education sciences

MDPI

Article

Taking the Challenge: An Exploratory Study of the Challenge-Based Learning Context in Higher Education Institutions across Three Different Continents

Antoine van den Beemt [1,†], Patricia Vázquez-Villegas [2,†], Sonia Gómez Puente [1], Fiona O'Riordan [3], Clare Gormley [3], Feng-Kuang Chiang [4], Chuntao Leng [5], Patricia Caratozzolo [2], Genaro Zavala [2,6] and Jorge Membrillo-Hernández [2,*]

1 Eindhoven School of Education, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
2 Institute for the Future of Education and School of Engineering and Sciences, Tecnologico de Monterrey, Monterrey 64849, Mexico
3 Teaching Enhancement Unit, Dublin City University, D09 DX63 Dublin, Ireland
4 Center for Future Education, School of Education, Shanghai Jiao Tong University, Shanghai 200030, China
5 Student Innovation Center, Shanghai Jiao Tong University, Shanghai 200030, China
6 School of Engineering, Universidad Andres Bello, Santiago 7500973, Chile
* Correspondence: jmembrillo@tec.mx
† These authors contributed equally to this work.

Abstract: Teaching by subjects and contents where students passively receive knowledge is increasingly obsolete. Universities are opting for teaching strategies supporting skills development to face the labor, social, environmental, and economic conditions afflicting us. Employers demand increasingly complex skills; universities have identified experiential learning as giving access to real situations and learning by doing. One of the most advanced strategies is Challenge-Based Learning (CBL). Through real problem situations, faculty and students collaborate to solve an established challenge, with or without external stakeholders. This educational advancement has been global and is developing graduates with international skills, which ensures a world-class standard. Here we report a global study carried out in universities from three different continents, and we analyze the implementations of CBL in educational programs through cases in Mexico, The Netherlands, Ireland, and China. Developing skills and competencies is evident, and CBL is a viable way to ensure the success of Higher Education graduates. Obstacles in the transformation of faculty towards CBL are a similar fence in all cases. For CBL, the path needs to be explored, as it is on the frontline of educational developments that can be most helpful for developing a new paradigm in education.

Keywords: curriculum; higher education; educational innovation; flexibility; STEM

check for updates

Citation: van den Beemt, A.; Vázquez-Villegas, P.; Gómez Puente, S.; O'Riordan, F.; Gormley, C.; Chiang, F.-K.; Leng, C.; Caratozzolo, P.; Zavala, G.; Membrillo-Hernández, J. Taking the Challenge: An Exploratory Study of the Challenge-Based Learning Context in Higher Education Institutions across Three Different Continents. *Educ. Sci.* **2023**, *13*, 234. https://doi.org/10.3390/educsci13030234

Academic Editor: Ana Garcia-Valcarcel Munoz-Repiso

Received: 29 November 2022
Revised: 19 January 2023
Accepted: 16 February 2023
Published: 23 February 2023

1. Introduction

In education, students engage in solving complex problems through discovery and experimentation. In the process, students learn to analyze, synthesize, reflect, and evaluate in iterative cycles while explaining the reasoning from findings to make decisions [1,2]. Skills for investigating the phenomena of concern are developed, teamwork is promoted, and the capacity for interaction is increased [3]. In this sense, it is expected that professionals in education could be able to recognize, analyze, and resolve complex situations, and manage knowledge through permanent learning [4]. Higher education responds to these expectations by looking for different learning and curricular approaches.

At the beginning of the 21st century, an educational trend emerged worldwide, advocating for the transition towards more learner-centered curricula in higher education, enhancing the skills and knowledge required for complex activities [5]. For this transition, active learning or learning by doing showed the most promising results in achieving meaningful and lifelong learning [6]. Challenge-Based Learning (CBL) is an experiential learning approach [7,8] that is active, learner-based, collaborative, transformative, real-life, reflective, contextual (based on traditions and place of study), multidisciplinary, and creative [9,10]. In addition, it contains coaching, mentoring, and modeling elements and can be carried out in face-to-face, digital, or blended formats [11,12].

Theoretical Framework

The educational concept of CBL is an evolution from approaches including Problem-Based Learning (PBL), Project-Based Learning (PrBL), and Design-Based Learning (DBL). They share generating engagement in students, who become the leading actors in constructing their learning. Through these approaches, students engage with real-world problems and are encouraged to participate in developing specific solutions. One of the main differences between CBL and the other approaches is the focus on designing the problem, the process, and the solution, to fit with students' professional future [13]. CBL emulates the modern workplace experience, harnessing students' interest in their education while developing key skills and competencies [14,15]. To emphasize the evolution in approaches and supply context for the origins of CBL, Table 1 presents the key characteristics of each of the four approaches. However, we acknowledge the controversies in defining the boundaries of each included approach.

Table 1. Key characteristics of Project, Problem, Design, and Challenge-Based Learning [1].

Technique	CBL	PBL	PrBL	DBL
Learning object	Real-world problems	Hypothetical designed problems	Academic, specific, world-related task	Discipline-specific
Object characteristics	Open, problematic, real solution needed	Often fictional, not real solutions are needed	A predefined problem requires a solution	Open-ended, real-life/authentic, hands-on, multi/interdisciplinary
Expected outcome	Variable solutions to develop a more profound knowledge of the subjects.	To solve the problem at hand. Student's dialogue to reach a conclusion	To follow the plan to the end to carry out the unique assigned project	Acquisition of disciplinary knowledge and skills development
Expected product	Open, creative, contextual, and innovative solutions to result in concrete actions	None, focus to learn	A presentation or implementation of the solution	The learning process is leading. Innovative solutions
Student's role	Analyze, design, develop and execute	Work with the problem	Work with the assigned project	Gather knowledge, analyze, explore, validate, and apply
Instructor's roles	Designer, coach, co-researcher	Facilitator, guide, adviser	Facilitator, manager	Coach, process and self-development, facilitator
Assessment	Tackle the challenge in a way stakeholders measure	Ability to reason and apply their knowledge	Product	Product, process, skills, and knowledge

[1] Information obtained from [13,16–18].

A challenge in CBL is an activity, task, or situation that represents an incentive and an obstacle to overcome and that requires the development and application of diverse, inter-, and multidisciplinary knowledge to be solved. The challenge triggers the generation and application of new knowledge and the necessary tools or resources [17]. In this way, it has been said that CBL fits the Industry 4.0 requirements [19] since students develop skills and knowledge when working on challenges with their communities' faculty and experts.

However, Gallagher and Savage [9], in a review of the existing literature, highlight several issues with current understandings of CBL, which somewhat detract from its potential impact, including the use of mixed or no frameworks, the application mainly in STEM, and relatively little focus on whether the challenge was met. These issues imply the need for solid research evidence to inform decisions about when and how to use CBL as a pedagogical approach. Furthermore, in their literature review, Leijon et al. [20] identified just 36 articles on CBL over 11 years. Although the number of reports is increasing, more research and guidelines are needed to ensure that CBL truly benefits student learning—and, most importantly, achieves significant societal impact. A lack of information regarding the institutional scale application of CBL and the effect of different contexts has led to these knowledge gaps in such a complex and versatile phenomenon, whose literature is only characterized by isolated empirical subject-related issues.

To enlighten future directions of CBL in the educational panorama, research is necessary to provide a common ground for CBL implementation [9]. Thus, this paper aims to explain how CBL has been implemented in higher education institutions in different contexts to contribute to developing skills and competencies in higher education. Therefore, this work intends to answer the following research questions: (1) How do different universities implement CBL? And (2) How is CBL a good strategy for developing skills and competencies in higher education students?

2. Methodology

To explain and compare CBL implementation in higher education institutes in Mexico, the Netherlands, Ireland, and China, a comparative case study (CCS) approach was chosen [21]. Comparative case studies involve the analysis and synthesis of the similarities, differences, and patterns across two or more cases that share a common focus or goal, contributing to understanding how and why particular programs or policies work or fail to work. CCS advocates an emergent rather than a pre-determined design, considering actors and processes rather than a case bounded by specific space and time. This emergent design supports an exploratory approach to phenomena, focusing on narrative rather than pre-defined variables (see also [22]).

The structure of CCS offers comparison across three axes: transversally, comparing historically over time; vertically, comparing influences at international, national, regional, and local scales; and horizontally, contrasting cases with one another concerning social actors, materials, and influences [21]. The cases to be compared include Tecnologico de Monterrey in Mexico (TEC), Eindhoven University of Technology (TU/e) in the Netherlands, Dublin City University (DCU) in Ireland, and the Shanghai Jiao Tong University (SJTU) in China. The case selection was information oriented, aiming for maximum variation [22] in the development and implementation of CBL. However, they share a strive for educational innovation that leads to a better connection with today's complex societal issues. Thus, the common goal is curriculum development using CBL as an educational concept. The three CCS dimensions are operationalized as follows:

1. Transversal dimension (historical within-case developmental overview)—context and rationale for the implementation of CBL in each of the cases are described.
2. Vertical dimension (within-case description presents social actors and influences)—attitude and roles of students, faculty, and stakeholders.
3. Horizontal dimension (contrasting cases)—success factors and opportunity areas of each CBL implementation.

Data collection for each case consisted of institutional and/or national education policy documents, descriptions, and evaluations of educational innovation projects, and selected non-structured interviews with responsible faculty and/or educational researchers and staff.

3. Results

3.1. Transversal Dimension: Context and Rationale of CBL Implementation

The context (description of case studies) and rationale (logical basis) of CBL implementation across the four cases are summarized in Table 2. Afterward, the four case studies are described, as well as concrete examples of CBL courses for each case.

Table 2. Context and rationale of CBL implementation in the four case studies.

Case Study	TEC	TU/e	DCU	SJTU
Country	Mexico	the Netherlands	Ireland	China
University	Private, 26 campuses	Public, 1 campus	Public, 5 campuses	Public, 7 campuses
Number of students	35,000	14,000	17,000	40,000
Context of CBL implementation	Top-down institutional strategy; educational research on CBL.	Forerunner in the Netherlands and Europe in curriculum-wide implementation and research of CBL; combination of a top-down program with bottom-up initiatives.	ECIU member; strong tradition of working closely with industry and society in an interdisciplinary manner with an entrepreneurial mindset.	In October 2019, China’s Ministry of Education released ‘Quality 22, Teaching Reform’; Chinese universities actively incorporate best practices in higher education worldwide.
Rationale of CBL implementation	With the premise of academic quality strengthening and to face 21st Century challenges and opportunities; developed and implemented a new educational model: Tec21, starting in 2012 and fully implemented in 2019.	DBL: real-life problems promote meaningful learning and self-directed groups support development of problem-solving skills since the beginning of the 21st Century; since 2019, the evolution to CBL emphasizes small-scale and flexible education, implemented as embedded curriculum practice.	Five-year project; September 2021; CBL central pillar of educational innovation.	Need to cultivate innovative talent in engineering; in 1986, PBL first recognized as a successful teaching and learning approach; proposing a new engineering education in 2017; CBL is the extension of PBL since the beginning of the 21st Century.

