A Practical Guide to Understanding and Implementing Challenge-Based Learning

Kenan Dikilitaş · Tim Marshall
Masoumeh Shahverdi

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"This book describes in a thorough way why and how you can apply CBL in your classroom, not only based on theory but through the presentation of case studies. It also offers a challenge to its readers: try CBL and make it work in your classroom. With the help of this book, you'll succeed!"

—Dr. Lia Voerman, *Professor of high expectation education, Research Centre Urban Talent, Rotterdam University of Applied Sciences, The Netherlands*

"The book is a highly recommended contribution to the field of educational pedagogy, especially for educators, practitioners, centres for educational support and least of which educational researchers interested in learner-centered approaches combined with tackling real societal challenges."

—Andrea Brose, *Educational Lead, ECIU University*

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Introduction

Challenge-based learning (CBL) is an emerging pedagogical model and practical approach to learning and teaching in higher education. It is an important innovation within the field of education that takes learning beyond traditional methods to provide students with authentic challenges and equips them with skills that they will use in their future careers. However, it is not just important for students but can also be applied in other contexts, such as administrative departments, companies, or non-governmental organisations who address and solve their challenges in their specific workplaces or contexts. With its emphasis on critical thinking, collaboration, and communication, CBL also provides valuable transversal skills that can be used in a wide range of situations and work settings such as to complement the specific skills and knowledge required to solve a specific challenge.

Despite its importance, there are relatively few publications examining internationally situated practices of CBL within higher education. Nonetheless, while the curriculum-based use and implementation of CBL remains an underexplored and underrepresented area of research, there are key researchers currently working in this field in different international contexts, including universities in South America, the United States, and Europe, which is the geographical focus of this book.

Over a decade has passed since the first CBL pilots in higher education (see Chapter One). It therefore seems timely to cast a spotlight on this internationally situated novel pedagogical practice that not only shifts teacher–student roles and the authenticity of the learning process in higher education but also enables students to seek knowledge that facilitates their learning in multiple contexts including classroom and workplace settings. Exploring such practices can reveal how CBL occurs in different contexts in different ways. This book contributes to the emerging body of knowledge of CBL, building on existing practices and research that are sector and discipline specific. The book also provides a comprehensive guide to understanding and implementing CBL in both higher education and other educational contexts.

Today, CBL is used in universities across European higher education institutions in a wide range of programs at both undergraduate and postgraduate levels within internal curriculums. It is also used for extra-curricular programs that are at the forefront of international educational collaboration. It aligns with the future direction of higher education according to the European Council's strategic priorities for future education indicated as follows for the period between 2021 and 2030:

- Improving quality, equity, inclusion, and success for all in education and training;
- Making lifelong learning and mobility a reality for all;
- Enhancing competences and motivation in the education profession;
- Reinforcing European higher education;
- Supporting the green and digital transitions in and through education and training.

What is the Purpose of this Book?

This book aims to provide an overview of CBL for teachers and practitioners, stakeholders and CBL experts as well students. It also includes practical knowledge narrated by CBL practitioners mainly working in the European Consortium of Innovative Universities (ECIU—see next section) and implementing CBL in various settings. The overall purpose of the book is to bring together these experiences and generate knowledge from them, so it is possible for CBL stakeholders to access knowledge from lived experiences of its implementers across various contexts. Since CBL offers an emerging area of research, the practical knowledge generated could offer new insights into the theoretical understanding of it too. We adopted four key objectives including:

- to provide practical guides, resources, and tools for implementing challenge-based learning in a diverse range of settings.
- to inspire CBL practitioners with compelling examples of CBL implementations that could help them develop new insights into its use experience and strengthen the network of existing CBL practitioners.
- to give voice to both practitioners and students about the impact of CBL on both an individual and societal level as well as the development of new skills and competencies.
- to showcase and promote the societal benefits of adopting CBL for both educational and non-educational institutions and encourage greater use of CBL.

Who is it for?

This book is intended for both those that are completely new to CBL and those that are already familiar with it but are looking for an in-depth guide to its practical implementation. Our intention is that the book provides a practical and useful guide for CBL experts and teachers that are looking for a different approach to learning and teaching. They could learn about problem-solving that connects the classroom to real-life challenges and equips their students with the skills and competences they will need in their future careers. We hope it is also of interest to educational policy-makers who set the strategic direction of educational decisions in their institutions and want to boost innovation, stakeholder collaboration, and multidisciplinary working. Finally, as we demonstrate, CBL is also applicable in non-educational settings such as for professionals to solve in a new and creative way the problems they experience in their day-to-day work.

How it is Structured

Part I

Part one has three chapters:

Chapter 1 traces the historical development of CBL as an instructional and pedagogical to foreground the theory underpinning for those that are new to CBL.

Chapter 2 provides a practical phase by phase guide to the current CBL framework that is used in the case studies featured in part two of this book. It then presents a research review highlighting key CBL learning outcomes.

Chapter 3 explores in-depth the mechanisms for providing feedback, assessment, and evaluation in CBL with many practical tools and examples for practitioners.

Part II

Part two forms the central content of this book, in which we showcase case studies of contemporary CBL practice from a wide range of contributors in the CBL field. It has four chapters:

Chapter 4 sets out the process by which we commissioned our case studies and our rationale for the categorisation into micro, meso, and macro level frames of CBL implementation.

Chapter 5 includes five micro level case studies that examine CBL within specific educational practices, for example, within a particular academic discipline.

Chapter 6 includes five meso level case studies that examine CBL outside specific educational practices such as extra-curricular CBL implementation and outside of an educational context.

Chapter 7 includes three macro level case studies that focus on systemic and institutional perspectives to examine global issues that can be addressed through CBL.

Part III

Part three has two chapters.

Chapter 8 provides a detailed analysis of all the case studies, bringing together common themes that detail implications for future implementation of CBL and the benefits for students, practitioners, and stakeholders.

Chapter 9 gives direct voice of CBL experiences to colleagues and students through interviews and conversations, posing pertinent questions for the reader to reflect on for their own CBL implementation.

CBL and the ECIU

The European Consortium of Innovative Universities (ECIU), of which the University of Stavanger is a member, is one of the leading higher education alliances in Europe. It was founded in 1997 as a network of entrepreneurial universities and now has 13 members across Europe and one associate member in Mexico. These are:

- Aalborg University (Denmark)
- Dublin City University (Ireland)
- Hamburg University of Technology (Germany)
- Groupe INSA (France)
- Kaunas University of Technology (Lithuania)
- Linköping University (Sweden)
- Lodz University of Technology (Poland)
- Tampere University (Finland)
- Universitat Autònoma de Barcelona (Spain)
- Universidade de Aveiro (Portugal)
- University of Stavanger (Norway)
- Università di Trento (Italy)
- University of Twente (the Netherlands)
- Tecnológico de Monterrey (Mexico)

In 2019, the ECIU launched the ECIU University, a new international university selected by the European Commission as one of 17 international initiatives. In an Erasmus+ funded pilot project (2019–2022), the ECIU sourced over 160 challenges and had over 150 educators working with 600 plus students. The ECIU considers CBL as one of its pillars, and its mission is to integrate CBL across its institutional partners, requiring a deeper understanding of its principles and practices, as well as the skills and competences to adjust course syllabi accordingly. Challenges are related to the global themes of the UN Sustainable Development Goals to enable students to tackle pressing real-world issues.

Aside from CBL, the ECIU also supports a challenge-based research (CBR) agenda. CBR involves conducting research with partners from business, education, government, civil society, and citizens, using real-world challenges as a starting point to arrive at implementable solutions. This approach is similar to CBL and promotes multidisciplinary collaboration to address real-world challenges and create tangible policy changes. CBR aligns with the European Research Area (ERA) Policy Agenda 2022–2024, which aims to facilitate the implementation of the EU mission-oriented approach at all levels. CBR is a crucial part of the ECIU's 2030 vision, which involves using a CBR approach to develop joint European research and innovation programs with local research agendas to enhance research's societal impact and increase researchers' societal network.

We are very grateful to our partners in the ECIU for all their contributions to this book, including ten of the case studies, chapter reviews, feedback, and suggestions. As such, this book has a particular focus on the implementation of CBL within the ECIU Universities.

