EMERALD**HANDBOOKS**

THE EMERALD HANDBOOK OF CHALLENGE BASED LEARNING

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The Emerald Handbook of Challenge Based Learning

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INVESTOR IN PEOPLE

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Introduction – The Lay of the Land

Eliseo Vilalta-Perdomo, Jorge Membrillo-Hernández, Rosario Michel-Villarreal, Geeta Lakshmi and Mariajulia Martínez-Acosta

Introduction

The *Emerald Challenge-Based Learning Handbook* is the first comprehensive publication that offers an in-depth exploration on how to conceive, design, implement, and develop Challenge-Based Learning (CBL) initiatives in Higher Education Institutions (HEI). Other organizations that may benefit from experiential learning outcomes embedded in CBL include businesses, communities, or governmental agencies among others. This handbook is written not only for the academic community, who are looking at ways of making their teaching more engaging and committing, but is also targeting HEI managers, who are exploring complementary ways to support the institutional impact within their communities, or those who are interested in promoting research-based teaching. CBL is often seen as an educational approach that intersects open science and open innovation (Vignoli et al., 2021). However, this handbook can also find space in other professionals' bookshelves, for instance, governmental officials who aim to create better interconnections between academia and businesses (see Vilalta-Perdomo, Mapfaira, & Michel-Villarreal chapter in this handbook). The handbook may also be of relevance to Human Resources (HR) managers that use CBL as a laboratory to test candidates for potential jobs within their organizations, or as an approach to prepare their current employees through in-house training programs. An example on application to teachers' training is provided in this text (see Carlos, Rodrigues, & Ribeiro chapter in this handbook). CBL initiatives can also bring a "fresh pair of eyes" to look at innovative solutions in business, making it particularly valuable for small companies that do not have the manpower or resources to hire outside consultancy services (see Price, Michel-Villarreal, Pimanava, & Ge chapter in this handbook). It is also useful to large and mature enterprises, for instance, R&D managers in corporations that may need to find new approaches to maintain their knowledge up to date. Finally, the book is a source for Nongovernmental Organizations (NGOs) to organize events that help them to collect fresh insights, especially if they have interest in

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our future professionals. In summary, *The Emerald CBL Handbook* is an ambitious publication that presents contributions from international experts on this topic, from theory to practice, and provides insightful directions for future research on the conception, design, implementation, and development of CBL interventions within HEI.

This handbook provides multiple illustrations about the power of CBL to develop know-how and professional abilities on students, but one element that has not been fully explored is CBL capability to link different actors and coordinate their actions within our communities. Concerning this, the handbook also provides examples on how CBL-based courses can be designed and implemented to purposefully link different organizations: academia, with industry and government agencies. This is particularly relevant for small and medium-sized enterprises (SMEs) that can surmount their usual lack of resources, by participating in joint projects which may have positive impacts in their performance (Elvekrok, Veflen, Nilso, & Gausdal, 2018). Accordingly, this handbook shows different instances where CBL implementations support the establishment of vital links between businesses, public institutions, and universities, by means of sharing fundamental knowledge through an interdisciplinary approach. All these are vital aspects for innovation processes (see Mayer, Ellinger, & Simon chapter in this handbook). CBL implementations can be designed to become a laboratory for knowledge-based economic development, thus operating according to "an interactive rather than a linear model of innovation" (Etzkowitz, 2003). This suggests the use of CBL as an effective device for implementing the triple-helix of innovation (see Etzkowitz & Leydesdorff, 1995). In summary, this handbook provides evidence of CBL as a teaching/learning approach that develops educational environments where triadic relationships between university, industry, and government may flourish and mature, and their positive impacts be harvested.