3.1.1. Tecnologico de Monterrey, Mexico

Tecnologico de Monterrey is a private university located in northern Mexico. It is the number 1 private university in Mexico and 30 worldwide, following the QS ranking. To face the challenges and opportunities glimpsed in the 21st century, Tecnologico de Monterrey developed and implemented a new educational model: Tec21, starting in 2012 and fully implemented in 2019 [18]. As an Institutional objective, this model was under the premise of strengthening academic quality. CBL is one of the Tec21 Educational Model pillars, following: Flexibility (it consists of offering the students different alternatives to plan their development in congruence with the strengthening of personal identity); Inspiring trained faculty (characteristics of the professors that allow them to leave their mark and be an aspirational example to the people with whom they interact inside and outside the institution); and a Comprehensive educational experience that makes it memorable (induction of affinity relationships that favor personal and professional identity through experience) [18,19]. CBL pedagogical orientation with which challenges are implemented in block-type training units is part of the operation or execution of the educational model, which includes the dimensions of the challenge, student, environment, and faculty, which interact for learning.

Today, this institutional strategy has top-down permeated the entire Tec de Monterrey educational system. Nowadays, each career's semester, block, or week is based on CBL. More than 35,000 students, distributed in the 26 campuses in the country, from 44 careers, have been impacted by the Tec21 Educational Model and are part of the generations whose curriculum is designed under the philosophy of this new model [23]. Tec21 model is recognized as an Educational Innovation and a reference for Mexican and worldwide universities [24–27]. Recently, Tecnologico de Monterrey inaugurated the Institute for the Future of Education (IFE), where CBL is one strong line of research [28]. The IFE is strengthening the model with further educational research that will deepen the understanding of CBL use and its impact.

3.1.2. Eindhoven University of Technology, The Netherlands

Eindhoven University of Technology (TU/e) in the Netherlands has around 14,000 students and 2000 staff. It is a forerunner in the Netherlands and Europe in curriculum-wide implementation and research of CBL. This focus on CBL evolved from the introduction of DBL in the late 1990s. DBL was introduced at TU/e to embrace the principles that real-life problems promote meaningful learning and that self-directed groups guided by facilitators support the development of problem-solving skills [29,30].

At TU/e, the evolution from DBL to CBL emphasized small-scale and flexible education. Our university aims to implement CBL as embedded curriculum practice rather than as a different pedagogical approach to existing structures [9]. This also implies that TU/e allows for variety in CBL implementation across study components and departments [10]. The large-scale curriculum approach is based on a program that combines the implementation of bottom-up initiatives with research and a top-down program. The effects of faculty-led CBL experiments on student learning behavior and learning outcomes are studied in an evidence-informed setup.

3.1.3. Dublin City University, Ireland

Dublin City University (DCU) is a young, dynamic university with a distinctive mission to transform lives and societies through education, research, and innovation. DCU is relatively new to CBL. Industry involvement is key to DCU's success, as it was one of Ireland's first universities to introduce a work placement program [31]. DCU is a European Consortium of Innovative Universities (ECIU) member. The ECIU is a network of universities driven by a standard set of values and beliefs, one of which is a commitment to innovative forms of teaching and learning. The vision is to become an ECIU University where learners, academics, and researchers solve real-life economic and societal challenges. All members of the ECIU network have a strong tradition of working closely with industry and society in an interdisciplinary manner with an entrepreneurial mindset [32].

In 2020, DCU was awarded over GBP 20 million as part of the Irish government's Human Capital Initiative [33] underpinning the DCU Futures project. This five-year project aims to create a radically different undergraduate learning experience that will foster the development of graduates who can flourish in the unscripted world of the 21st century and play a pivotal role in advancing Ireland's future prosperity [34]. Ten new innovative multidisciplinary programs were launched in September 2021, with CBL as a central pillar of educational innovation. In this context, DCU can share some early CBL experiences and discuss lessons learned to date.

3.1.4. Chinese Universities

In October 2019, China's Ministry of Education released 'Quality 22, Opinions on Deepening Undergraduate Education Opinions on Deepening the Teaching Reform and Comprehensively Improving the Quality of Talent Cultivation' [35]. Under Quality 22, Chinese universities actively incorporate best practices in higher education worldwide.

Engineering education plays a crucial role in Chinese higher education. In the new economic policy proposed by the Chinese government, engineering education in universities is subjected to more rigorous standards, and the cultivation of innovative talent in engineering has become a central research topic in China [36]. For example, Cheng and Yang [37] improved cooperation between companies and schools to enhance talent cultivation. Li and Lin [38] determined that academic competition and high student scores correlated with teaching practices. Chen [36] proposed the 'five-in-one' innovative talent training system comprising classroom, practical teaching as a pedagogical tool, subject, secondary classroom activities as a supplement, and school–company cooperation as an extension to classroom education. Du et al. [39] found that IoT engineering courses lacked a platform and proposed the Technical Knowledge Map of IoT Engineering.

Over the past few decades, the total number of colleges and universities in China has increased, with 2738 public universities in 2020—including 1270 universities and 1468 higher education institutions [40]. Many university students are studying science, technology, engineering, and mathematics. In addition, the Chinese government has continued to promote engineering education to revitalize China's technological capabilities, building on the world's Industry 4.0 technological revolution and proposing a new engineering education in 2017, which improved engineering education at Chinese universities [41]. Scholars have also improved pedagogical methods and assessment systems to address the shortcomings of higher engineering education in China [42].

In China, CBL is the extension of PBL [43]. PBL was first recognized as a successful and innovative teaching and learning approach in higher engineering education. In 1986, the Shanghai Second Medical University and Xian Medical University were the first to introduce PBL in China. Since then, PBL's methodology has become more refined and commonplace in medical schools and has been applied to other teaching processes, such as integrated design experiments and engineering training. However, since the beginning of the 21st Century, CBL teaching has been gradually implemented in engineering and technology and has achieved some success.

3.1.5. Concrete CBL Courses Examples in the Four Case Studies

- Two successful examples of CBL at TEC. The first case concerns a system capable of helping civil protection personnel monitor, guide, and record crucial data in a seismic emergency, "TECuidamos". This system was developed for a year by students of Telecommunications Engineering and Electronic Systems, tutored by professors in Engineering and Education, through a web administrator and using route planning algorithms hosted on a cloud server to provide the user with an efficient escape route in real-time (https://www.mdpi.com/2071-1050/14/9/4931, accessed on 15 January 2023). The second case concerns the design and application of an academic cultural experience for university students who engaged in biodiversity preservation while developing research and problem-solving skills, "Axolotl Challenge: Saving Biodiversity Through Engineering." This experience focused on the generation of engineering solutions for the conservation of biodiversity and chinampas (floating agricultural gardens) in Xochimilco, a UNESCO World Heritage City (https://sciendo.com/article/10.2478/jtes-2022-0005, accessed on 15 January 2023).
- TU/e innovation Space project. TU/e innovation Space project is a graduate-level course aiming toward challenge-based learning in interdisciplinary student teams. The course is open to students from all university programs. However, it often attracts Industrial Engineering students. Students work on open-ended assignments in close interaction with high-tech companies and societal organizations in the university ecosystem. The course combines the design and engineering of a product/service/system and new business development. One of the main learning goals is "integration", operationalized when students develop a problem-driven, creative, and integrative design, resulting in an original and validated prototype that balances desirability, feasibility, and viability. Rather than lectures, the course involves studio-style group work,

self-study, and personal and team development. Out-of-the-box pressure-cooker-style workshops are given, either online or offline. Topics include pitching ideas, project management, interdisciplinary team building, or developing questions from ill-defined problems. Students are in the lead of their learning processes. Instructors take on the role of coaches in a supportive and co-learning manner. The course is part of educational innovation in TU/e Innovation Space.

- DCU hackathon academic intervention. A multidisciplinary and fully online hackathon for First Year science undergraduate students was carried out in 2022. This event was planned, developed, and delivered within a shared module—CS150 Interdisciplinary Science & BE112 Professional Skills for Scientists and Engineers—to support the development of a range of skills in students in addition to their disciplinary knowledge. A total of 227 students participated in the hackathon challenge set up to mimic a typically fast-paced, intense hackathon experience. Students collaborated intensively over three days to identify an essential question based on a 'big idea' of interest, investigate it as a team, and create a solution they ultimately had to present in an elevator pitch. Academics and teaching assistants were available at designated times to support students in teasing out and developing their solutions. The elevator pitches were attended by stakeholders from other areas of the university who acted as judges and provided constructive feedback on the presentations of a generally high standard. The hackathon utilized various innovative tools and technologies from the DCU Virtual Learning Environment and beyond. Educators should be committed to leading the students to develop competencies and skills that will awaken them in critically evaluating and developing strategies for their future: "engagement, groupwork co-operation, problem-solving ability, vision broadening, awareness of real-world problems... to summarise, learning" (https://www.dcu.ie/teu/edge-discovery-podcast-series, accessed on 15 January 2023).
- SJTU brief course description. Engineering Practice is a compulsory practical course for all engineering students (mainly first-year students) launched by the Student Innovation Center of SJTU and jointly developed by interdisciplinary teachers and educational researchers. It follows the principle of "student-centered" teaching, with two types of projects: "propositional" and "open-ended", which are based on students' interests. The projects focus on developing core skills such as analysis, synthesis, logical reasoning, critical thinking, and problem-solving. In addition, SJTU has built traditional practice spaces, modern manufacturing practice spaces, and electronic and electrical laboratories, creating 7×24 h open practice space, and established practice platforms with famous domestic enterprises to guide students to pay attention to social hotspots and technology frontiers based on the basic knowledge of the curriculum, to explore innovative ideas, methods and solve practical problems. In terms of teaching, it consolidates students' theoretical basis and skill foundation, strengthens their innovation ability through project practice, establishes an online modular resource library, adopts the teaching mode of "large class lecture + small class guidance", and focuses on process-oriented and diverse learning assessment of students.