Contents

Notes on Contributors

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Ignacio Alvarado-Aldea has been a part of the University of Seville since 2003, serving as an Assistant Professor since 2017. From September 2004 to September 2005, he was a Visiting Researcher at the Institute of Systems Theory in Engineering at the University of Stuttgart, Germany. He is the author or co-author of over 62 publications, 13 of which were presented at educational conferences. His research interests include predictive control for reference tracking, robust control, and applications using low resources devices.

Dr. Jurgita Barynienė is an Associate Professor and ECIU university expert for challenge-based learning application in study programmes and modules, provides training coaching sessions for teachers who want to apply this method in practice.

Frank van den Berg is a Senior Educational Consultant at the University of Twente, the Netherlands. He is responsible for the Educational

Leadership Programme, the Programme Directors meetings, and the Senior University Examination Qualification. From 2017–2022, he was involved in the ECIU as a member of the Challenge-Based Learning working group. He was a member of the Task Force 'Assessment in Challenge Based Learning' of the ECIU University and co-organised the ECIU Strategic Challenge—a CBL-experience where students combined working on their individual Master thesis while simultaneously working on an international interdisciplinary team challenge. Frank is an experienced trainer of CBL-workshops, both for students, teachers, and staff.

Dr. Sílvia Blanch is an Associate Professor at the Basic, Developmental and Educational Psychology Department at the Universitat Autònoma de Barcelona. Her work and publications are linked to innovative methodologies such as Portfolio, Cooperative Learning, Service-Learning, and more recently Challenge-Based Learning. She is the former coordinator for Capacity and Development in the ECIU University and also part of the team for teaching and promoting CBL at the UAB.

Federico Citterio was a student at the University of Trento, graduating with a Master's in Psychology in 2023. He came across Challenge-Based Learning for the first time while enrolled in the ECIU challenge "Building the University of the Future" offered by the University of Twente. It was the first time in his academic career that he had the chance to actively influence his educational program and take ownership of his learning process. Currently, Federico works in the HR department of a large Milanese company.

Rosario Chamorro-Moreno is an Associate Professor at the University of Seville. She has been teaching at the undergraduate and postgraduate levels since 2011. Her expertise lies in rigid and flexible multi-body railway dynamics, theory of machines and mechanisms and vibrations. Her teaching contributions have been collected in nine publications, one innovation project as principal investigator, and six innovation projects as member of the working team. She has supervised 10 final degree projects.

Dr. Asta Daunorienė is an Associate Professor at the EDU_Lab Center for Excellence in Teaching and Learning, which motivates teachers to experiment, choose, and apply suitable and innovative didactic methods to ensure the quality of studies. Asta also is an ECIU university expert for challenge-based learning.

Kenan Dikilitaş currently works as a University Pedagogy Professor at the University of Bergen. He is affiliated with the Faculty of Psychology. In his role, Kenan conducts pedagogical courses designed for university teachers, focusing on their professional development, particularly in integrating technology into teaching practices. Prior to his current position, Kenan had worked in Turkey, contributing significantly to the field of education. During this time, he engaged in teaching and supervising both undergraduate and graduate students in the realm of language education. Furthermore, he played a pivotal role in mentoring in-service English language teachers, guiding them in the implementation of action research initiatives.

Cecilia Enberg works as a Pedagogical Developer at Linköping University. She holds a keen interest in Education for Sustainable Development (ESD) and pedagogical methods for fostering sustainability competences and action orientation among learners. She teaches courses with a CBL approach to both students and university teachers.

Jeanette Engzell is an Assistant Professor in industrial organisation at Linköping University. Jeanette explores entrepreneurship within established companies or organisations, intrapreneurship. She teaches courses in entrepreneurship, innovation, project management, and organisation primarily at the Faculty of Technology. Jeanette is particularly interested in incorporating challenge-based learning (CBL) as a pedagogical approach in her courses, with a focus on motivating students and providing authentic learning experiences within contexts involving real-life challenges. As a teacher, Jeanette has a strong interest in sustainable development and solving societal issues through interdisciplinary student group work.

Dr. Daniel Franco, Former Elected Dean of the Engineering School of the Universitat Autònoma de Barcelona, is an Associate Professor at the Department of Computer Architecture and Operating Systems. He has developed activities fostering open innovation, entrepreneurship, and technology transfer by means like design thinking and computational thinking. He is the co-organiser of the AI4ALL programme that aims to train people in AI and entrepreneurship. Recently, he has been involved in the ECIU European University introducing challenge-based learning and digital micro-credentials to students.

Javier González-Carbajal is a Research Engineer at the University of Seville. He developed his Ph.D. in the field of nonlinear dynamics of mechanical systems, with an application to an industrial case: the vibration compaction of quartz agglomerates (thesis defended in 2017). Since his predoctoral stage, he has combined his research work with teaching mechanical engineering courses (mechanical design, theory of machines and mechanisms, machine elements, theory of elasticity) in two prestigious Spanish Universities: The University of Seville and Rey Juan Carlos University, in Madrid. In total, he has imparted more than 500 hours of theoretical and practical mechanical engineering lessons.

Clare Gormley, SFHEA, is Senior Academic Developer at Dublin City University (DCU). She is a Senior Fellow of Advance HE (SFHEA), a Fellow of the Staff and Educational Development Association (FSEDA), and is currently a doctoral candidate with a thesis focused on Challenge-Based Learning (CBL). Clare has led and facilitated multiple professional learning initiatives for DCU academic staff, particularly on the design and implementation of challenge-based learning (CBL) in teaching practice. She has published in a range of peer-reviewed journals on topics related to professional learning in higher education and is also Chair of the DCU CBL Working Group.

Robin de Graaf is an Associate Lecturer and Teaching & Learning Fellow at the University of Twente. He has an M.Sc. in Civil Engineering & Management and a Ph.D. in Strategic Urban Planning. His teaching and research focuses on the design management of construction projects, and on innovative teaching approaches. He is particularly interested in challenge-based learning and how it can contribute to educating Engineers of the Future. He is one of the initiators of the online CBL tool called Challenge Up. This tool supports teachers with implementing CBL in their courses.

Aida Guerra works at the Centre for PBL in Engineering Science and Sustainability under the auspices of UNESCO, Aalborg University, Denmark. Her research interests are in Education for Sustainable Development and Problem-Based Learning (PBL) and she holds a Ph.D. in Engineering Education for Sustainable Development and PBL.

Pedro Haro is an Associate Professor at the University of Seville. He has been involved in teaching activities (bachelor, master, and doctorate levels) in the field of process engineering since 2012. He has been vice-dean for quality assurance (2019–2023), in charge of the EUR-ACE accreditation of engineering programs in the Higher Technical School of Engineering. He is the coordinator of different innovation teaching projects including Challenge-Based Learning.

Tatiana Iakovleva is a Professor of Entrepreneurship at Stavanger Business School with a Ph.D. in Entrepreneurship from Bode Graduate School of Business (2008). Her research primarily focuses on the role of universities in regional development, entrepreneurial intentions, gender in entrepreneurship, social responsibility in business development, and the impact of digitalisation on societal transformations. Additionally, she has integrated Challenge-Based Learning into her teaching methodologies, enhancing student engagement and practical application of theoretical concepts.

Adina Imanbayeva is an Educational Development Officer at the Centre of Expertise in Learning and Teaching at the University of Twente. Adina began her CBL journey by supporting ECIU CBL pilots at UT. She later defended her MSc thesis, "CBL for Fostering Students' Sense of Impact," in which the CBL Implementation Continuum was first defined as a way of operationalising CBL in courses. Adina continued her work on the Continuum through collaborative efforts at UT, leading to "Challenge Up." Adina is currently supporting UT teachers in implementing CBL and pursuing a Ph.D. focused on student empowerment.

Anders Jidesjö is a Senior Lecturer at Linköping University. His teaching is in science, technology, and medical education and his research is mostly concerned with students' perspectives from a relevance aspect. In such work, questions of sustainable teaching and learning are a concern. In this connection, he has been part of implementing challenge-based learning approaches at different levels in several educational courses and programs. A specific interest is the quality for students to apply personal, community, or global challenges and acquire content knowledge necessary to interact and deal with them.

Olga Karageorgiou studied International Relations in Greece, and then started an international carrier with Erasmus+ projects around Europe. She started her second Bachelor's in Psychology and Master's in Educational Sciences and Technology, while at the same time working in the University of Twente as a teacher for Social Sciences and as an assistant for courses where challenge-based learning and case studies were taught. She assisted multiple courses and took part in conferences about CBL and has been guiding groups in this method for three years.