Understanding Challenge-Based Learning

CBL is a cutting-edge alternative to traditional teacher-centered and summative assessment education. CBL integrates traditional learning modules with real-life challenges that require innovative solutions and can be applied to a variety of subjects. Examples of these can be found in this handbook: aerospace (Salgado-Sánchez, Lapuerta, & López-Fernández), finance (Lakshmi, Quach, & Goggin), operations management (Vilalta-Perdomo, Mapfaira, & Michel-Villarreal), and tourism (Peretta, Cuomo, Milesi, & Rovelli). In this sense, CBL is usually characterized as an active and experiential learning approach (Gallagher & Savage, 2020) which follows a multidisciplinary approach that encourages students to leverage technology used in everyday life to solve real-world problems (Pornpongtechavanich, Eumbunnapong, & Piriyasurawong, 2021).

Looking at the CBL genealogy, initial efforts can be traced from Vanderbilt University (2001) and Nichols and Cator (2008), and other attempts could be identified from Tecnológico de Monterrey (2011). Since then, CBL has been gaining momentum at various HEIs worldwide, and in many HE disciplines

(Leijon, Christersson, Gudmundsson, & Staaf, 2021). The rationale behind such increase in the attention of academics might be that CBL is "a pedagogical approach that actively engages students in a situation that is real, relevant and related to their environment, which involves defining a challenge and implementing a solution" (Tecnológico de Monterrey, 2015, p. 3). Through CBL, learning modules may be devised to provide the necessary theoretical and practical knowledge that supports the creation, design, and conduction of interdisciplinary interventions to solve real-life challenges. These interventions involve academic actors (i.e., students and staff), communities (industry, or public and third sector–based), and even government agencies, working in unison to explore alternative courses of action to address global challenges with local actions.

CBL shows similitudes with other teaching and learning approaches. In this sense, it might be argued that CBL integrates aspects of other educational practices, such as Problem-Based Learning (PBL), Project-Oriented Learning (POL), and contextual teaching and learning (Johnson, Smith, Smythe, & Varon, 2009). Common aspects among these approaches are critical thinking, problem-solving, collaborative learning, autonomy, and others (Binder, Nichols, Reinehr, & Malucelli, 2017; Membrillo-Hernández et al., 2019). The main difference between CBL and other approaches lies in the use of real-life situations and the need for real, concrete solutions. Unlike POL or PBL, which often uses predefined controlled situations or fictitious problem situations, CBL confronts students with an open, relevant problem for which there is no premade (universal) solution (Membrillo-Hernández et al., 2019); this tends to increase uncertainty and the need for self-direction. Conversely to PBL or POL, CBL is less constrained by conceptual, physical, or time boundaries; there is an expectation that sustainable engagements, between students and the community, will continue after the academic period is formally over. CBL is unique in its capacity to transcend the classroom and facilitate change in the real world. Moreover, CBL is a means to introduce users to "out-of-the-box thinking" as opposed to PBL, which introduces a problem and expects students to solve it. In summary, CBL is a form of engaged research where different actors share knowledge, technologies, methods, and resources for their mutual and collective benefit where the level of uncertainty is high. The developmental of procedural skills in the face of high uncertainty and proposal of solutions is of great benefit in modern times where systematic risks are widely prevalent.

CBL is operationalized through three consecutive stages supported by an ongoing process of documenting, reflecting, and sharing (Nichols, Cator, & Torres, 2016). These stages consider engagement, investigation, and action (see Fig. I.1). To *engage* (stage 1), students and/or other stakeholders move from big ideas into essential questions that become translated into a particular challenge. This step considers the development of what Kolb (1984) calls the "concrete experience" ability. The engagement step provides an actionable challenge that considers a sense of urgency for finding concrete solutions; this process of creative tension is a trigger for innovation (Senge, 1990), and it is the result of Kolb's "reflective observation" put into practice. To *investigate* (stage 2) requires a team focus on knowledge acquisition. The aim is to identify what is known and what is