3.2. Vertical Dimension: Roles and Attitudes

Table 3 compares the four case studies, referring to the role of instructors and their attitude regarding the implementation of CBL and the attitude of students. Next to instructors and students, CBL possibly knows a third kind of actor: non-academic actors, also known in the literature as external stakeholders [17].

Table 3. Comparison of the CBL implementation aspects in the four case studies.

Case Study	TEC	TU/e	DCU	SJTU
Instructors' role and attitude	Interdisciplinary; collaborative and versatile. Instructors become designers, coordinators, advisors, lecturers, and evaluators. To decrease overwhelming, some institutional guidelines have been developed.	Instructors in the role of coaches who supervise knowledge acquisition and competence development. Engagement in CBL implementation through bottom-up experiments, involvement in a CBL task force, and allowing variety in interpreting CBL.	Instructors are open to change; willing to explore CBL. CBL requires planning and support, resources, and trust in students. Multiple professional learning options are available to staff.	Interdisciplinary; faculty must have accomplishments in both academia and industry; must organize and understand the direction of project implementation and provide timely guidance to students' problems.
Student attitudes	Resisted frustration for not solving the challenge due to lack of clarity, time, or high complexity, presenting high-stress levels, even when students received high grades.	High motivation and anxiety for open and complex challenges. Over time this anxiety decreases as students develop knowledge and skills for solving the challenge.	Students are optimistic about CBL and value engaging in authentic experiences.	CBL stimulates students' interest and ability to use information, learn independently, and work in teams
Role of stakeholders	Agent or entity from the manufacturing or services sector, government, civil society, or community groups with which the institution establishes a long-term collaboration link. They receive a fresh and external perspective for innovation, reach student talent, and identify trends in the organization's development.	An innovation Space as an innovation hub was created to facilitate collaboration with the industry. Stakeholders guide students throughout the project, help in decision-making, or by resource provision.	The industry contributes in the form of lightning master classes, keynote speakers, mentors, and judges.	The role of stakeholders is limited and unclear. Subject leaders can organize training by relevant experts, conduct interdisciplinary exchanges, and provide guidance through classroom observation and data-driven feedback.

3.2.1. Instructors' Role and Attitudes

In Tecnologico de Monterrey, CBL made the role of instructors more collaborative and versatile. Faculty provide relevant situations for students' education and dedicate time to relationships with stakeholders to add value to the challenges. Instructors become designers, coordinators, advisors, professors, and evaluators [44]. Because all these roles overwhelmed them at the beginning of the CBL implementation, collaborative networks [45] have encouraged reflection and feedback, which positively account for embracing the new educational model [46]. Furthermore, these networks are reported to tackle coordination obstacles, help adopt new didactic tools and design, think out of the box [47], and support beyond teaching [48].

All instructors have also been trained in CBL implementation as the essential element of curricular design. Workshop sessions on CBL were held by The Center of Educational Development and Innovation and include content modularization and development, CBL theory, competence evaluation, technological tools [48], fostering teamwork and interest in self-development [49], and development of skills such as critical thinking, collaborative work, problem-solving, and ethics [50].

At TU/e, a collaborative network of instructors and researchers has been established to collect and share evidence contributing to the CBL implementation. Additionally, instructors were engaged in CBL implementation through bottom-up experiments, involvement in a CBL task force, and allowing variety in interpreting CBL. Some instructors experienced reluctance caused by insecurity in moving to student-centered education and doubts about ensuring the development of rigorous discipline knowledge [51].

To decrease instructors' reluctance and increase their engagement, an instrument labeled 'CBL compass' was developed to map CBL characteristics in courses and projects [10]. These characteristics include educational vision, teaching and learning, and facilities and support. The instrument aims to start reflection and dialogue about implementing CBL aspects in a course or project rather than benchmarking courses on their level of CBL. The CBL characteristics from the compass were then translated into design principles, which helped the implementation of CBL itself [52]. These design principles establish a common ground among all CBL experiments without inhibiting the instructors' creativity. They offer a helpful framework for faculty to identify what is essential in their course (vision) and help them to redesign their teaching and learning approach and determine what sources of support are needed. However, design principles are intended "to help others select and apply the most appropriate substantive and procedural knowledge for specific design and development tasks in their own settings" [53] rather than being "recipes for success" [52].

In the case of DCU, faculty have been more open to change. The Teaching Enhancement Unit (TEU) is encouraged by the instructors' openness to using the recommended CBL framework, structure, and approach. CBL implementation is very resource-intensive for the TEU. They have a central and active role in advancing CBL application across the university. In addition to a calendar of CBL workshops and regular meetings to facilitate sharing CBL experiences across the university, they established and Chair the DCU CBL Working Group. The CBL Working Group report to the DCU Education Committee and has tightly defined Terms of Reference (TOR) to guide the work and membership. The group comprises academic representation from all five faculties, student and student support, and a learning designer from DCU Studio. The working group is responsible for advancing formal procedures, guidance, and support for academic staff. This includes developing a DCU-oriented definition of CBL and designing a CBL learning pathway to guide the implementation of CBL over time. This pathway is being co-designed via a design sprint workshop with academics to co-create a pathway from Year One to the Final Year. Feedback from this sprint is currently being analyzed and formally written up and will culminate in a graphic or visual to represent the CBL pathway in DCU. In 2022, TEU also ran a successful hackathon for academics [54] to give staff new to this form of CBL a practical experience of a hackathon in action.

In China, the Student Innovation Centre of Shanghai Jiao Tong University (sjtu.edu.cn, accessed on 23 July 2022) advocates for interdisciplinary education; it focuses on developing core skills such as analysis, synthesis, logical reasoning, critical thinking, and problem-solving. The Centre emphasizes integrated learning and the application of knowledge; thus, students must consciously develop their knowledge of professional theories, frontier knowledge, and knowledge of related disciplines to solve practical problems. Therefore, faculty must have accomplishments in both academia and industry.

Implementing CBL prioritizes students' autonomy; however, during project implementation, instructors should organize and understand the direction of project implementation and provide timely guidance to students' problems. The interactive classroom requires faculty to demonstrate high classroom management and organizational skills, such as ensuring classroom discipline and handling divergent thinking. The preparation of instructors in developing CBL is crucial for student learning. The level of work increases since it has been shown that training students in practical group work results in a better CBL experience [55]. It is recommended that instructors make a clear statement of course expectations to avoid student frustration.

3.2.2. Student's Attitude

Through interactions with faculty, peers, and stakeholders, students learn to interrelate with the world around them, opening their possibilities to apply the knowledge acquired to benefit society. Students' knowledge gained in CBL experiences is often higher than in traditional education. However, faculty training and definition of sub-competencies and evaluation instruments are essential to successfully developing challenges [19].

Each of the four cases shows how frustration and anxiety have been factors that students have had to overcome in implementing CBL [51]. Nonetheless, students have obtained better grades and the skills and competencies declared in many CBL courses. Therefore, CBL appears helpful in this regard. Students' attitude towards CBL has been determined amongst others by the participation of the stakeholders in the challenges.

In the case of Tecnologico de Monterrey, some challenges have immersed the students in real-life challenges of world-leading companies (namely Boehringer Ingelheim, Covestro, and Becton–Dickinson), where challenges have been designed by company members and faculty [17]. Other nationwide challenges have needed the participation of 3000 to 4000 students on different campuses to solve the challenges of some companies, creating proposals to strengthen the marketing strategy and the business model. Winners had the experience of presenting their recommendations to senior executives of the corporations of these companies [23].

At TU/e, students in CBL courses reported high motivation and anxiety for open and complex challenges [51]. Over time, this anxiety decreases as students develop knowledge and skills for solving the challenge. Students also reported a need for a precise mapping of learning goals to activities and assessment because often it appeared unclear how and on what criteria they were assessed. However, students reported support in developing ownership, self-directed learning, and collaborative learning. In this context, faculty ask for competence development in supporting students, especially assessing and integrating discipline knowledge.

At DCU, students reported enjoying the challenges and the opportunity they offered them to engage with the industry. In one example, the relationship with the partner, Carbon Intensive Regions in Transition, was core to a successful output [56]. The partner, Eastern Midlands Region Assembly (EMRA), was so impressed with the final outputs—report, elevator pitch video, and infographic—that they invited the students to present at an international conference in this space. DCU business students (100+ per day, 600 in total) who participated in the Hack4Change social innovation hackathon over five days were generally very positive about their experience [57]. While some students report anxiety around the uncertainty of CBL, the TEU works hard to support academics and scaffold the CBL experience to reduce students' sense of unease.

Having agency in refining the challenge and working in groups sustained and motivated students, as some mentioned: "without good interest in the topic and good relationships with teammates, it would have been difficult to finish the project". In general, the ECIU students were very positive about their experiences "I learned a lot, especially about managing and organizing". Within DCU Futures' experience, students reported similar feedback to ECIU and Hack4Change. In addition, they said they are used to more certainty and structure in the approach, although it should be mentioned that these were first-year students.

In the case of China, the few available evaluation case studies indicated that CBL stimulates students' interest and ability to use information, learn independently, and work in teams. Therefore, integrating curriculum structure and teaching design in Chinese universities with CBL has effectively improved students' competitiveness. It is recommended that faculty make a clear statement of course expectations to avoid student frustration. Students choose CBL courses because approximate real-world situations are flexible, challenging, and intellectually stimulating. Moreover, CBL teaching is mainly applied in group practice courses since collaborating in groups can provide a sense of accomplishment and improve group communication, making it effective in national and international university research competitions. To our knowledge, only a few works regard the student experience on CBL [43,55]. Studies report the need for more research on CBL, working in smaller groups, and more financial resource and administrative support for the initiative. On the other hand, studies have indicated deeper learning in course subjects, as well as an increase in self-directed, creative, and innovative skills [55,58].

3.2.3. Role of Stakeholders

The involvement of non-academic actors as stakeholders is considered an important characteristic of CBL and partly of PBL [10]. CBL engages students by involving stakeholders from academia, industry, or the societal context [13]. A distinction can be made between (1) university-developed challenges, reflecting little collaboration with external stakeholders, and (2) challenges brought and actively supported by stakeholders [17]. This distinction supports variety in the scope and complexity of challenges.

