Challenge-based learning an emergent educational model for Engineering Education in the post-COVID era

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The transformation of education is constant, technological advances, the evolution of science, new concepts, new challenges, new experiences and global situations such as the COVID-19 pandemic make it necessary to have educational models that go at the same speed of change and adaptation. In the same way, teachers must be increasingly prepared and open, receptive, willing to face current challenges through continuous training so that they can keep up with the pace of development. In the same way, students are increasingly technological, active and voracious in acquiring knowledge. In general, students today are “digital natives” and teachers aged 40 and over are mostly “technological migrants” which puts the faculty at a disadvantage that has to be reduced to the maximum [1]. Circumstances such as the 2020 pandemic have, in many cases, transformed traditional educational models including technological and pedagogical innovations that emerged in response to the social and economic changes that students and teachers are experiencing in the 21st century. In particular, events like COVID-19 have significantly changed the way we teach [1]. Educators are now challenged to seek holistic, endogenous, and sustainable educational models.

Fig.1. Manuscripts published and indexed in SCOPUS on Challenge-Based Learning (Title, Abstract, Keywords) from 1993 to September 23, 2021 (http://www.scopus.com)

What modifies what? education transforms social reality or does social reality modify what we teach and the teaching methodology? It is actually a two-way dynamic interaction. We cannot deny that the world has been transformed by the advancement of all fields of engineering and the way of teaching has evolved as a response to the needs and demands of society. The general trend is the shift towards teaching based on professional competences, which has led universities to adapt the courses so that the acquisition of knowledge is closely linked to the development of professional (labor) competencies and, on the other hand, using techniques and instruments to evaluate them. The concept of *competence* has been established as a synonym of *competitiveness* or *capacity*, which is imposing standards similar to economic ones in the educational system, where quality conditions and the presence of compliance indicators prevail. Thus, many workers today demand skills rather than knowledge. This has led to the need for competency development and assessment systems to penetrate the educational system, and for this reason, teaching based on competencies has been imposed which, worth the redundancy, is to train graduates who are competent.

The new educational model implemented at Tecnológico de Monterrey, the Tec21 model, aims to provide students with a comprehensive training that prepares them to face the challenges of our changing and uncertain world and ensure the international competitiveness of its graduates. There are four fundamental pillars of the model: a) Challenge-Based Learning (CBL); b) flexibility; c) empowered and inspiring teachers; and d) comprehensive and memorable educational experiences. In the Tec21 Educational Model, there are two categories of competencies to be developed: disciplinary and transversal. The first refers to all the knowledge, skills, attitudes and values that are considered necessary for professional practice [2]. The transversal competences are the skills that are developed throughout the training process of a student in any discipline; They are useful for the life of the graduate and have a direct impact on the quality of professional practice.

It is common to confuse CBL with project-based learning (PBL) as both pedagogical techniques engage students in real-world situations and involve them in developing solutions to specific problems. However, these strategies differ in that CBL offers general open problems from which students will determine the challenge to tackle, rather than receiving a problem to solve. PBL presents a problem to solve and often uses fictional case scenarios. On the other hand, in CBL, the objective is not the solution of the problem itself, but the process of developing skills; the final product can be tangible or a proposed solution to the challenge [3] .

The fundamental principle of CBL theory is that students learn better when they actively participate in open learning experiences than when they passively participate in structured activities. Thus, CBL provides opportunities for students to apply what they learn to real-life situations where they face problems, discover for themselves, test solutions, and interact with other students within a given context. CBL is a comprehensive and holistic approach for learning that combines experience, cognition, and behavior. It should be mentioned that teachers must also have a special preparation; the implementation of the Tec21 model has not been easy [4, 5], and there is a lot of reluctance to change and the transformation of being a teacher who teaches and evaluates in the traditional blackboard way to a different teacher that teaches and evaluates by competencies. Interestingly, what we have found is that students learn better and despite the difficulty of transformation, teachers find in the CBL technique an innovative and active way for the teaching-learning process [4, 5, 6].

Challenges for the CBL technique are generated internally by expert teachers or by external entities. In the Tec21 model, companies or external organizations are called training partners with whom agreements are established in accordance with the objectives of the educational model [7]. This, of course, implies an understanding on the part of the training partner that the main objective is the development of competencies through solving the challenges. On the other hand, the university undertakes to respect at all times the confidentiality of the process, the intellectual property of the resolution of the challenge, and the guidelines of both the school and the training partner to understand how students can develop skills through the CBL experience [7].

When the SCOPUS database is searched for the topic of Challenge-Based Learning, it is evident that the publication of scientific studies only began in 2006 and has grown exponentially (Fig. 1), reaching a maximum in 2020 with almost 400 articles on the subject, which will be easily surpassed in 2021. This clearly indicates that this educational model may be a keystone in the future of education.

It is important to note that academic institutions such as the Tecnologico de Monterrey recently inaugurated the ***Institute for the Future of Education***, where a research group (IRG) was formed with experts in educational innovation to establish strategies on Socially Oriented Interdisciplinary STEM Education (SOI-STEM) having CBL as one strong line of investigation [8].

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Author(s)

Jorge Membrillo-Hernandez

Jorge Membrillo-Hernandez is a Researcher of the Institute for the Future of Education at Tecnologico de Monterrey and a Professor at the School of Engineering and Sciences in the Department of Bioengineering. He currently serves as President of the Mexico Section of the International Society of Engineering Pedagogy. His research topic focuses on the study of implementation strategies and evaluation of educational models based on Challenges. He has published 60 articles with more than 1450 citations to his works with an index h-22. He is PhD in Biotechnology from King's College London, University of London and postdoctoral stays at the University of Sheffield and Harvard University.

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