for the Evaluation of Competence-Based Learning Implementation in Higher Education Institutions: Criteria and Indicators. Tuning Journal for Higher Education, 6 (2), 127-174.

Brendle, J., Lock, R., & Piazza, K. (2017). A study of co-reaching identifying effective implementation strategies. International Journal of Special Education.

Chizhik, E. W., & Brandon, R. R. (2020). Making Virtual Co-Teaching Work in a Covid-19 Environment. Issues in Teacher Education, 29(1/2), 142-148.

Del Val, J.L., Campos, A. & Garaizar, P. (2010). LMS and Web 2.0 tools for e-learning: University of Deusto´s experience taking advantage of both. IEEE EDUCON 2010 Conference, 1751-1757.

Elias, M. (2011). Implementing the Bologna Process: an example of policy recontextualisation–the case of Spain. Higher Education and Society in Changing Times: looking back and looking forward, 62-73.

European Commission, Directorate-General for Education, Youth, Sport and Culture. (2017). ECTS users' guide 2015. Publications Office.

Gil, E. (1999). La pedagogía de los jesuitas ayer y hoy. Madrid: Universidad Pontificia Comillas.

Gvaramadze, I. (2012). Developing generic competences in online virtual education programmes at the University of Deusto, Campus-Wide Information Systems, 29 (1), 4-20.

Kolb, D. A. (1999). Learning style inventory. Boston, MA: McBer and Company.

Lozia Edgardo M., Jarré Dirk, (2015). https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/biomedical-engineering-and-care-services

Michigan Technological University, 2022. https://www.mtu.edu/biomedical/department/what-is/

Morelock, J. R., Lester, M. M., Klopfer, M. D., Jardon, A. M., Mullins, R. D., Nicholas, E. L., & Alfaydi, A. S. (2017). Power, perceptions, and relationships: A model of co-teaching in higher education. College Teaching, 65(4), 182-191.

Svobodová, Z. (2020). Virtual Co-Teaching: reflection, reality and potential. Vzdělávání dospělých, 36-41.

Tuning Educational Structures in Europe. (2003). A pilot project by and for higher education institutions supported by the European Commission in the framework of the Socrates programme. 1-7.

Universidad de Deusto. (2001). Marco Pedagógico UD. Orientaciones Generales. Universidad de Deusto.

Wohlgemuth, V., Saulich, C., & Lehmann, T. (2019). Internationalising education–Cross-country co-teaching among European higher education institutions. In 5th International Conference on Higher Education Advances (HEAd'19),1035-1042.