In CBL, the aim is for students to be able to face learning experiences from a local, national, or international scenario. Challenges must be relevant to the industry or other organizations at the local level to develop competencies. Thus, at Tecnologico de Monterrey, the role of an external education partner was created. This is an agent or entity from the manufacturing or services sector, government, civil society, or community groups with which the institution establishes a long-term collaboration link to meet challenges [18]. External stakeholders receive a fresh and external perspective for innovation, reach student talent, identify trends in the organization's development, and contribute to transformation by training entrepreneurial leaders [59].

To facilitate collaboration with industry at TU/e, a learning hub and expertise center for CBL and entrepreneurship education called innovation Space was created [60]. Its approach and ecosystem facilitate an open and interdisciplinary community where students, faculty, researchers, and stakeholders create and share knowledge on the design and solution of challenges and CBL research. One of the goals is to facilitate collaboration with industry by, for instance, linking education to practice and boosting students to have a tangible impact on their projects. Training is tailored to students for topics such as entrepreneurship or 3D printing. TU/e innovation Space is characterized by an inter-program collaboration and multi-stakeholder involvement for, amongst others, assessment. External stakeholders influence learning by, for example, guiding students throughout the project implementation and towards achieving the project's outcomes of students, helping in making decisions on project execution, or by resource provision [61]. The innovation Space courses are interdisciplinary, challenge-based, hands-on (i.e., learning by doing, developing a prototype or minimal viable product), requiring an entrepreneurial mindset (i.e., dealing with uncertainty, taking entrepreneurial aspects into account), and contributing to personal and team development.

DCU Business School has a strong relationship with the industry and were able to secure contributions in the form of lightning master classes, keynote speaker, mentors, and judges. Industry involvement was central to the success of the Hack4Change series [57] because it created an authentic opportunity for students to showcase their learning to potential employers, an opportunity they valued. The DCU Futures project calls on industry and research partners to contribute to the CBL experience. Industry involvement in year one primarily includes guest speakers and submission of challenge ideas. As the students progress through their degrees, the industry will be expected to play a more central role, particularly in the final year.

Discipline leaders play a crucial role in promoting CBL in China. Only by recognizing the advantages of CBL education and supervising curriculum reform can schools promote CBL more thoroughly. Schools can also guide and encourage research by receiving funding from the Board of Education, which provides the opportunity to study relevant research abroad and attend or organize various academic conferences. There is a need for studies that report improvements in learning using CBL with a stakeholder contribution in the Asian context. Subject leaders and heads of departments must decide on the implementation of CBL, curriculum design, faculty recruitment and regularly conduct teaching and research.

Faculty require the proper resources to be skilled in CBL teaching. Subject leaders can organize training by relevant experts, conduct interdisciplinary exchanges, and provide guidance through classroom observation and data-driven feedback.

3.3. Horizontal Dimension: Success Factors and Opportunity Areas

Table 4 shows the success factors and the areas of opportunity detected in the four case studies. As can be seen, there is a similarity between the four cases. Many success factors are centered on the cultural change permeating the university ecosystem. However, successful educational change needs a supportive environment [62]. The main requirement is the commitment of faculty and students to test and continue the CBL framework. This also requires funding and the involvement of stakeholders in creating engaging challenges. To achieve this, work must be achieved on implementing technology in the classroom and the lifelong learning paradigm, allowing students, faculty, and companies to generate an innovative problem-solving ecosystem. Raising awareness of the advantages of CBL through further research and dissemination of successful results is also an area of opportunity.

Table 4. Success factors and opportunity areas of CBL implementation in the four case studies.

Case Study	TEC	TU/e	DCU	SJTU
Success Factors	CBL is a keystone in the educational model. Faculty commitment to strengthening competencies. Creation and solution of international challenges.	Availability of funds to experiment with and research aspects of CBL. Organization of a CBL program. Strong faculty support staff	University's commitment to CBL at the highest level. Faculty are keen to explore and interested in CBL. Teaching Enhancement Unit (TEU) support	Increased awareness of the fact that CBL can improve students' skills. CBL is considered an enabler of the reinvention of the traditional class paradigm.
Opportunity areas	Faculty must take risk in the use of technology in the classroom. Enhancement of the lifelong learning paradigm.	Overcome instructor-reported feelings of insecurity. Unfamiliarity with stakeholders and how to engage them in student scaffolding	Resolve questions regarding the time and range of support needed for CBL. Faculty engagement.	Students are accustomed to the traditional learning system. More work regarding CBL is needed.

3.3.1. Success Factors

The four cases each reflect that commitment at the university level, or even the national level, is essential for a successful CBL implementation. In the CBL implementation in Tecnologico de Monterrey, students and faculty adjust to the new educational model. The open innovation paradigm pushed the academic community to embrace relations and communicate with society and stakeholders. A fearful panorama during the first years of the implementation was overcome, resulting in CBL being the keystone in the educational model.

In China recently, authorities emphasized that learning is the center of teaching activities, students are the main body of learning, and the purpose of teaching is for students to learn more efficiently through scientific and advanced teaching methods. Rethinking how institutions work has been promoted in China as a trend through policymaking, such as Made in China 2025, the 13th Five Year Plan, Internet Plus, and Belt and Road Initiative, to produce critical thinkers and makers who thrive in China's evolving economy.

At TU/e, university commitment is found in combining bottom-up innovations with a top-down CBL program. This university-wide program facilitates and monitors CBL experiments. The CBL research agenda as part of this program is the guiding document for research on principles of CBL, student learning behavior and learning outcomes, didactical/pedagogical aspects of CBL, and facilitating structures [63].

Any innovation knows an initial stage of reluctance. In the four cases, most faculty have become committed to strengthening their understanding and competencies, preparing challenges to solve real-world problems, and testing them [64,65]. At DCU, traction and interest in CBL across the university are reported to be high. Academics are keen to explore and understand it better.

At TU/e, faculty commitment was supported by the availability of funds to experiment with and research aspects of CBL. Over 40 faculty-initiated CBL experiments are being conducted in various departments and institutes [52]. These experiments show different CBL characteristics and implementations, ranging from small-scale assignments to curriculum-wide initiatives consisting of open-ended, complex challenges presented by stakeholders and focusing on self-directed learning and interdisciplinary skills. This flexible and diverse approach of CBL enables the adjustment to different contexts and subject areas. In addition, the redesign of the bachelor engineering programs TU/e-wide includes a CBL curriculum line in all graduate engineering study programs.

Significant funding also ensures commitment to CBL over the coming years at DCU. The ECIU current project ended in October 2022, and a new proposal has been entered for significant funding to advance the work undertaken in CBL and innovative pedagogies. Perhaps even more center stage in DCU is the remaining years of the DCU Futures project, where CBL forms a core part of the innovative pedagogy.

The challenges created by faculty members at Tecnologico de Monterrey have transcended institutional and geographic borders, reaching other universities [66,67] and significantly increasing students' skills (i.e., collaboration and negotiation effectiveness) [23]. In China, the Student Innovation Centre of Shanghai Jiao Tong University (sjtu.edu.cn, accessed on 23 July 2022) focuses on developing core skills such as analysis, synthesis, logical reasoning, critical thinking, and problem-solving. The Centre emphasizes integrated learning and the application of knowledge; thus, students must consciously develop their knowledge of professional theories, frontier knowledge, and knowledge of related disciplines to solve practical problems.

Another success factor is research to make impact measurable. DCU faculty are keen to explore and understand CBL better, but some still need more evidence of its impact to adopt it. Large research programs at TU/e and Tecnologico de Monterrey support the development and implementation of CBL. The IFE of Tecnologico de Monterrey aims to offer a platform for deploying these studies and strengthening impact assessment strategies integrated into the educational model to transform education [18]. Potential efforts and suggestions to accomplish this goal are, for example, investments in digital technology [68] and scalable challenge living-lab platforms, integrate different sectors, stakeholders, and communities, based on interconnected technology and socio-cultural and Quality of Life impact while providing an educational framework in which students are highly motivated, engaged, and prepared to tackle different problems that involve government, community, industry, and academia [69–72].

Despite funding and research, instructors might not always feel competent enough for their new role in CBL [51,52]. Scholars have increasingly noted that CBL can improve students' abilities to engage in autonomous learning, problem-solving, and critical thinking [73–75]. It is also an innovative enabler approach that has driven the reinvention of the traditional classroom paradigm [76]. CBL is conceptually straightforward but challenging to implement. It is more demanding than traditional methods. For example, in China, frustration has become the norm among students largely accustomed to traditional learning systems [75]. Implementing CBL prioritizes students' autonomy; it requires instructors to demonstrate classroom management and organizational skills, such as ensuring classroom discipline and handling divergent thinking.

At TU/e, a strong support staff provides pedagogical input for instructors and advice on educational technology and tools. Because TU/e allows flexibility in CBL, this creates various CBL implementations for each discipline. This variety is influenced by instructors' perceptions and operationalizations of CBL and responds to a conscious choice to adopt CBL and its characteristics flexibly. Support staff should understand the respective disciplines and intended CBL characteristics. Despite the newness of CBL, DCU faculty report that the Teaching Enhancement Unit (TEU) is invaluable in supporting them in rolling out CBL. TEU has developed a comprehensive implementation guide, glossary, case studies, and a CBL Virtual Learning Environment Hub.

3.3.2. Opportunity Areas

In contemporary education, faculty should manage technologies, communicate effectively and efficiently with students, and evaluate skills development [77]. Moreover, technology is a keystone in education, so this must be considered when betting for CBL [76]. At Tecnologico de Monterrey, faculty reported fear of taking the risk of using technology in the classroom, a lack of procedures and on-site support, and a need for more training. Similarly, instructors reported feelings of insecurity and a lack of competence regarding coaching tasks at TU/e [51]. There are questions about the time required to plan such events and the range of support needed for success, which may be difficult for a publicly funded institution such as DCU to resolve.

Thus, at Tecnologico de Monterrey, intensive courses have been designed for faculty to overcome these obstacles. This goes hand in hand with the rest of the Education 4.0 paradigms, in which universities must prepare faculty to be lifelong learners [59], promoting curiosity, motivation, and perseverance among instructors [78].

There are also questions about how academics can support all types of students to succeed in such a fast-paced environment. The authenticity of learning activities is strengthened by stakeholders from academia, industry, governmental partners, or NGOs, who serve as 'challenge owners', framing the real-world problem to address. These stakeholders support student learning by defining the challenge, giving feedback in most cases [79], and transferring expertise [80]. Possible obstacles here are the unfamiliarity of stakeholders and faculty with CBL and how to engage stakeholders in student scaffolding or assessment.