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Cia Lundvall is a certified upper secondary school teacher and has worked with marketing and taught students in rhetoric and Swedish for many years. She has previously worked as facilitator at Almi East Sweden AB. She is also a part-time lecturer at the Department of Management and Engineering at Linköping University. In her facilitator role, she monitored students' group processes, fostered innovative thinking and entrepreneurial mindset, and trained students in pitch techniques. With five years of active involvement in CBL, she has co-authored papers and has been invited to workshops to share her expertise and inspire others.

Tim Marshall is a Research Assistant in the Higher Education Pedagogies unit (UniPed) at the University of Stavanger. He has been involved in many Challenge-Based Learning implementations as a facilitator and mentor in both intra-curricular and extra-curricular iterations. He is also a Work Package Lead for the European Consortium of Innovation Universities (ECIU) developing learner guidance models for students across the network and is also involved as the lead for developing a use experience strategy for the ECIU. CBL is used as a learning model throughout the ECIU, so this role has presented many opportunities for him to be involved in the development of contemporary CBL practice across Europe. He has an MA in English Literature from University College London.

Charlotte Norrman is a Senior Associate Professor at the Department of Management and Engineering at Linköping University. Her research focus is on innovation and entrepreneurship in early stages ventures, and she also works with regional development. During the latter years, she also has paid a great interest in pedagogical issues and pedagogical development, especially regarding challenge-based learning and she has contributed to several pedagogical conferences in this area. She has been teaching in the area of innovation and entrepreneurship for 20 years and the main pedagogies applied in her teaching are, and have been, project-based learning and challenge-based learning.

Dr. Fiona O'Riordan, SFHEA, is Dean of Teaching and Learning at CCT College, Dublin. She is a member of the National Forum and the NAIN where she was part of the working group that developed the National Academic Integrity Guidelines. She is also a founding member of ICEP in 2008. Her current research areas include Challenge-Based Learning and assessment design to promote academic integrity with a particular focus on Interactive Oral Assessment. Her contribution to this chapter is in relation to experience working as Academic Developer for DCU, and her role as Programme Coordinator (secondment from DCU) to ECIU.

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Donatella Puglisi is an Associate Professor of Applied Physics at Linköping University and specialises in interdisciplinary research and innovation projects in the fields of novel gas sensing devices and digital technologies for a variety of applications with a focus on volatile organic compounds. As a seasoned educator with two decades of experience in Sweden and Italy, she excels in designing and developing courses at various academic levels, fostering inclusive learning environments, and experimenting with innovative pedagogical approaches that combine challenge-based, project-based, problem-based, and Agile-based learning. Additionally, her contributions to technology transfer, networking, and community engagement underscore her commitment to societal impact.

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Myra Ronzoni is the ECIU University Project Manager at the Universitat Autònoma de Barcelona. She is responsible for the operational implementation of CBL at the UAB, working on the design of learning experiences (challenges and micro-modules), admission of learners (students and lifelong learners), and recognition (micro-credentials). She is developing these activities simultaneously at the local level (UAB) and the international level (ECIU University), contributing to the alignment of the strategies of both institutions.

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Professor Petr Sauer is the founder and former chairman of the Department of Environmental Economics at PUEB. He currently serves as the director of the Institute for Sustainable Business at the Faculty of International Relations of UEP.

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Dr. Nadine Stahlberg works at the Center for Teaching and Learning at Hamburg University of Technology (TUHH). She is involved in the educational qualification program for innovative and interdisciplinary teaching at TUHH. She is also involved in activities of the ECIU University (European Consortium of Innovative Universities) and coordinates the ECIU Strategic Challenge, a CBL-format in which students combine writing their individual master’s thesis while simultaneously working on an international interdisciplinary team challenge.

Dr. Inga Stasiulaitienė is an Associate Professor and ECIU university teamcher who has been using the challenge-based learning method with students and has the practice how to apply this method in extra-curriculum modules.

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PART I

CBL History and Practice

CHAPTER 1

CBL and Its Evolution as an Instructional and Pedagogical Practice

What Is Challenge-Based Learning (CBL)?

In the context of higher education, CBL is a continuously evolving pedagogical practice that helps teachers redesign the process of teaching by connecting the theoretical knowledge of a particular subject to its practical application outside of the classroom, more specifically in the industry. Teachers are expected to grant time and space for their students to work as a team and make a number of decisions about the relevance between what they learn and what actually happens in the industry and how disciplinary knowledge looks like in practice. Teamworking is a crucial component of CBL to reflect 'how individuals with different skill sets collaborate in the workforce' (Nichols & Cator, 2008) and its importance is emphasised throughout this book.

At its core, CBL is transformative in inspiring students to take ownership of the learning process and develop a wide range of skills that are applicable beyond traditional teaching and assessment. The case studies (in Part II of this book) demonstrate how CBL practices are perceived, implemented, and assessed in several contexts by teachers and how it helps different student, and teachers assume diverse pedagogical roles within its framework.

CBL can be described as both an emerging pedagogical approach and a practice of instruction. It involves 'a pedagogical approach that actively engages students in a situation that is real, relevant, and related to

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their environment, which involves defining a challenge and implementing a solution' (Tecnologico de Monterrey, 2015). There is debate among CBL researchers regarding whether CBL is an 'educational concept' or a teaching method (Doulougeri et al., 2022a).

The definition from Nichols and Cator (2008) is the most often quoted from existing literature:

> Challenge Based Learning is an engaging multidisciplinary approach to teaching and learning that encourages students to leverage the technology they use daily to solve real-world problems. Challenge Based Learning is collaborative and hands-on, asking students to work with peers, teachers, and experts in their communities and worldwide to ask good questions, develop deeper subject area knowledge, accept and solve challenges, take action, and share their experience.

In line with Apple (see section 'Where Did CBL Come From?'), Nichols et al. (2016), in their CBL Guide, provides the following 12 points that characterise the definition of CBL is:

1. Flexible and Customisable

CBL offers flexibility for the process of learning and allows for customisation for diverse purposes where students have opportunities to create their own paths to learning and collaboration. It can, therefore, be implemented as a guiding pedagogy or integrated with other progressive approaches to learning such as design thinking.

2. Scalable

CBL can be practiced with multiple points of entry and adapted at a small and large scale depending on the purpose of use. Students could manage an increasing amount of work, resources, or the learning process and outcomes.

3. Free and Open

CBL does not impose proprietary ideas, products, or subscriptions but grants users and implementers agency to design and redesign their process of implementation. It also allows them to own their outputs including ideas and materials through copyright procedures.

4. Learner-Driven

CBL encourages students to drive their own learning and self-regulate the process of collaboration with CBL team members and stakeholders, which positions them in charge of their own learning.

5. Authentic

CBL provides stakeholders, including students, teachers, and industry representatives, with a dialogical space to contribute to academic standards and building deeper connections with the content of learning. CBL students deal with authentic issues emerging in real-time context in collaboration with their stakeholders who deal with co-generated challenges rather than given ones based on the curriculum in the university.

6. Global

CBL inspires all industrial stakeholders to work together with students and focus on meaningful contextualised and realistic challenges to develop local and context-appropriate solutions. This reflects the 'glocal 'perspectives where global approaches inform and shape local practices, decisions, and innovations.

7. Relevant

CBL establishes an authentic relevance between academic disciplines and their own real-world experiences with a joint reflective and critical process. This cooperation helps them create innovative ideas and action plans to address contextualised challenges they have yet to explore and handle. Students become key mediators to develop local solutions to a number of industrial and social issues.

8. 21st-Century Skills-Oriented

CBL involves an extensive framework by which students can nurture their critical thinking, communication skills, creativity, problem-solving, perseverance, collaboration, information literacy, and technology skills and digital literacy. Students are observed to experience all these skills more autonomously during their CBL engagement compared to relatively less active engagement in their school courses without CBL implementation.

9. Technology-Integrated

CBL encourages the strategic use of technology for researching, analysing, organising, collaborating, networking, communicating, publishing, and reflecting on the challenges which might lead to innovation. For example, students communicate through synchronous and asynchronous modalities and participate in CBL activities ubiquitously. They learn to stay connected within their network to continue teamwork.

10. Learner-Centred

CBL places students at the centre of the learning process where their needs, interests, and abilities are aligned with the challenges they create and with the collaboration they prefer to establish.