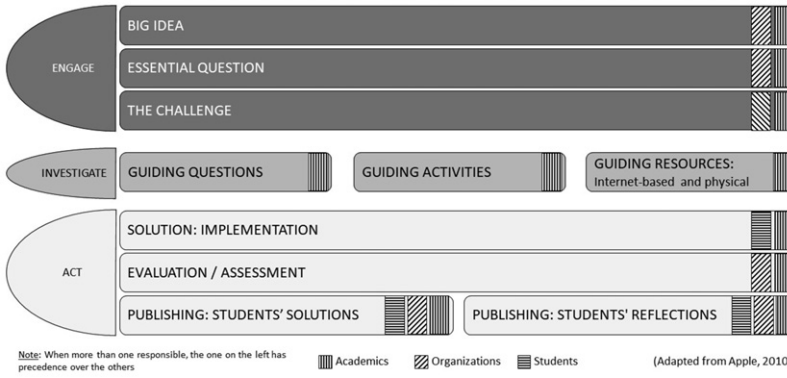

Fig. I.1. Challenge-Based Learning Framework.

not, and to develop real and achievable solutions to the challenges. This is then a research process, where educators provide a set of guiding questions, guiding activities, and guiding resources, to support students in what Kolb calls "abstract conceptualization." To *act* (stage 3) brings into play Kolb's ability concerning "active experimentation." This stage considers the development and implementation of grounded solutions in a real setting. These solutions are evaluated, and students receive feedback and learn from their success/failure. Furthermore, students document and make public their findings; students also reflect on their learning process to become independent learners. Both of these, to share their solutions and reflect on their learning, are fundamental characteristics of CBL. To provide open-access to the solutions, web-based communities and public events with participants of the community are commonly used (Apple, 2010; Dutra Moresi et al., 2017).

CBL is highly flexible regarding duration, intensity, and integration with additional frameworks and techniques. A recent review of literature identified that the flexibility of CBL "paves the way for more innovative hybrid approaches to student-led learning, vital for many higher-level institutions" (Gallagher & Savage, 2020, p. 16). Because of its flexibility, the duration and intensity of the three CBL stages can vary. Nichols et al. (2016) have documented several variations of CBL interventions that have emerged. For instance, in terms of length, interventions can last a day, several days, weeks, months, or even longer. Usually, longer interventions provide students with an increased level of choice and responsibility through the participation in all the stages of the framework, whereas shorter interventions may only implement some of the three stages in Fig. I.1. Another aspect that tends to vary is the breadth and depth of the implementation of the solution. This will likely depend on the length of the intervention and the availability of resources (Nichols et al., 2016). For instance, a "Standard Challenge" has a duration of one month or longer, and the three stages of the framework are implemented, including the implementation of the solution(s). Other interventions, such as the "Nano Challenges," are more teacher-directed,

involving the participation of students in the last two stages only (investigate and act), sometimes without the actual implementation of solutions in real settings. The flexibility of CBL also allows its integration with other frameworks or techniques to better fit different disciplines, courses, and institutional needs. Examples of successful adaptations include CBL and iPad mobile learning technology (Marin, Hargis, & Cavanaugh, 2013), CBL and Design Thinking (DT), (Gama et al., 2018), and CBL and competency-based education (Félix-Herrán, Rendon-Nava, & Jalil, 2019).

This handbook aims to provide evidence regarding the positive reception that students have on CBL-based modules (see Scroccaro & Rossi chapter). Some of the reported motivations to prefer CBL-based modules are the desire to learn something beyond their own major, aiming for interdisciplinary focus and breadth of knowledge, and wanting to do something with real-life impact (see Montaudon-Tomas, Amsler, and Pinto-López chapter). It is important to notice though that students also like the possibility to choose their own project; even though, in some cases, students struggled with the structure of the assessment (see Vilalta-Perdomo, Mapfaira, & Michel-Villarreal chapter). CBL is a very practical option to resume competency-based education in the post-COVID-19 era. This book discusses several alternatives that describe CBL application examples that undoubtedly significantly improve the employability skills of the new graduates. Very importantly, any program can be suitable for CBL implementation.

Organization of the Book

This handbook illustrates the use of CBL in different disciplines at university level. It provides real examples on how to implement CBL in different disciplines, and reports lessons learned concerning this approach. Furthermore, it proposes how to use CBL in disciplines less connected to CBL practice, such as accounting, finance, marketing and sustainability, food technology, biomedicine, and ICT to name a few. The CBL methodology is a technique that can, and is recommended, be used multidisciplinary and transdisciplinary to have solutions from different approaches. Additionally, it presents findings from its implementation based on students' first-hand experiences. Finally, it confirms that the CBL approach increases students' understandings in real-life settings and is conducive to students' development of twenty-first century skills.