The teaching model implemented in Chinese universities is subject-centered, and a systematically structured curriculum ensures that students have sound professional knowledge. The knowledge gained from such a structured curriculum may restrict the student's ability to transfer knowledge, making it inefficient for the practical application of knowledge.

In the third case study, at DCU, one of the main obstacles is the absence of a CBL unit or innovative pedagogy lab where initiatives such as this can be researched and evaluated, despite the high-level commitment and funding. Although academic developers in the TEU offer CBL support, it is limited in its ability to provide robust evidence-based research that will help convince more reticent academics. The educational developers are upskilling through engagement with the literature, working with colleagues in ECIU, and other more informal collaborations with the Eindhoven University of Technology and the Tec de Monterrey.

After COVID-19, the need to modify the way of teaching became clear. The main concern focused on the sudden change from face-to-face to digital education. In this sense, some researchers have considered the contributions of CBL in designing new online teaching practices [81,82]. The proposal is to implement real scenarios and multi-faceted pedagogical practices using ICTs to empower students to obtain more profound durable learning skills and interaction [81]. These practices must include more technical support and faculty training in academic targets [82]. This leads to theoretical and administrative implications that the leaders of the institutions must consider.

4. Discussion

Responding to the first research question: How do different universities implement CBL? Figures 1–4 show four flowcharts representing the four cases studied in this work.

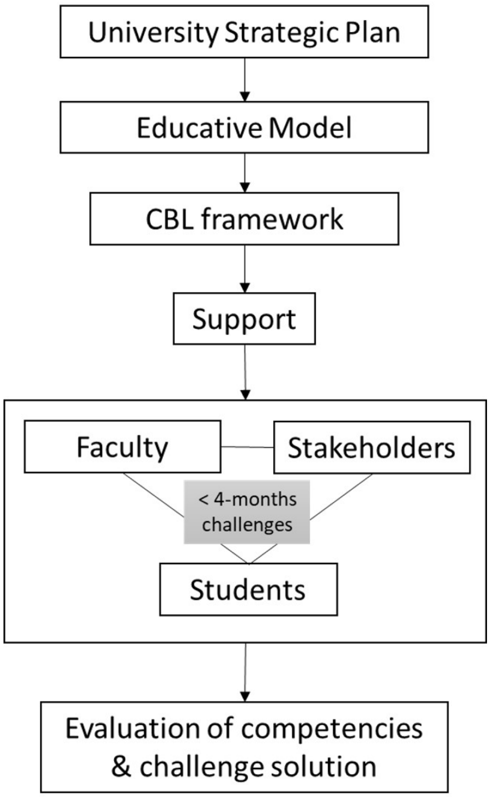

Figure 1. Schematic flowchart of CBL implementation process by Tecnologico de Monterrey.

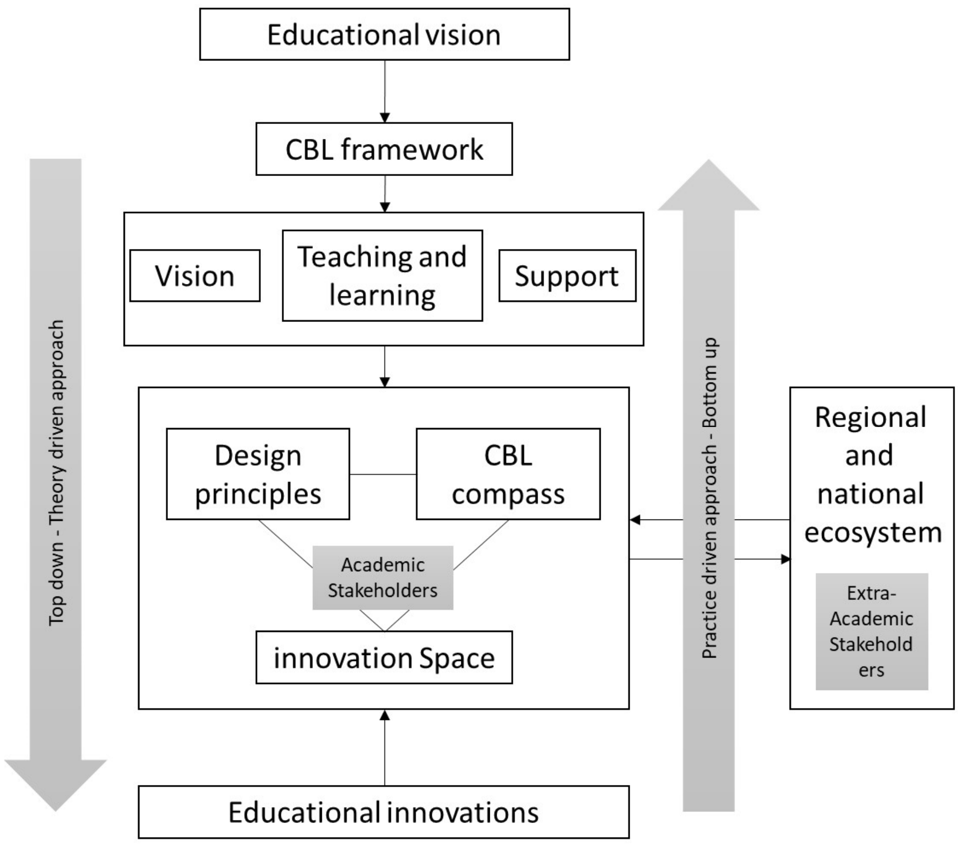

Figure 2. Schematic flowchart of CBL implementation process by the Eindhoven University of Technology.

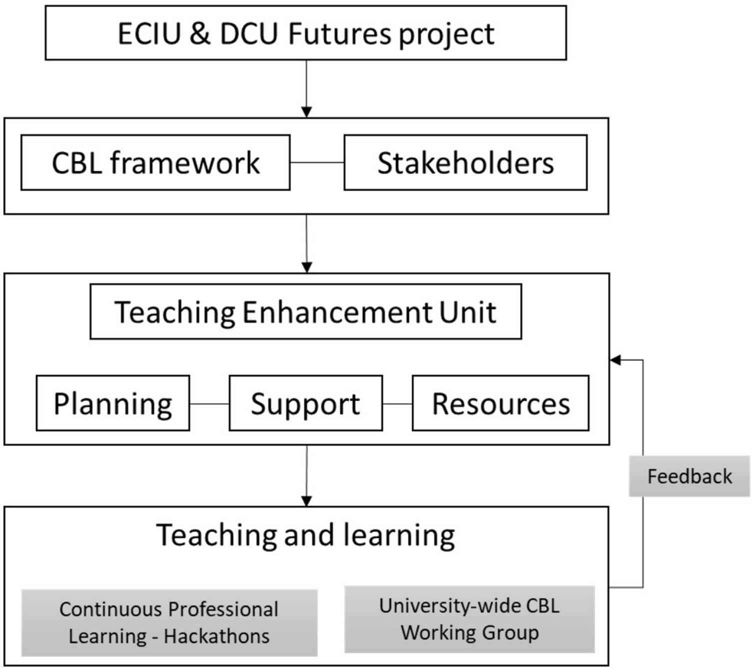

Figure 3. Schematic flowchart of CBL implementation process by Dublin City University.

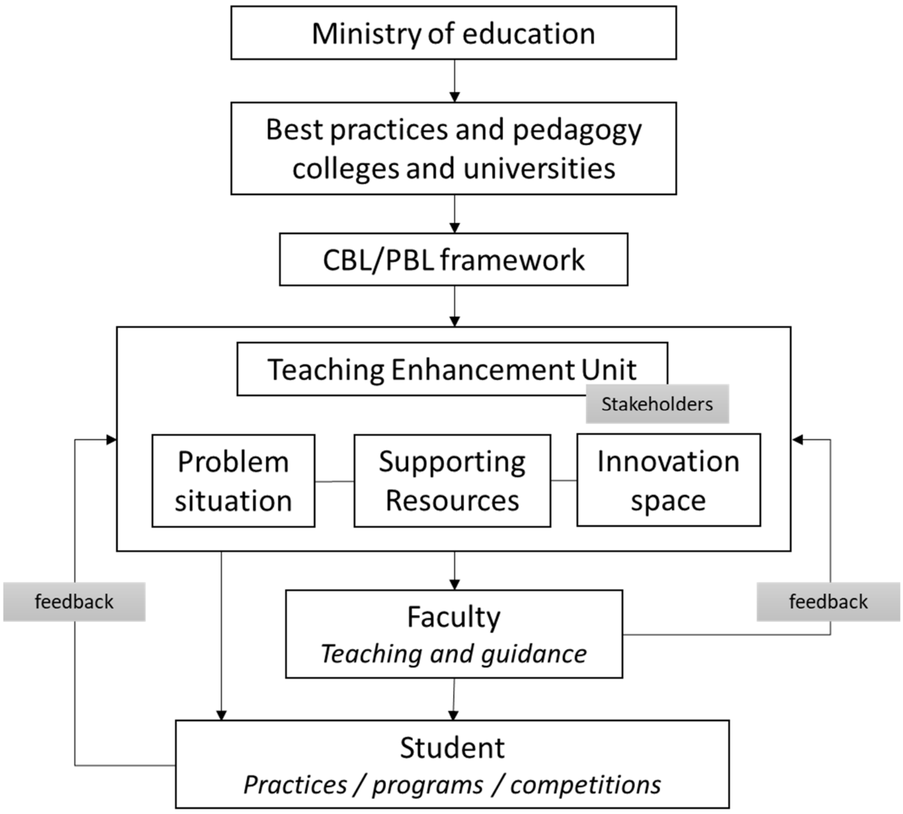

Figure 4. Schematic flowchart of CBL implementation process by Shanghai Jiao Tong University.

One way to implement CBL is vertically permeating the University's vision (Figure 1). In this case, it is considered that there is a broad relationship with relevant parties. This top-down system can become chaotic if there are no support tools for faculty and students, which requires a considerable investment of resources in training instructors accustomed to a non-student-centered teaching system. Another way of implementation is in an iterative process—top-down and bottom-up (Figure 2). In this case, the concept of CBL is developing within the University ecosystem, considering the results of educational innovations implemented by students and faculty in a space designed for this purpose. In an iterative exchange with the regional and national ecosystem, consisting of companies, NGOs, and governmental bodies, a snowball effect is created in which faculty, students, and stakeholders come together to solve significant challenges for the community. The mushrooming of pilots and experiments boosted a fruitful proliferation of educational experiences with CBL allowing a meaningful construction of CBL as a concept.