11. Formative

CBL requires teachers to allow students to self-assess their own learning process, including their emerging ideas, their solutions to the challenges, and the resulting products. Students also learn to document their reflective process as part of academic engagement which helps them learn how to learn within the practices of CBL.

12. Reflective

CBL opens a shared space where students can engage in deep critical reflection as they formulate, refine, develop, and elaborate on the challenges in collaboration with other stakeholders. This reflective process unveils several issues that may not have emerged during the task itself. As a team, they take stock and contemplate the events by considering the direction of their CBL practice. These reflective pauses maintain the relevance and purpose of their teamwork.

These definitional characteristics emphasise the 'importance of using the CBL approach to bridge the gap between theory taught at higher educational institutions and the application of it in the real (business/industry) world' (Afzali, 2022) creating and using customised and localised outputs such as tailored problem-solving frameworks, industry-specific case studies, hands-on simulations, and collaborative projects that align with real-world challenges and opportunities. Johnson and Adams (2011) argue that CBL was formulated with the intention of fostering creativity and encouraging risk-taking, all within a structured framework that provides students with both a rich subject matter that nurtures these skills and the autonomy that engages them more in exploration.

The State of Research

Although literature often refers to CBL's formalisation through Apple's initiatives in 2008, educational research had started to use the term 'challenge-based' prior to this, especially in the field of bioengineering (see section 'A History of CBL—The First Two Pilot Studies'). In 2020, Gallagher and Savage undertook a comprehensive literature review of CBL, reviewing over 100 articles, report that CBL as an acronym, started to be used in academic literature in 2001 (Gallagher & Savage, 2020). Therefore, for more than two decades, CBL has been in use as a pedagogical term.

Gallagher and Savage's findings show that of these 100 articles, most publications were conference papers or proceedings (65%), followed by peer-reviewed journal articles (33%), and book chapters (2%). The article also provides interesting geographical insights, and combined with our own research we know that historically, CBL research was concentrated in the USA and Mexico in the 2010s with the Netherland, Italy, and Spain joining them at the countries with the most publications in the 2020s. In the case studies featured in this book, we present novel CBL research in terms of less represented countries with contributions from Sweden (3) and Norway (2) but also Germany, (1) Lithuania (1), and Ireland (1) as well as vignettes from Denmark and the Czech Republic.

In addition to the Nichols and Cator (2008) guide, we can point to two other significant publications in the field of CBL. The October 2015 edition of the EduTrends journal, published by Tecnológico de Monterrey in Mexico (an ECIU affiliate member), provides a concise guide to CBL, positioning it within the broader framework of experiential learning. As this chapter also sets out, the guide differentiates CBL from other learning approaches like problem-based and project-based learning and traces its evolution from challenge-based instruction to the current Apple CBL model.

Key topics covered include implementation strategies featuring examples from Tecnológico de Monterrey and other institutions, the benefits of CBL in enhancing student engagement and developing critical skills, the role of the teacher in facilitating CBL, including and guiding the learning process, and finally challenges and future trends in CBL adoption. These are all themes that will be explored in depth in this book (see, in particular, Chapters 2 and 8).

The *Emerald Handbook of Challenge Based Learning* was published in 2022 and features contributions from international experts across sixteen chapters. Edited by academics from Tecnológico de Monterrey in Mexico, Aston Business School, Royal Agricultural University, and Lincoln International Business School in the UK, the book is organised into three main themes. First, the theory of CBL which, explores the theoretical foundations of CBL situating it within the broader context of experiential learning. Secondly, it details the practice and implementation of CBL through the practical aspects of offering guidance on how to design, implement, and assess CBL initiatives across various disciplines. Finally, the book concludes with an evaluation of the impact of CBL on students and institutions and discusses future implementation and future research opportunities. Each chapter provides insights into specific aspects of CBL, reflecting on real-world applications and student experiences. The handbook targets both academic and professionals and is relevant to business, governmental, and non-governmental sectors. Our book also intends to be of practical usage to such a wide range of audiences.

In summary, we believe that there is a need to build upon the existing CBL knowledge with continuing research to focus on developing best practice strategies, exploring long-term impacts, understanding teacher practice, and conducting comprehensive comparative studies. Ongoing research will help to achieve definitional clarity and provide guidance for clear implementation of CBL across different educational contexts.

Where Did CBL Come From?

In 2008, Apple initiated the Apple Classrooms of Tomorrow—Today (ACOT2) project to identify the essential design principles of the 21st-century learning environment, with a focus on high schools. CBL was a key component of ACOT2 as it helps demonstrate positive impact of technology integration on teaching and learning and Apple products and platforms were used to support research, collaboration, and the creation of multimedia presentations.

This initiative followed the tradition of the original Apple Classrooms of Tomorrow (ACOT) project, a research and development collaboration among public schools, universities, and research agencies on the USA that Apple began in 1985 and continued for a decade until 1995.

Beyond the ACOT projects, CBL emerged from a long history of experiential learning methods that aim to provide students with more practical and hands-on pedagogical experiences that reshape their university learning process. It evolved and took elements from other educational approaches including Problem-Based Learning (PBL) and Project-Based Learning (PjBL), (van den Beemt et al., 2022). It is worth briefly contextualising its emergence by overviewing the development of PBL and PjBL.

In higher education, PBL was pioneered by Howard Barrows and his colleagues at McMaster University, Faculty of Health Sciences in Canada in the late 1960s to facilitate learning basic science concepts in the context of clinical cases. At that time, PBL 'showed innovation comprised of four elements: an ill-structured problem, substantive content, student apprenticeship, and self-directed learning' (Gallagher, 1997). These fundamental strands facilitated tackling a problem through self-directed learning. PBL has been 'successfully adapted across various disciplines in higher education, including natural sciences, social sciences, or humanities' (Ball & Pelco, 2006; Camp, 1996).

Barrett and Moore (2011) argue that curricula can be redesigned to embrace PBL by shifting the educational approach from faculty-centred to student-centred through initiating an interdisciplinary process. This perspective is also supported by other stakeholders in diverse disciplines who play a key role in students' experiences and learning. In support of this view, Norman (2005) reports that PBL has become an instructional practice that significantly influences pedagogies in diverse subjects and disciplines worldwide.

PBL therefore centred around students tasking them with completing projects that required them to apply their knowledge in practical settings. It focused on promoting collaboration, critical thinking, and problem-solving abilities among students. These elements have all been adapted to CBL in various ways.

A sister approach to PBL, PjBL has its roots in the late 19th-century progressive education movement influenced by John Dewey's emphasis on experiential learning and problem-solving. The formalisation of the 'Project Method' in the early to mid-twentieth century laid the groundwork for hands-on, interdisciplinary approaches. The 1960s and 1970s saw a resurgence of interest in experiential education, setting the stage for PjBl's modern iterations and supporting and aligning with the goals of developing 21st-century skills. PjBL is seen as a learning and teaching method that actively involves students in real-world projects that could also accommodate their personal interests. Both PBL and PjBL require process-based engagement in researching and responding to authentic, compelling, and complex questions, problems, or challenges. However, the key difference from CBL is the minimised role of external stakeholders in problem-solving and project development. Another could be that PBL and PjBL could be implemented with younger learners at primary and secondary schools where they engage in projects as part of teachers' instructional processes. Since CBL requires advanced collaborative skills, presence, and action in the business and industrial contexts, it could be better implemented with and by adult students. However, PBL and PjBL could also be implemented with and by adults depending on how they are incorporated in the courses.

For example, PjBl has relevance for engineering studies as it involved students working on authentic projects that required them to apply engineering knowledge to solve complex problems. This approach emphasised hands-on learning, collaboration, and integration of multiple disciplines, aligning well with the goals of CBL. Through PjBL, on the other hand, engineering students are facilitated to develop soft skills including communication, teamwork, adaptability, critical thinking, creativity, conflict resolution, and negotiation, which became greater. Schools and universities aim to prepare future engineers as individuals who can communicate, collaborate in the modern workplaces.

Having described each, CBL, PBL, and PjBL share some commonalities such as their focus on solving real-world issues as well as on interdisciplinarity/multidisciplinary collaboration. CBL is even more learner-directed in that it allows students to choose their tasks independently and interdependently and how these tasks can be planned, sequenced, followed, completed, and assessed. There is also a greater focus on connecting the classroom to awareness into global issues where industrial and business stakeholders enrich the learning process in addition to the energy generated through collaborative teamwork among students.