The structure of this handbook considers three different sections: (1) CBL Theory, where CBL concepts and its education environment are presented; (2) CBL Practice, where examples concerning CBL design, implementation, and evaluation are provided; and (3) CBL Impact, where CBL boundaries, and future research and development are explored.

Section One, *CBL Theory*, includes the following chapters:

- Chapter 1 presents a case study of building a learning hub for developing, sustaining, and disseminating research-informed CBL practices at the Eindhoven University of Technology (TU/e). This learning hub for education

innovation fosters the collaboration between students, industry, research, and societal organizations and drives the continued development of the CBL approach at TU/e. The chapter also provides insights drawn from postcourse evaluation surveys of two flagship courses, the innovation Space Bachelor End Project (ISBEP; third year bachelor level) and the innovation Space Project (ISP; Master's course level).

- Chapter 2 discusses how the CBL concept has been developed at Eindhoven University of Technology and describes the development and use of two educational resources aimed to facilitate conceptualization, design, and research of CBL for curriculum designers and teachers. The first resource is a set of CBL design principles, the second is a curriculum mapping instrument called the "CBL compass." Both educational instruments are discussed, and their application showcased. Finally, preliminary findings and insights are examined.
- Chapter 3 focuses on the implementation of the Tec21 Educational Model at Tecnológico de Monterrey. The model is based on four fundamental pillars: (1) CBL; (2) flexibility; (3) inspiring faculty; and (4) integrated and memorable education experiences. This chapter describes the experience of implementing such education model. Conclusions so far are that students acquire more knowledge in CBL classes than in face-to-face classes; however, faculty require an adequate training program and there must be a prior design of the competency assessment instruments. Testing of various assessment instruments found that checklists and rubrics are the most accepted, appropriate, objective, and transparent in CBL courses, based on faculty and students' surveys. Finally, in the opinion of employers, students educated with CBL as a didactic technique have greater acceptance in the working world because they develop competencies for real challenges.
- Chapter 4 closes this section by recognizing CBL's lack of appeal to non-STEM subjects and the need for further development. It points out the need for a formal implementation framework, code of practice, and standard procedures for CBL delivery. In this chapter, it is argued that blending a DT pedagogy with CBL can potentially provide the stability that CBL currently lacks. At the same time, it also presents a more inclusive proposition to potential non-STEM audiences. This is done by systematically analyzing academic literature to reveal the synergies and common touchpoints between DT and CBL.

Section Two, *CBL Practice*, illustrates several CBL design, implementation, and evaluation process by means of a series of examples collected from different disciplines. The chapters included are as follows:

- Chapter 5 describes CBL experiences concerning Finance. A description regarding the implementation of a student-run investment fund is provided. This fund was designed by experienced staff members and set up and run formally by students at University of Lincoln in 2018 after a pilot. The ethos of

the Fund is not to teach students just how to invest, but to put students in a real-life investment setting where they deal with the running of day-to-day activities of managing investments through a practical framework. In doing so, students discover, adapt, and apply theoretical models to funds while preparing performance reports. One noticeable outcome has been the impact on students' employability, by demonstrating their involvement in the Fund, which has put them in touch with investment banks and future employers. The functioning of the Fund is analyzed in this chapter, and suggestions and practical steps involved in setting up such a CBL schema are provided.