Another form of implementation observed in this work is that the very definition of the University involves a type of experiential teaching and a soul of challenges, such as CBL (Figure 3); generally, in relatively young universities, this process is also iterative. However, the size of the university could cause a need for more resources for CBL implementation. In this case, the snowball effect and the communication of successful results become more important so that more instructors and students are involved in this type of learning.

Finally, the transformation of educational systems has occurred in a brief period due to the needs of the new generations of students in a world where population growth is accelerated, impacting the use of resources, and requiring more significant differentiation, in addition to the advent of the digital era. Implementing approaches such as CBL in universities has required a gradual cultural change. For most Chinese university teachers, the preference for PBL is caused by CBL being new to them. However, in communities where technology has made considerable advances, such as China, the shift to approaches such as CBL in the teaching-learning system is inevitable. A fourth possible implementation approach could be that of Figure 4.

The Chinese Ministry of Education has suggested that Chinese colleges and universities should actively incorporate best practices and pedagogy in higher education worldwide, such as the PBL and CBL frameworks. The teaching Enhancement Unit (TEU) is constructed by organizing interdisciplinary talents (teachers), utilizing group wisdom, and combining multiple professional fields. It includes the creation of problem situations, the development of resources, and the construction of innovative spaces. These facilitate the faculty to guide students to apply knowledge in practice, projects, and competitions based on their interests and ability levels and to identify problems and give guidance promptly through classroom observation and data-driven feedback. In addition, organizations such as the Student Innovation Centre of SJTU (https://si.sjtu.edu.cn/home, accessed 23 July 2022) can also directly support students' learning. During the process, faculty and students provide feedback to TEU for further optimization (See Figure 4).

However, whether top-down or bottom-up, in all four cases, the response from faculty and students has been similar: at the beginning, there was frustration and a sense of being overwhelmed owing to an increased workload. The participation of stakeholders is a crucial element in the successful implementation of CBL. This gives a sense of accomplishment when the students are aware of their solutions' impact on industry and society. Besides, applying the acquired knowledge in the early stages of university studies ensures student engagement to culminate in their degree.

This leads to answering our second research question: How is CBL a good strategy for developing skills and competencies in higher education students? Universities are committed to providing knowledge and well-being to society; they are expected to comply with a social responsibility for educating professionals and institutions' collaboration and paying attention to community needs [83]. Implementing CBL means that students receive training in higher-order thinking, where the emphasis is on cultivating and developing students' core competencies. Students choose CBL courses because approximate real-world situations are flexible, challenging, and intellectually stimulating.

Moreover, CBL can improve group communication, making it effective nationally and internationally. When working on challenges, students could achieve unfavorable or unexpected results; however, it is essential to remember that unsuccessful solutions and implementations are potential sources of experiences and learning that contribute to training skills development. It is also vital to incorporate metacognitive activities that support the analysis and reflection of learning experiences regardless of the results.

The students' challenges in their future professional environments demand skills that transcend traditional academic settings [84]. However, students usually are not accustomed to exposure to real and unstructured problems requiring non-pre-defined solutions. Thus, competencies must be developed to tolerate and reduce uncertainty [85]. Some of these competencies are developed through CBL.

In the case of Tec de Monterrey and TU/e, the proposal is to establish sustainable thinking for the coming years. We expect that in the following years, CBL will become the vehicle to prepare students to provide emerging solutions to global problems. Therefore, networking among universities and compiling joint efforts to investigate the benefits of CBL in education will bring exciting results in preparing forthcoming generations of students. In the DCU context, the primary objective of CBL is to develop skills and competencies in students. We increasingly recognize resource implications with implementing CBL, particularly at scale. More evidence to justify resource expenditure is necessary and will require substantial research investment in the near and distant future. In the Chinese context, there is a gap in the transition between PBL and CBL.

Recent studies have shown that CBL offers significant advantages over the traditional way of teaching compared to PBL. The leap between the two approaches can occur in the degree to which faculty trust digital technologies to prepare and deliver academic content. In this sense, the support of the government and the heads of the universities will be vital in the speed at which we approach an education aimed at solving the challenges that the future holds for us, where technology is relevant.

In all cases, the implementation of CBL opens avenues for future directions that can be considered for its implementation. Firstly, because of its flexible embedding in the curriculum, CBL can be molded to each discipline. This interpretation of CBL promotes a platform for curriculum design accompanying the development of knowledge and skills. Secondly, a CBL program will provide direction and structure to university-wide CBL activities in education and research, facilitating a rapid acceptance and dissemination of CBL throughout educational programs and all the university's layers. Furthermore, the role of innovation Spaces or playgrounds to experiment with CBL from a broader perspective, as in the case of TU/e, could supply good research and experimentation opportunities. In this sense, the bottom-up stimulation of experiments assures acceptance, diminishes feelings of a top-down process, and informs the university executive board in deciding the next steps of CBL throughout the university. Finally, broad approaches to carrying out innovations on CBL create an excellent platform to introduce innovations, as there could be drastic changes, for instance, in assessment for and as learning.

Study Limitations and Future Work

Our study was limited by the number of included cases. Although the cases were selected based on maximum variation [22] aiming to explore CBL implementations, more cases could yield a richer description on multiple dimensions. Future research should add to this descriptive approach to CBL curriculum development.

The CCS method allowed us to answer each case's research question. Our research approach also yields relevant aspects of CBL implementation that support faculty and educational management in considering CBL for their specific context. However, in our effort to compare CBL implementations from an educational perspective, we limited the included aspects. Examples of such elements are funding, regulations, productivity indicators, timeframes, or evaluation strategies, as well as the level of involvement of stakeholders within the implementation process (time, human resources, economic resources, external resources, or facilities that are used for the students, the intellectual property clauses, among others). From a positivistic viewpoint, future research could focus on these aspects in different settings, with the aim of generalizing results.

5. Conclusions

Through this manuscript, it has been shown that there is a growing interest in universities worldwide in the assimilation of change. This change focuses on solving the challenges that we face around the world, which can well be represented in sustainable development goals. However, given that it is an empirical work, some limitations should be addressed. For instance, only four countries were compared at different levels of CBL implementations and with different aims. Future research should be accomplished to include more countries (with a preference for the Southern Hemisphere) and make an inventory with an interview guideline or survey.

Lastly, a high capacity for adaptation and innovation is required in the face of an uncertain future. Betting on CBL constitutes a frontline in university education as an indication of progress toward developing professionals with the necessary skills to face the industry's requirements. CBL turns university institutions into critical elements of society, in which there should be an ecosystem of cooperation for the development of solutions, in which the student chooses and manages their learning in a guided manner by professors who, with their experience and knowledge, in addition to the participation of stakeholders, provide it with the necessary tools to be successful.

Five aspects can be distinguished [76] that should be applied to education in general, considering the significant changes in the world (i.e., climate change, digitization): (1) driving innovation is a top responsibility of universities; (2) real-world skills are needed to deepen learning outcomes and prepare students for the workforce; (3) there is a gap between technology and pedagogy; educators require ongoing professional development and support; (4) artificial intelligence is driving greater personalization and efficiency; and (5) online, mobile, and blended learning are inevitable. In response to these challenges, CBL is an excellent bet for changing the educational paradigm throughout this CCS.

Author Contributions: Conceptualization, A.v.d.B., S.G.P., F.O. and J.M.-H.; Data curation, A.v.d.B. and P.V.-V.; Formal analysis, A.v.d.B. and P.V.-V.; Investigation, A.v.d.B., P.V.-V., S.G.P., F.O., C.G., F.-K.C., C.L. and P.C.; Methodology, A.v.d.B.; Resources, F.O., C.G. and F.-K.C.; Software, P.V.-V.; Supervision, J.M.-H.; Validation, S.G.P. and F.O.; Visualization, P.V.-V.; Writing—original draft, A.v.d.B. and P.V.-V.; Writing—review and editing, A.v.d.B., P.V.-V., S.G.P., F.O., C.G., F.-K.C., C.L., P.C., G.Z. and J.M.-H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing is not applicable to this article.

Acknowledgments: The authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this work.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Cavanaugh, C. Project-Based Learning in Undergraduate Educational Technology. In Proceedings of the SITE 2004—Society for Information Technology & Teacher Education International Conference, Atlanta, GA, USA, 1–6 March 2004; Association for the Advancement of Computing in Education (AACE): Waynesville, NC, USA, 2004; pp. 2010–2016. Available online: https://www.learntechlib.org/primary/p/14733/ (accessed on 15 May 2022).
2. Karaman, S.; Celik, S. An Exploratory Study on the Perspectives of Prospective Computer Teachers Following Project-Based Learning. *Int. J. Technol. Des. Educ.* **2008**, *18*, 203–215. [CrossRef]
3. Rugarcia, A.; Felder, R.M.; Woods, D.R.; Stice, J.E. The Future of Engineering Education: Part 1. A Vision for a New Century. *Chem. Eng. Educ. CEE* **2000**, *34*, 16–25.
4. Gómez Puente, S.M.; van Eijck, M.; Jochems, W. Professional Development for Design-Based Learning in Engineering Education: A Case Study. *Eur. J. Eng. Educ.* **2015**, *40*, 14–31. [CrossRef]
5. Gadola, M.; Chindamo, D. Experiential Learning in Engineering Education: The Role of Student Design Competitions and a Case Study. *Int. J. Mech. Eng. Educ.* **2019**, *47*, 3–22. [CrossRef]