More specifically, Swiden (2013) notes that the primary distinction between PBL and CBL lies in CBL's emphasis on exploring real-world issues, such as enhancing the use of sustainable resources. Similarly, Tang and Chow (2021) argue that students have the freedom to select a global issue and a related topic without being limited by pre-established rules and conditions set by teachers. Van den Beemt et al. (2022) also emphasise that CBL is a highly practical approach that equips students with skills and competencies applicable to their future careers. They specifically highlight a significant distinction between CBL and other approaches, underlining the focus on designing the problem, the process, and the solution to accommodate students' professional futures.

Beyond its educational application, CBL finds relevance in various contexts, including professional training. The relationship between CBL and professional training is symbiotic, as CBL effectively mirrors the dynamics of the modern workplace (van den Beemt et al., 2022). This is due to its flexible framework (see the next section), facilitating the generation of innovative ideas throughout the learning process. However, distinctions emerge in terms of presentation, the typology of problems, and the approach to solving them, as CBL is more focused on addressing real and open problems rather than fictional or purely academic ones (EduTrends, 2015).

Gunnarsson and Swartz (2022) focused on the connections between the Conceiving-Designing-Implementing-Operating (CDIO) framework and challenge-based learning and summarised many common aspects between CBL, PjBL and PBL as:

- Formulation of intended learning outcomes.
- Characterisation and choice of the Big Idea/challenge/project task.
- Team formation, roles in the team, and team operation and development.

- Structure and methods for the work process.
- Methods and tools for continuous feedback and assessment.
- The role of the teacher/coach/facilitator/mentor.
- Interaction with external stakeholders/challenge providers (Gunnarsson & Swartz, 2022) (Fig. 1.1).

Below we present a short vignette penned by Aida Guerra. It showcases how elements of CBL such as solving authentic problems in collaborative teams evolve from the experiential learning processes inherent in problem-based learning. The two examples of PBL implementation could offer practical insights for the readers who are shuttling between PBL and CBL.

Vignette One

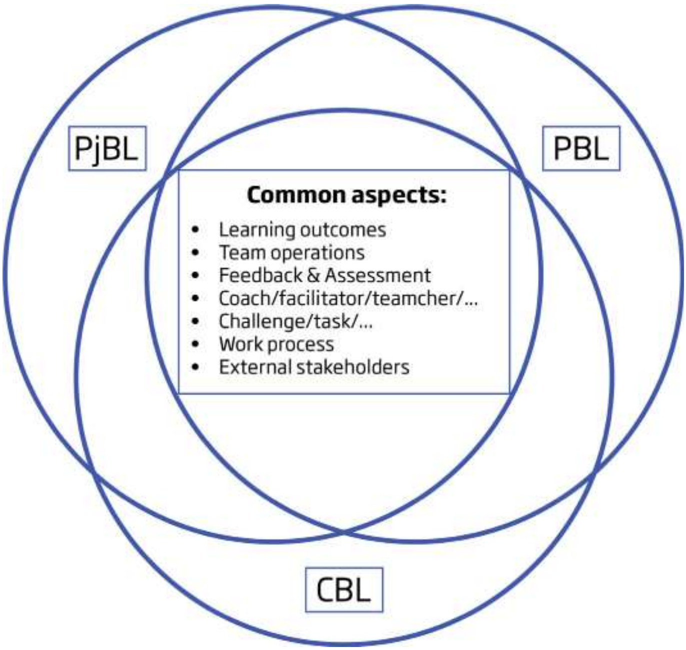

Fig. 1.1 Common aspects of PjBL, PBL, and CBL (Gunnarsson & Swartz, 2022)

Vignette supporting student learning in collaborative, problem-oriented, project-organised learning environments by Aida Guerra, Aalborg University

CBL belongs to the landscape of problem-oriented, collaborative, contextual, student-centred learning approaches like PBL. Similarly, in a PBL environment group of students learn by solving real and authentic problems. PBL can be defined from different perspectives, namely from the learning principles (e.g., problem-orientation, collaborative, contextual, experiential, and exemplary learning, interdisciplinary, participant-directed, relation theory-practice), from the curriculum organisation and models (e.g., case-based, and project-organised) (Graaff & Kolmos, 2003; Guerra & Ulseth, 2017; Kolmos et al., 2009; Savin-Baden & Howell, 2004). Social and professional engineering trends calls for a new engineer qualification profile with emphasis on deep technological knowledge and competence but also communication, complex problem solving, interdisciplinary collaboration, lifelong learning, among others. Literature has shown that problem-oriented, project-organised, collaborative learning environments are suitable to develop such competences in engineering students (Guerra, 2015; Guerra et al., 2017; Guerra & Nørgaard, 2020; Hasse et al., 2013; Holgaard et al., 2017).

However, it should not be taken for granted that students are able to collaborate, solve real authentic problems, and manage their projects when put together in teams in such learning environments. Like developing any other skills, students need the support from institution and staff. PBL and CBL are demanding and complex learning environments for both students and staff. There are a re-definition of roles, negotiation and decision making of what is important to learn and why. Additionally, the problem-orientation and collaboration also enable to a set of elements, that always been impacting students learning, emerge and become explicit, namely personal life goals, values, beliefs, emotions, etc. Therefore, it is important to recognise such complexity, their effects on individual and collective student learning and train them with proper knowledge, skills, and competences for them to thrive and succeed.

This vignette reports on the importance of scaffolding students learning in problem-oriented, collaborative, project organised learning environments, such as PBL and CBL. I start by describing two PBL courses which I am responsible for, and which the purpose is to provide students with *basic knowledge and resources to develop their collaborative, learning and problem-oriented capabilities.*

PBL Training for Students: Example of Short and Long Courses

Both PBL courses present different formats, duration and integrate different PBL environments. However, they are both grounded in the same learning principles, and aim to address similar learning outcomes.

Short PBL Course: Example from MAREENE Program (France)

The design, implementation, and evaluation of the short PBL course piloted in the MAREENE program was first published in 2020 (Guerra et al., 2020). MAREENE is an international programme on Reliability based structural Maintenance for Marine Renewable Energy, delivered at Université de Nantes (France), and developed in collaboration with Aalborg University (AAU), Norwegian University of Science and Technology (NTNU) and University College Dublin (UCD). Its curriculum is problem-based, project organised (PBL), where small groups of students solve real and authentic problems within civil and marine engineering through a project of two ECTS[1]. Besides the project, students also have online courses, which provide technical knowledge and support their project work.

The short PBL course is integrated in the project module and has a workload of 15 h (Fig. 1.2). Its main purpose is to support students in their project module and addresses the following topics: collaboration, project management, academic co-writing, and documentation, which are core elements of PBL working processes.

The short PBL course is fully online and is designed according to PBL principles, i.e., it is participant-directed, experiential, problem oriented, team-based, exemplary, and relation between theory-practice (Kolmos et al., 2009). Four online seminars, with assignments in between that are carried

Fig. 1.2 Short PBL course as part of a 2 ECTS project module

out individually and as a group, integrates the course (see appendix 1 and 2).

Guerra et al. (2020) *elaborates on the short PBL design, implementation, and evaluation, including students' qualitative viewpoints on the course. In overall, students refer that course structure, materials, and assignments supported their learning and that have met their expectations from a moderate to a large extent. They also consider the course and topics addressed relevant, including for future projects they will be involved in.*

Long PBL Course: Example from Engineering Education at Aalborg University (Denmark)

At Aalborg University (Denmark), since 1974 all educational programmes are organised around problems (Aalborg University, n.d.), this means all students learn by solving real and authentic problems since day one of their studies (Aalborg University, 2015). Generally, in engineering education, semesters are organized on three course modules of five ECTS each and a problem-based project module of 15 ECTS (see for example, Aalborg University, 2023). To support student learning, in the first semester, first year students have a course dedicated to PBL, two courses dedicated to engineering fundamentals and a project module (Fig. 1.3). This means that PBL competences are part of the overall competence profile of the program formal curriculum.

The course addresses multiple topics from different areas, making it interdisciplinary by nature. Example of the topics addressed are: (1) definition of PBL, (2) problem design, (3) theory of science, (4) project management (planning and collaboration), (5) sustainability and technology assessment, (6) reflection and learning theory. Example of syllabus can be found at (Aalborg University, 2022).

General organisation of each sessions addressing a given topic is as follows: (i) preparation (i.e., self-study activity), (ii) lecture, or workshop, (iv) assignment submission, (v) constructive feedback (written and/ or oral). Figure 1.4 illustrates the overall structure of each topic addressed.