- Chapter 6 suggests that CBL should be designed to go beyond ensuring learning from challenges and focusing only on the organizational needs stated at the beginning of the process. A workshop on destination management, held from October 2020 to February 2021 in the frame of tourism studies at the University of Bergamo, is the device used to illustrate CBL resilience. Due to the COVID-19 pandemic, this workshop was entirely run through digital channel, and it successfully provided five Destination Management Organizations (DMOs) and an association among hosts in the Bergamo Alps with a variety of digital communication products. Requirements identified to run successful CBL implementations were the need for reliable tourism data, cooperation among local actors, prerequisites in building a new website, the role of food and recipes in promoting a destination identity, best practices in guiding guests through planned itineraries, and the role of a city administration in controlling overtourism.
- Chapter 7 relates different CBL activities implemented at Universidad Politécnica de Madrid (UPM), with a shared objective: provide the students a learning experience that covers the acquisition of technical knowledge, soft skills, and other generic competences, while bringing them closer to the current technologies and industry. After a decade implementing CBL, different research methodologies and instruments have been used to evaluate its impact on different aspects of the learning process. This chapter describes the main CBL activities performed, focusing on the instruments used to evaluate them. Special attention is drawn on the main advantages and disadvantages of implementing CBL from a learning perspective, as well as the associated impact in the student's motivation and student–teacher relationship. Different teaching scenarios are assessed, thus making it possible to compare CBL against traditional methods.
- Chapter 8 shows how to use CBL in Operations Management (OM) education, with a focus on Industry 4.0 technologies. The UoL4.0 Challenge is an initiative that implements CBL in an English university. In there, an OM module was designed to provide the necessary theoretical and practical knowledge to solve challenges concerning digital technology implementations within real organizations. This chapter explores the effectiveness of UoL4.0 Challenge in providing opportunities for experiential learning and evaluates the appropriateness of CBL to develop twenty-first century skills. Findings suggest that the proposed CBL approach is an experiential learning approach that may increase students' understanding of OM in real-life settings and can

be conducive to students' development of twenty-first century skills, including critical thinking, communication, collaboration, and creativity.
- Chapter 9 provides suggestions and tools for novel ways of assessing the learning process in CBL. Through a challenge launched by the University of Trento, involving a local nonprofit integrative health fund, an integration of the formative with the summative assessment is proposed. This approach not only evaluates the final outcomes but also the learning process. Experiences concerning the fundamentals and the difficulties of self-directed learning are described, through students' interventions on the codesign of their learning experience, monitoring their teamwork, and assessing their progress. Some findings point out toward the importance of instructors' support and guidance for a successful CBL implementation.

Section Three, *CBL Impact*, investigates a series of transversal topics where CBL boundaries, and future research and development are explored. Some of the topics explored are ethics, sustainability, social innovation, the relevance and impact on stakeholders, and the training of teachers on CBL. This section ends with an exploration on the future of CBL research, implementation, and development.

- Chapter 10 presents the implementation of ethics education via CBL in three European settings (TU Eindhoven, The Netherlands; University of Lübeck, Germany; and CBI-Fusion Point, a Spanish consortium constituted by ESADE, IED Barcelona Design University, and Polytechnic University of Catalonia). The chapter documents the process of setting up three CBL courses that engage students with grand societal topics, which require the integration of ethical concerns from the design stage of technological development. The authors also reflect on the challenges of teaching ethics via CBL and the lessons they learned by delivering experiential learning activities rooted in real-life challenges and contexts marked by high epistemic uncertainty. The contribution reflects the transition to remote teaching, and presents strategies employed to enhance online communication and collaboration.
- Chapter 11 reinforces the opportunity that CBL provides for students to act on a global issue at the local level and make a positive difference in their communities. This chapter presents a theoretical framework that links Sustainable Development Goals (SDGs), adopted by the United Nations, with the CBL methodology. In addition, a method is proposed to incorporate SDGs in the development and solution of challenges related to academic activities. This method is illustrated with a module of the Tec21 Educational Model, whose objective was to propose sustainable solutions to challenges in several Mexican municipalities. This chapter confirms that SDGs are an effective vehicle for the generation of CBL experiences with the participation of strategic partners, such as governmental organizations and NGOs.
- Chapter 12 analyzes the way in which CBL is conceptualized and used in a private university in Puebla, Mexico, to promote social innovation. The university has recently changed its educational model, by incorporating more integrative teaching and learning methodologies. The change considers the