6. McCarthy, M. Experiential Learning Theory: From Theory To Practice. *JBER* **2016**, *14*, 91–100. [CrossRef]
7. Johnson, L.F.; Smith, R.S.; Smythe, J.T.; Varon, R.K. *Challenge-Based Learning: An Approach for Our Time*; New Media Consortium: Austin, TX, USA, 2009.
8. Kolb, A.; Kolb, D. Experiential Learning Theory as a Guide for Experiential Educators in Higher Education. *Exp. Learn. Teach. High. Educ.* **2017**, *1*, 7–44. [CrossRef]
9. Gallagher, S.; Savage, T. Challenge-Based Learning in Higher Education: An Exploratory Literature Review. *Teach. High. Educ.* **2020**, 1–23. [CrossRef]
10. Van den Beemt, A.; Van de Watering, G.; Bots, M. Conceptualising Variety in Challenge-Based Learning in Higher Education: The CBL-Compass. *Eur. J. Eng. Educ.* **2022**, 1–18. [CrossRef]
11. Colombari, R.; D'Amico, E.; Paolucci, E. Can Challenge-Based Learning Be Effective Online? A Case Study Using Experiential Learning Theory. *CERN IdeaSquare J. Exp. Innov.* **2021**, *5*, 40–48.
12. Membrillo-Hernández, J.; Ramírez-Cadena, M.d.J.; Caballero-Valdés, C.; Ganem-Corvera, R.; Bustaman-te-Bello, R.; Benjamín-Ordoñez, J.A.; Elizalde-Siller, H. Challenge-Based Learning: The Case of Sustainable Development Engineering at the Tecnologico de Monterrey, Mexico City Campus. *Int. J. Eng. Pedagog. IJEP* **2018**, *8*, 137–144. [CrossRef]
13. Kohn Rådberg, K.; Lundqvist, U.; Malmqvist, J.; Hagvall Svensson, O. From CDIO to Challenge-Based Learning Experiences—Expanding Student Learning as Well as Societal Impact? *Eur. J. Eng. Educ.* **2020**, *45*, 22–37. [CrossRef]
14. Malmqvist, J.; Rådberg, K.K.; Lundqvist, U. Comparative Analysis of Challenge-Based Learning Experiences. In Proceedings of the 11th International CDIO Conference, Chengdu, China, 8–11 June 2015.
15. Santos, A.R.; Sales, A.; Fernandes, P.; Nichols, M. Combining Challenge-Based Learning and Scrum Framework for Mobile Application Development. In Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education, Vilnius, Lithuania, 4–8 July 2015; Association for Computing Machinery: New York, NY, USA, 2015; pp. 189–194.
16. Puente, S.G.; Eijck, M.; Jochems, W. Exploring the Effects of Design-Based Learning Characteristics on Teachers and Students. *Int. J. Eng. Educ.* **2014**, *30*, 916–928.
17. Membrillo-Hernández, J.; Ramírez-Cadena, M.J.; Martínez-Acosta, M.; Cruz-Gómez, E.; Muñoz-Díaz, E.; Elizalde, H. Challenge Based Learning: The Importance of World-Leading Companies as Training Partners. *Int. J. Interact. Des. Manuf.* **2019**, *13*, 1103–1113. [CrossRef]
18. Olivares, S.L.O.; Islas, J.R.L.; Garín, M.J.P.; Chapa, J.A.R.; Hernández, C.H.A.; Ortega, L.O.P. *Tec21 Educational Model: Challenges for a Transformative Experience*; Editorial Digital del Tecnológico de Monterrey: Monterrey, Mexico, 2021.
19. Caratozzolo, P.; Membrillo-Hernández, J. Evaluation of Challenge Based Learning Experiences in Engineering Programs: The Case of the Tecnologico de Monterrey, Mexico. In *Visions and Concepts for Education 4.0*; Auer, M.E., Centea, D., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 419–428.
20. Leijon, M.; Gudmundsson, P.; Staaf, P.; Christersson, C. Challenge Based Learning in Higher Education—A Systematic Literature Review. *Innov. Educ. Teach. Int.* **2022**, *59*, 609–618. [CrossRef]
21. Bartlett, L.; Vavrus, F. Comparative Case Studies: An Innovative Approach. *Nord. J. Comp. Int. Educ. NJCIE* **2017**, *1*, 5–17. [CrossRef]
22. Flyvbjerg, B. Five Misunderstandings about Case-Study Research. *Qual. Inq.* **2006**, *12*, 219–245. [CrossRef]
23. Tecnologico de Monterrey. Annual Reports. 2021. Available online: https://tec.mx/en/about-us/annual-reports (accessed on 10 June 2022).
24. Murgatroyd, S. Preparing for a Different Future-Learning in an Age of Disruption. *Rev. Parag. Educ. Distancia REPED* **2020**, *1*, 27–40.
25. Pérez-Sánchez, E.O.; Chavarro-Miranda, F.; Riano-Cruz, J.D. Challenge-Based Learning: A 'Entrepreneurship-Oriented' Teaching Experience. *Manag. Educ.* **2020**. [CrossRef]
26. Pieprz, D.; Sheth, R. Singapore and Mexico Are Inventing the 21st-Century Campus. *Plan. High. Educ.* **2017**, *45*, 90–107.
27. Barragán, M.R. Example of Organization That Adapts to Current Economic and Social Demands. *J. Adm. Sci.* **2021**, *3*, 1–5. [CrossRef]
28. Membrillo-Hernandez, J. Challenge-Based Learning an Emergent Educational Model for Engineering Education in the Post-COVID Era—IEEE Teaching Excellence Hub. Available online: https://teaching.ieee.org/challenge-based-learning-an-emergent-educational-model-for-engineering-education-in-the-post-covid-era/ (accessed on 7 August 2022).
29. Gómez Puente, S.M.; Jongeneelen, C.J.M.; Perrenet, J.C. Design-Based Learning in Mechanical Engineering Education. In *Project Approaches to Learning in Engineering Education*; de Campos, L.C., Tadeu Dirani, E.A., Manrique, A.L., van Hattum-Janssen, N., Eds.; Sense Publishers: Rotterdam, The Netherlands, 2012; pp. 89–108. ISBN 978-94-6091-958-9.
30. Gómez Puente, S.M.; van Eijck, M.; Jochems, W. Towards Characterising Design-Based Learning in Engineering Education: A Review of the Literature. *Eur. J. Eng. Educ.* **2011**, *36*, 137–149. [CrossRef]
31. DCU Office of the Vice-President Academic Affairs. DCU Futures: Reimagining Undergraduate Education for an Unscripted World. Available online: https://www.dcu.ie/ovpaa/dcu-futures (accessed on 17 September 2022).
32. ECIU European Consortium of Innovative Universities. Available online: https://www.eciu.eu/member/dublin-city-university (accessed on 17 September 2022).
33. Higher Education Authority Human Capital Initiative. Available online: https://hea.ie/skills-engagement/human-capital-initiative/ (accessed on 17 September 2022).

34. Dublin City University INTRA Internships. Available online: https://www.dcu.ie/intra (accessed on 17 September 2022).
35. Ministry of Education of the People's Republic of China. Opinions on Deepening the Reform of Undergraduate Education and Teaching to Improve the Quality of Talent Training. Available online: http://www.moe.gov.cn/srcsite/A08/s7056/201910/t20191011_402759.html (accessed on 15 October 2022).
36. Chen, T. Training Mode of Innovative Talents in Higher Engineering Education in China. *Educ. Sci. Theory Pract.* **2018**, *18*, 3254–3265. [CrossRef]
37. Cheng, S.Q.; Yang, J.B. The training of innovative talents in universities by university-enterprise cooperation model. *Technol. Innov. Manag.* **2011**, *32*, 507–510.
38. Li, J.C.; Lin, J.L. Promoting the cultivation of innovative talents through combination of practical teaching and academic competition. *Exp. Technol. Manag.* **2011**, *28*, 1–4.
39. Du, B.; Chai, Y.; Huangfu, W.; Zhou, R.; Ning, H. Undergraduate University Education in Internet of Things Engineering in China: A Survey. *Educ. Sci.* **2021**, *11*, 202. [CrossRef]
40. Statitsa. Number of Public Colleges and Universities in China between 2010 and 2020. Available online: https://www.statista.com/statistics/226982/number-of-universities-in-china/ (accessed on 15 October 2022).
41. Zhuang, T.; Xu, X. 'New Engineering Education' in Chinese Higher Education: Prospects and Challenges. *Tuning J. High. Educ.* **2018**, *6*, 69–109. [CrossRef]
42. Zhuang, T.; Cheung, A.C.K.; Tam, W. Modeling Undergraduate STEM Students' Satisfaction with Their Pro-grams in China: An Empirical Study. *Asia Pac. Educ. Rev.* **2020**, *21*, 211–225. [CrossRef]
43. Lin, J.; Chen, C.A. Study of Challenge-Based Learning Based on Enhancing Innovative Ability. In Proceedings of the 7th International Research Symposium on PBL, Beijing, China, 19–21 October 2018; pp. 58–67.
44. Juárez, E.; Aldeco-Pérez, R.; Velázquez, J.M. Academic Approach to Transform Organisations: One Engineer at a Time. *IET Softw.* **2020**, *14*, 106–114. [CrossRef]
45. Gamez-Perez, K.; Avilés, E.M.; Rangel, R.R. Teacher's learning and collaboration using innovative teams: Professional learning community. *Eurasia Proc. Educ. Soc. Sci.* **2016**, *5*, 217–222.
46. Castro, E.; López, I.; Zavala, G. Work in Progress: Social Networks Analysis in the Transition of an Educational Model among Groups of STEM Teachers. In Proceedings of the 2019 ASEE Annual Conference & Exposition, Tampa, FL, USA, 1 June 2019.
47. Avilés, E.M.; Aguilar, A.G.G.; Rangel, R.R.; Moreno, E.S. Creating Real Learning Experiences Rather than Teaching Based on the Traditional Transfer of Mathematical Information, at College Level. In *Research Highlights in Education and Science 2016*; Wu, W., Alan, S., Hebebci, M., Eds.; ISRES Publishing: Ames, IA, USA, 2016; pp. 40–47.
48. Caratozzolo, P.; Alvarez-Delgado, A. Education 4.0 Framework: Enriching Active Learning with Virtual and Technological Tools. In Proceedings of the 7th International Conference on Education ICEDU, Virtual, 6–8 April 2021; pp. 616–630.
49. Glasserman-Morales, L.D.; Portuguez Castro, M. Analysis of Teaching Work Culture Oriented to the Development of Entrepreneurship Skills. In Proceedings of the Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'21), Barcelona, Spain, 26–29 October 2021; Association for Computing Machinery: New York, NY, USA, 2021; pp. 248–253.
50. Membrillo-Hernández, J.; García-García, R. Challenge-Based Learning (CBL) in Engineering: Which Evaluation Instruments Are Best Suited to Evaluate CBL Experiences? In Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal, 27–30 April 2020; pp. 885–893.
51. Van den Beemt, A.; MacLeod, M.A.J. Tomorrow's Challenges for Today's Students: Challenge-Based Learning and Interdisciplinarity. In Proceedings of the 49th SEFI Annual Conference: Blended Learning in Engineering Education: Challenging, Enlightening—And lasting? SEFI ISEL, Online, 30 November 2021; pp. 578–587.
52. Doulougeri, K.; van den Beemt, A.; Vermunt, J.D.; Bots, M.; Bombaerts, G. Challenge-Based Learning in Engineering Education: Toward Mapping the Landscape and Guiding Educational Practice. In *The Emerald Handbook of Challenge Based Learning*; Vilalta-Perdomo, E., Membrillo-Hernández, J., Michel-Villarreal, R., Lakshmi, G., Martínez-Acosta, M., Eds.; Emerald Publishing Limited: Bingley, UK, 2022; pp. 35–68. ISBN 978-1-80117-491-6.
53. Van den Akker, J.; Gravemeijer, K.; McKenney, S.; Nieveen, N. *Educational Design Research*; Taylor & Francis Group: Abingdon, UK, 2006.
54. DCU Business School. DCU Hackathon. Available online: https://business.dcu.ie/hack4change/ (accessed on 17 September 2022).
55. Tang, A.C.Y.; Chow, M.C.M. Learning Experience of Baccalaureate Nursing Students with Challenge-Based Learning in Hong Kong: A Descriptive Qualitative Study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 6293. [CrossRef]
56. European Consortium of Innovative Universities Challenges: Carbon-Intensive Regions in Transition. Available online: https://challenges.eciu.org/challenges/2468603/carbon-intensive-regions-in-transition (accessed on 17 September 2022).
57. DCU Business School. *DCU Hack4Change*; DCU Business School: Dublin, Ireland, 2021.
58. Yang, Z.; Zhou, Y.; Chung, J.W.Y.; Tang, Q.; Jiang, L.; Wong, T.K.S. Challenge Based Learning Nurtures Creative Thinking: An Evaluative Study. *Nurse Educ. Today* **2018**, *71*, 40–47. [CrossRef]
59. Caratozzolo, P.; Friesel, A.; Randewijk, P.J.; Navarro-Duran, D. Virtual Globalization: An Experience for Engineering Students in the Education 4.0 Framework. In Proceedings of the 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference, 26 July 2021.