Guerra (2015), Holgaard et al. (2017), Moesby (2010), Mosgaard & Spliid (2011) are examples of publications which report research carried out and elaborate on in which ways PBL education is carried out at Aalborg University (Denmark). For example, Holgaard et al. (2017), describes the approach taken at Aalborg University to design problems. In the past three years, PBL trends emerged in the landscape of Aalborg University PBL environment research and development, namely the Megaprojects

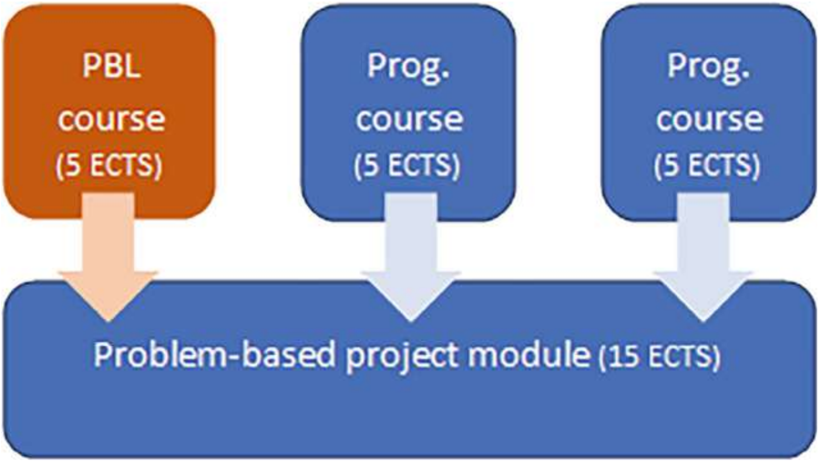

Fig. 1.3 General organisation of B.Sc. 1st year engineering programmes

(Aalborg University, 2020*), microcredentials (AAU micro), student agency for sustainability (Guerra* et al., 2022*), PBL progression and professional competences (UCPBL), student wellbeing (Chen* et al., 2023*).*

Lessons Learned and Concluding Remarks.

There are three main lessons I take from my 10 years of teaching practice in a PBL environment. They are:

- ***Practice what you preach****. The course follows the PBL principles, namely it is problem-oriented (e.g., students must identify a challenge in a one of the thematic areas that integrate the course, problematized it, design an experiment/ solution, implement and evaluate it), contextual (e.g., student projects are used as case studies to exemplify and apply the knowledge and tools learned throughout the course), experiential and participant-directed (e.g., students choose what is more important for them based on their experiences, and they decide how to manage their learning and working processes using the tools given such as the group contract and the ground rules the group should abide to*
- ***The power of reflection.*** *Reflection is corner stone of the course and an ongoing activity, both for students and the lecturer. Reflection takes two main formats: (i) through constructive feedback that the*

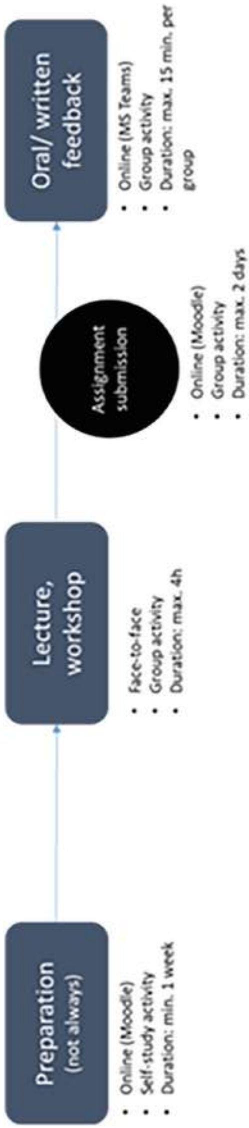

Fig. 1.4 Organisation of a PBL course session from Aalborg University (AAU)

lecturer provides to groups after each thematic session and assignment submission (see Fig. 1.4). It is also through these assignments that students transfer and apply the knowledge their learn to organise group and project work. (ii) Through a small report where students elaborate on their learning and working processes. This report is called process analysis, and it is structured around learning cycle, namely Kolb Cycle of Learning, and focus on four main areas, which are project management, collaboration, supervision, and learning. The process analysis report is a practice from AAU and, typically, first-year students produce three of these reports.

- ***Emphasis on the process and exemplarity.*** *The process is structured and exemplary, which followed by reflection enable students to generate the knowledge on content but also procedures on how to address challenges and potentials among team members and in their working processes, as well as evaluate the outcomes of the actions taken. The emphasis on the process and exemplarity are particularly relevant in the short term PBL course since the time is limited to develop further.*

Nonetheless, the implementation of these courses is not exempt of challenges. The interdisciplinary nature of the PBL courses is a challenge for students, which in several moments do not take it 'seriously' because it is not real engineering. On the other side, as students experience more problem-based, project organize throughout the semester, they tend value more the knowledge, tools the course provide and the skills they develop as part of it. Still, it is a challenge for them to fully grasp the importance of such scaffolding. Additionally, in the last 10 years of teaching practice in the AAU PBL environment, my empirical observation enables me to make two assumptions: (i) most students have worked in teams before, but their experiences are rated as bad, or very bad. This is especial visible in international students coming to study at AAU. (ii) Students that have prior work experiences tend to value more such courses and scaffolding activities. As they state: 'we know why we are here and what we want to take from here'. Several first years do not have such experience and maybe connection with work environment in yearly years might provide valued experiences which enable them to value and recognize the importance of transversal and professional skills beyond the STEM ones. However, such assumptions have not yet been proven to be true or not, which require further investigation.

A History of CBL—The First Two Pilot Studies

At the core of this book in Part II is a collection of case studies showcasing real examples of CBL in practice in a contemporary context. It is therefore worth foregrounding these initial pilot studies as cases to learn from, adopting historical perspectives in relation to the first implementations of CBL in various contexts.

The First CBL Pilot Study

The first CBL pilots took place in 2009 in the USA involving 321 students and 29 teachers across six high schools, who collaborated on projects including a variety of disciplines (Johnson et al., 2009). Based on the data from both students and teachers, the New Media Consortium (NMC) and Apple Education analysed the results of this pilot, making an overwhelmingly positive case for the benefits of CBL and its wider use. According to Johnson et al. (2009), four out of five students expressed a willingness to recommend the approach to their peers. Teachers also observed that students exhibited a higher level of engagement with the content and surpassed their anticipated learning outcomes at the outset of the project. Both groups of participants indicated that students acquired meaningful knowledge and demonstrated enhanced global and community engagement. Despite concerns about scheduling the projects, the schools effectively organised them within various time frames, with no discernible difference in the outcomes or the quality of student work. In summary, the initial pilot results strongly support the broader implementation of CBL. Teachers expressed a positive assessment of the experience, noting that students surpassed expectations in terms of outcomes, attitude, and behaviour. Although initially uncertain about the project's efforts, 80% of students reported a positive impact on their communities and schools due to their participation (Johnson et al., 2009.)

The Second CBL Pilot Study

Building on the first pilot outlined above, the second pilot study, conducted by Johnson and Adams (2011), constituted a more in-depth study of CBL across education levels, from primary to graduate, introducing CBL into higher education. It focused on several areas including evaluating the effectiveness of CBL, expanding, and understanding the experiences of students and teachers, and identifying the success factors, such as implementation success, instructional successes, and student success. Similar to the results from the first pilot study, the majority of the participating students reported that they had learned more than they expected, worked harder than usual, and felt like they were part of solving problems in their community. The feedback showed that 94% of students agreed that group work allows students to develop new skills, and 91% of teachers reported that they intended to use CBL again. Moreover, 75% of teachers also agreed that there was an increased overall engagement (Johnson & Adams, 2011). The conclusion of the second pilot study reported an increase in engagement, additional time dedicated to addressing the challenge, the creative use of technology, and greater student satisfaction with their schoolwork. Equally important was the result that there were no striking differences in the student experience across the different educational levels and ages. This was not only a testament to the versatility and flexibility of CBL as a pedagogical practice, but also provides evidence that supports how it practically motivated students to attend classes and perform well in practical terms (Johnson & Adams, 2011).

CBL Prior to 2008 and the STAR Approach

The early use of CBL in academia can be traced back to the discipline of bioengineering within the collaboration among US universities including Vanderbilt University, Northwestern University, the University of Texas, and the Harvard/MIT Health Sciences Technology Program acronymised as VaNTH. This academic partnership contributed to the emergence, development, and implementation of CBL for biotechnology (Brophy & Bransford, 2001). In this collaborative consortium, the term was used as challenge-based instruction (CBI) in their research outputs, which later shifted to CBL. In addition to using CBL-related terminology, VaNTH also adopted the STAR Legacy Cycle, used primarily at Vanderbilt University. The abbreviation STAR stands for software technology for action and reflection and is often referred to as the initial implementation model of CBI by Brophy (2005). The STAR approach contained six phases: *challenge, generate ideas, multiple perspectives, research, and revise, test your mettle, and go public* in a project-focused enquiry cycle used for module development aimed at enhancing the learning experiences of students (Birol et al., 2002). CBL's model has, therefore, used and refined STAR's six-phased approach into three major phases which include *engage, investigate, and act*.

A key difference between the STAR approach and Apple's CBL model is the definition of challenges. While for educators using the Apple model students would generally determine the nature of their challenge, educators using the STAR approach determined the challenge for their students. This is a distinction that shows how students are empowered differently in both approaches. While the Apple model CBL creates opportunities for co-ownership of the challenges with stakeholders and positions them as decision makers and critical thinkers by building relevance to the industry, they undertake the central role of determining their own challenge. On the other hand, the STAR approach predetermines the challenges and expect particular solutions which would not be the case for the Apple's CBL model. However, both approaches expect students to learn through the field engagement with the industry as Bransford et al. (2000) highlight the role of building on knowledge and skills through exploring new contexts and refining them. In Chapter 2, we will explore how these early iterations and models of CBL evolved into the framework used today.

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CHAPTER 2

CBL Framework Today and CBL Learning Outcomes

The CBL Framework Today

The CBL framework originally evolved from the “Apple Classrooms of Tomorrow—Today” (ACOT2) project in 2008 as outlined in Chapter 1 and it has been used by the ECIU universities and other universities (see case studies in Part II). The framework simplifies the original ACOT2 version into three distinct phases: *Engage*, *Investigate*, and *Act* (see Fig. 2.1). Each phase includes multiple activities that prepare the students to engage and complete the next phase. Within each of the phases, there are opportunities for mini-investigation cycles which we present in subsections. However, these phases are iterative in nature which are closely interwoven. So, students need to build on each phase and each sub-phase which inform one another in a progressive manner. While CBL encourages students to explore and address their challenges in a framework, it also offers a space where they can exercise agency and learn interdependently as a team. The uniqueness behind the framework is that it is not only collaborative among students but also with the external stakeholders. Now we present each phase in Fig. 2.1.

The Engage Phase

As Fig. 2.1 shows, the first phase of CBL, the *Engage* phase can be divided into three parts: sharing a big idea, finding essential questions, and

K. Dikilitaş et al., *A Practical Guide to Understanding and Implementing Challenge-Based Learning*,
https://doi.org/10.1007/978-3-031-67011-4_2

Fig. 2.1 ECIU challenge-based learning framework (*Source* https://www.eciu.org/for-students/about#cycle)

finally creating a challenge. We explore these parts and their interrelation sequentially, while adding an additional fourth section on the importance of team formation as the foundation for the challenge.

Team Formation

In CBL, the formation of effective teams is essential for successful implementation. Establishing a conducive teamworking environment and ethos right from the outset is paramount. Nichols and Cator (2008) underline the significance of this activity and emphasise that teams need to carefully consider roles, responsibilities, and their developmental process. In CBL, students have fluid roles throughout the challenge, so they can nurture all skills iteratively and be flexible and adaptive to the requirements of their challenge as it evolves.

Optimal team size is suggested to be comprised of four to five learners, as indicated by Nichols et al. (2016). Teams should be formed based on a diverse range of criteria, including educational background, personal interests, gender, nationality, age, experience, and skill sets. By embracing such diversity, teams can harness a greater set of perspectives and expertise, enhancing their problem-solving capabilities.

A multidisciplinary composition is ideal, ensuring a blend of proficiencies and skills within each team. In CBL, where roles are fluid and skills are nurtured iteratively, the small composition of teams enables flexibility and adaptability to evolve challenges as students can take on different roles at different points in the challenge. This may be more difficult in intra-curricular challenges where participants are all studying the same academic discipline, however, in modern education, even intra-curricular courses have a greater number of students of different nationalities and even ages with lifelong learners returning to education.

Team formation methods can vary, either autonomously driven by students or facilitated by teachers and CBL practitioners. Each approach presents its own set of advantages and disadvantages. The former gives students greater ownership over their team selection and the responsibility for their decisions, however, they may be inclined to form a team with others they already know well which limits the potential diversity of their team and could lead to individuals feeling excluded if they are not chosen to be part of a team. It may also be inefficient and time-consuming while the learners decide on their team. The latter has the advantage that teachers should be familiar with the backgrounds and skills of all the participants and can therefore design groups that are well-balanced. This method is more efficient although it maintains the hierarchical position of the teacher in a more traditional role and it also means that if disputes arise between team members, they may feel that the teacher is responsible.

An alternative approach involves playful 'ice-breaker' activities to form groups randomly. This method not only furthers essential skills like leadership, communication, and collaboration but also injects a sense of spontaneity and inclusivity into the team formation process. Activities such as solving puzzles using non-verbal communication can serve as effective catalysts for team cohesion and camaraderie.

Below are reflections on how students formed their team and the importance of both team building and working in a multidisciplinary team.

> Before we started forming teams, we had some ice breaking and some kind of activities and played games. So, we had to kind of come together

in mutual interests and mutual background.—University of Stavanger - student

The teacher and the challenge providers formed the groups by themselves. They started analysing the backgrounds of each individual and then they put them together in a group with diverse fields of interest. So, we could explore with group members from different backgrounds, we got a chance to learn a lot of different new things which we were not familiar with. The team members were from Germany, from Ireland, from Italy, Poland, India and Bangladesh—University of Stavanger - student

The Big Idea

A key activity in the *Engage* cycle, sharing a 'Big Idea,' was retained from the ACOT2 CBL process described in Chapter 1. Big Ideas are single concepts that present a wicked societal problem—an ever-evolving complex societal issue. These concepts are 'broad and explored in multiple ways that are relevant to learners and the larger community' (Nichols et al., 2016). In the ECIU context, these have historically been linked to the UN sustainability development goals. However, the Big Idea is broad enough to let students explore various options for societal and industry-related solutions (co-developed and formulated with other stakeholders). Examples of Big Ideas include:

1. Climate Change
2. Community
3. Relationships
4. Creativity
5. Health
6. Sustainability
7. Democracy
8. Water
9. Food
10. Transport

In intra-curricular implementation, the teacher or CBL practitioner assigns the Big Idea to students, typically aligning with the course title they are studying. Conversely, in extra-curricular CBL projects, usually external stakeholders, sometimes known as challenger providers (CPs) such as companies or organisations, provide the Big Idea. The Big Idea then directly addresses an issue the CP wishes to solve, and students collaborate with these CPs throughout their challenge. A third alternative is that students can select their own Big Idea. In this scenario, students are encouraged to create a list of ideas that match the challenges faced by society, adapting these ideas to the specific contexts and issues encountered in their own countries and regions (Nichols & Cator, 2008). Through these discussions and collaborative efforts, students collectively choose the Big Idea. These principles of autonomy and self-direction remain at the core of CBL learning as key to students' engagement and learning.

Finding Essential Questions

Once the Big Idea has been decided upon in partnership between the teacher, the team of students and the external stakeholder/CP, they can then progress to the *Engage* phase. In this phase, students move from the Big Idea to a concrete and actionable challenge using the essential questioning process (Nichols et al., 2016; Swiden, 2013). This process encourages students to develop many different essential questions before refining it down to a single essential question relevant to their challenge.

Essential questioning enables learners to put the Big Idea into context and make it personal (Nichols et al., 2016), reflect students' interests and community needs, and highlight the crucial aspects about the big idea. As a team, students begin to ask and answer a number of essential questions based on their interests and the societal issues that they are faced with. They then proceed to categorise and prioritise these questions for further exploration. By categorising and prioritising questions based on their significance, participants can efficiently approach finding solutions to the identified challenge (Apple Inc., 2010).