60. Reymen, I.; Bruns, M.; Lazendic-Galloway, J.; Helker, K.; Cardona, A.V.; Vermunt, J.D. Creating a Learning Ecosystem for Developing, Sustaining, and Disseminating CBL the Case of TU/e Innovation Space. In *The Emerald Handbook of Challenge Based Learning*; Vilalta-Perdomo, E., Membrillo-Hernández, J., Michel-Villarreal, R., Lakshmi, G., Martínez-Acosta, M., Eds.; Emerald Publishing Limited: Bingley, UK, 2022; pp. 13–33. ISBN 978-1-80117-491-6.
61. Brans, C.; Reymen, I.M.M.J.; Valencia Cardona, A.M.; Pepin, B.E.U.; Bruns, M. High Stakes Assessment in Inter-disciplinary Challenge Based Learning. In Proceedings of the 17th CDIO International Conference, Bangkok, Thailand, 21–23 June 2021.
62. Fullan, M. *The New Meaning of Educational Change*, 5th ed.; Teachers College Press: New York, NY, 2015; ISBN 978-0-8077-5680-5.
63. Van den Beemt, A.; Van de Watering, G.; Bots, M. Organising Evidence Informed Innovation: The Development of a Research Agenda. In Proceedings of the 50th SEFI Annual Conference, Barcelona, Spain, 19–22 September 2022.
64. Daspro, E. Assessing the Global Readiness of Organizations: An Experiential Approach. In *The Palgrave Handbook of Learning and Teaching International Business and Management*; Gonzalez-Perez, M.A., Lynden, K., Taras, V., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 243–257. ISBN 978-3-030-20415-0.
65. Gonzalez Almaguer, C.A.; Caballero Montes, E.; Acuña López, A.; Zubieta Ramírez, C.; Saavedra Gastelum, V.; Barbosa Saucedo, E.A.; Lule Salinas, M. Design Thinking and Design of Experiments: The Fusion of the School of Design and Industrial Engineering to Create Learning Experiences in the Tec21 Educational Model. In Proceedings of the 23rd International Conference on Engineering and Product Design Education (E&PDE 2021), VIA Design, VIA University, Herning, Denmark, 9–10 September 2021. [CrossRef]
66. Islas, Á.; Franklin Uraga, J.J.; Ortega Pérez, P.; Juárez-Hernández, A.E. Theory of Multiple Intelligences Applied to Teamwork with Intervention under Challenge-Based Collaborative Learning Strategy for Improvement of Online Learning. *Int. J. Educ. Res.* **2021**, *9*, 79–92.
67. Arrambide-Leal, E.J.; Lara-Prieto, V.; García-García, R.M.; Membrillo-Hernández, J. Impact of Active and Challenge Based Learning with First Year Engineering Students: Mini Drag Race Challenge. In Proceedings of the 2019 IEEE 11th International Conference on Engineering Education (ICEED), Kanazawa, Japan, 6–7 November 2019; pp. 20–25.
68. Hernandez-de-Menendez, M.; Escobar Díaz, C.A.; Morales-Menendez, R. Educational Experiences with Generation Z. *Int. J. Interact. Des. Manuf.* **2020**, *14*, 847–859. [CrossRef]
69. Huertas, J.I.; Mahlknecht, J.; Lozoya-Santos, J.d.J.; Uribe, S.; López-Guajardo, E.A.; Ramirez-Mendoza, R.A. Campus City Project: Challenge Living Lab for Smart Cities. *Appl. Sci.* **2021**, *11*, 11085. [CrossRef]
70. López, H.A.; Ponce, P.; Molina, A.; Ramírez-Montoya, M.S.; Lopez-Caudana, E. Design Framework Based on TEC21 Educational Model and Education 4.0 Implemented in a Capstone Project: A Case Study of an Electric Vehicle Suspension System. *Sustainability* **2021**, *13*, 5768. [CrossRef]
71. Salinas-Navarro, D.E.; Garay-Rondero, C.L. Requirements of Challenge Based Learning for Experiential Learning Spaces, an Industrial Engineering Application Case. In Proceedings of the 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Takamatsu, Japan, 8–11 December 2020; pp. 1–8.
72. Toscano-Alonso, M.; Aguaded, I.; Manotas Salcedo, E.M.; Farias-Gaytán, S.C. Producción audiovisual universitaria: Espacios de innovación docente en Iberoamérica. *Rev. Iberoam. Educ. Distancia* **2021**, *25*, 41–58. [CrossRef]
73. Rodríguez-Chueca, J.; Molina-García, A.; García-Aranda, C.; Pérez, J.; Rodríguez, E. Understanding Sustainability and the Circular Economy through Flipped Classroom and Challenge-Based Learning: An Innovative Experience in Engineering Education in Spain. *Environ. Educ. Res.* **2020**, *26*, 238–252. [CrossRef]
74. Conde, M.Á.; Rodríguez-Sedano, F.J.; Fernández-Llamas, C.; Gonçalves, J.; Lima, J.; García-Peñalvo, F.J. Fostering STEAM through Challenge-Based Learning, Robotics, and Physical Devices: A Systematic Mapping Literature Review. *Comput. Appl. Eng. Educ.* **2021**, *29*, 46–65. [CrossRef]
75. Tang, A.C.Y.; Chow, M.C.M. To Evaluate the Effect of Challenge-Based Learning on the Approaches to Learning of Chinese Nursing Students: A Quasi-Experimental Study. *Nurse Educ. Today* **2020**, *85*, 104293. [CrossRef]
76. Adams Becker, S.; Cummins, M.; Freeman, A.; Rose, K. *2017 NMC Technology Outlook: Nordic Schools. A Horizon Project Regional Report*; New Media Consortium: Austin, TX, USA, 2017.
77. Membrillo-Hernández, J.; García-García, R.; Lara-Prieto, V. From the Classroom to Home: Experiences on the Sudden Transformation of Face-to-Face Bioengineering Courses to a Flexible Digital Model Due to the 2020 Health Contingency. In Proceedings of the International Conference on Interactive Collaborative Learning, Tallinn, Estonia, 23–25 September 2020; pp. 488–494.
78. Matsumoto-Royo, K.; Ramírez-Montoya, M.S.; Conget, P. Opportunities to Develop Lifelong Learning Tendencies in Practice-Based Teacher Education: Getting Ready for Education 4.0. *Future Internet* **2021**, *13*, 292. [CrossRef]
79. Pepin, B.; Kock, Z. Students' Use of Resources in a Challenge-Based Learning Context Involving Mathematics. *Int. J. Res. Undergrad. Math. Ed.* **2021**, *7*, 306–327. [CrossRef]
80. Puente, G.; Doulougeri, K.; Bruns, M. Coaching Practices in Challenge-Based Learning: Characteristics and Practices in Student's Projects. In Proceedings of the 18th International CDIO Conference; Worldwide CDIO Initiative, Reykjavik University, Reykjavik, Iceland, 13–15 June 2022.
81. Yan, L. Observation of Online Foreign Language Teaching Model Based on Massive Open Online Course and Small Private Online Course During COVID-19 School Closure. In Proceedings of the International Conference on Education Studies: Experience and Innovation (ICESEI 2020), Moscow, Russia, 30 September–1 October 2020; Atlantis Press: Paris, France, 2020; pp. 468–473.

82. Mensah, I.K.; Zeng, G.; Luo, C.; Lu, M.; Xiao, Z.-W. Exploring the E-Learning Adoption Intentions of College Students Amidst the COVID-19 Epidemic Outbreak in China. *SAGE Open* **2022**, *12*, 21582440221086628. [CrossRef]
83. Fernández, L.; Fernández, S.; Rey, L.; Bobillo, M. Innovation in the First Mission of Universities. *J. Innov. Manag.* **2018**, *6*, 32–48. [CrossRef]
84. World Economic Forum. New Vision for Education—Unlocking the Potential of Technology. Available online: http://widgets.weforum.org/nve-2015/ (accessed on 1 November 2022).
85. Tauritz, R. How to Handle Knowledge Uncertainty: Learning and Teaching in Times of Accelerating Change. In *Learning for Sustainability in Times of Accelerating Change*; Wageningen Academic Publishers: Wageningen, The Netherlands, 2012; pp. 299–316. ISBN 978-90-8686-757-8.