After analysing the answers through brainstorming sessions, they select one essential question that resonates with all team members and addresses a critical issue in their society. This process also helps identify the needs and expectations of society, companies, or organisations with whom students collaborate to formulate challenges for them. For example, if the big idea is sustainability, students might ask the following essential question: '*How do we reduce food waste on campus?*' as formulated by students at the University of Stavanger (UiS) who took the Sustainability and Green Transition course in Autumn 2023, which used the CBL framework.

Collaboration among participants is crucial in formulating these essential questions, as they serve as the bridge connecting individual experiences with the overarching concept. Essential questions are not only answerable through research but also help in directing efforts and providing a framework for addressing the challenge. Understanding the different types of questions, ranging from surface-level inquiries like 'when' and 'what' to deeper explorations prompted by 'why' and 'what if,' is vital. Practicing the generation of diverse questions helps in honing this skill, with no question being considered unworthy. In the example of the UiS course mentioned above, different questions were formulated before they agreed on a single, essential question.

1. How does the waste produced by the university affect the environment?
2. What can individuals do to reduce their food wastage?
3. What can the local community do to reduce food wastage?
4. Why does food waste occur at different stages of the food supply chain?
5. How can technology and innovation be used to reduce food waste?
6. How might new facilities on campus reduce food waste?
7. How can initiatives be designed to address these factors and promote a more sustainable food culture?

It is important to ensure that students understand the process of formulating their essential question and arrive at a single question that is actionable and measurable. Practitioners can schedule specific brainstorming sessions to give students the space to explore the big idea in a creative and holistic way. By guiding students through the process of formulating essential questions and refining these down to a single question, practitioners can ensure that this leads to a challenge that is both realistic and implementable.

Creating a Challenge
After choosing a single essential question emerging from the 'Big Idea' and the process of choosing a single essential question, students formulate a practical challenge that is relevant to real-world contexts and offer societal benefits (Nichols & Cator, 2008). Challenges should be actionable, measurable, and immediate (Nichols et al., 2016) and often use words

such as 'increase,' 'improve,' or 'reduce.' To continue with the example from the UiS course, one such challenge was identified as '*Increase the quality of waste sorting at the University of Stavanger.*'

As with the process of refining down from multiple essential questions to a single one, students brainstorm to generate multiple challenges based on their interests, their responses to their essential questions, and thinking about the broader societal needs. When choosing the challenge, students should also take intro factors such as time management and practicality. They can get feedback on these factors as well as feasibility and actionability by sharing them with their teacher and CBL practitioner and their external stakeholder as challenge providers. Developing a local solution to a global problem gives the students personal meaning in implementation in their own unique context. However, it is important to note that if the challenge is too broad or vague, then they may struggle with successfully tackling it, whereas if it is too narrow, then it may limit skills development. Finally, it is important that all team members have equal 'buy in' and a sense of collective ownership to ensure that the challenge is real and meaningful as personal connection drives involvement in the process (Apple Inc, 2010).

Below are reflections on the *Engage* phase that underscore the importance of dedicating sufficient time to this phase and challenge definition.

> Academics should work closely with students during the Engage phase to help them define the challenge. If time and support is not dedicated to the Engage phase, students may find it difficult to solve the challenge.—Dublin City University (see Case Study Eleven in this book)

> I think the Engage phase is the most challenging because once you are through this phase the ball keeps rolling but you have to find the challenge. It made it easier to do it in a CBL way than in another way kind of know what you want to do or who you want to speak.—University of Stavanger - student

The Investigate Phase

Once students have created their challenge in the *Engage phase*, they initiate the *Investigate* phase during which they conduct rigorous research to address the challenge and develop actionable and sustainable solutions. During this phase, students contribute their own knowledge and skills and collaborate to conduct research activities. They first formulate guiding questions that help them identify and collect further information for analysis of the potential solutions of the challenge (Nichols et al., 2016). Then, to expand the existing set of information and answer these questions, they identify guiding resources and conduct activities such as synthesising all the knowledge co-constructed as a teamwork. Finally, they reflect on the initially formulated challenge to verify the extent to which it has been addressed and could provide a robust basis for the solution (Swiden, 2013) before analysing their materials. We now provide detailed information for each of these sub-activities.

Identifying Guiding Questions

Students first develop guiding questions to help them work towards the solution to their challenge. The guiding questions help gain the knowledge needed to develop a solution to the challenge. In the *Investigate* phase, asking as many questions as possible is key to scoping the breadth and depth of the investigation. Therefore, the teacher or CBL practitioner needs to encourage students to pose and write their own guiding questions and ensure that they are suitably relevant and applicable to their challenge (Ambrosi & Hermesen, 2023).

In the *Engage* phase, the single essential question is required to identify a specific challenge, while in the *Investigate* phase, students can develop as many guiding questions as they need to acquire the knowledge needed to work towards a solution. For example, the following questions can be examples of guiding questions that can be asked at the *Investigate* stage:

- How much waste is produced on campus from the use of disposable food containers?
- What is the cost of disposable food containers?
- Are the different types of food containers recyclable?
- Is there a difference in the environmental impact of the different types of food containers?
- What is the environmental impact of cleaning dishes?
- What is the cost of cleaning dishes?

Guiding Activities and Resources

To answer such questions, students develop guiding activities and resources. These could include gathering relevant reports or data for their challenge or interviewing stakeholders involved in the challenge. The multidisciplinary nature of CBL teams is a real strength for this phase as tasks can be allocated according to team members' particular skills such as research, writing, production of visual materials, or working with data. Team members should be encouraged to take on as many different roles as possible such as organiser, researcher, and interviewer, so that they gain a wide range of skills in leadership, in communication within the team and with stakeholders, in team building, and in collaboration.

To support student investigations, teachers can also provide a wide range of guiding resources including contact information of expert stakeholders for interviews. Teachers should provide tools to help students during the *Investigate* phase that help them better frame their activities.

This could be as simple as getting them to map out the different kinds of stakeholders (internal and external) and their respective needs and priorities. It could be to encourage them to conduct a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis or use a problem-solving tool like the fishbone diagram. This is a visual diagram used in brainstorming to set out the root causes of a problem by categorising relevant factors such as environmental, financial, regulatory, stakeholders, etc.

The *Investigate* phase can often be the most time-consuming and challenging for students as they move from the conceptual and theoretical *Engage* phase to the practical application of the guiding activities. However, these activities can in turn generate more guiding questions, which continue to emerge throughout the challenge (Nichols et al., 2016). For example, following an interview with a stakeholder, the information provided may lead to the development of further guiding questions that require going to new stakeholders or other sources of information. The Challenge Institute (2018) provides some useful tips on how best to conduct research in this phase:

- Create good guiding questions by checking them with teachers/ CBL practitioners and other teams before you prioritise the most important questions.
- Search effectively by using a wide range of sources such as scholarly journals, articles, blog posts, or current events.
- Ensure to check the validity of these sources and build relevance.
- Use networks including family, friends, teachers, local community, which can help find answers.

- Avoid bias by questioning your assumptions and prejudices which might be manipulated by a pre-conceived solutions you might already have in your mind.
- Revisit and re-examine new ideas by being open to diverse perspectives and being self-critical.

Doing the Analysis
At the end of the *Investigate* phase, students in teams develop skills such as transcribing interviews, analysing them, synthesising, and summarising large amounts of data, and creating visual representations of the key findings. Using the results, they write up an interim report, a short reflection, or a presentation on which teachers and CBL practitioners can provide informal feedback (see Chapter 3 for more details).

The Act Phase

In the final phase, *Act*, stakeholders, team members, peers, and experts revisit and assess a variety of possible solutions. At this stage, teachers and CBL practitioners should ensure that students' proposed solutions align with the research findings based on the collected and analysed data. This approach helps them keep under control the predetermined ideas and develop solutions based on evidence and analysis (Nichols et al., 2016) rather than one's own assumptions. In this phase, students establish a contextual plan for the implementation of one solution before finally evaluating the feasibility of the challenge and reflecting on their successes and failures.

Coming up with a Solution
As with the process of refining essential questions in the *Engage* phase, teams initially develop multiple potential solutions, as the team of students is multidisciplinary and therefore will have a diverse range of perspectives on solutions. Through this process, the team should then select one solution through prototyping, experimentation, different problem-solving techniques, or other means. Then, the team needs to evaluate their chosen solution in different ways. Teachers and CBL practitioners can provide them with problem-solving techniques to evaluate the solution such as the Six Thinking Hats. This technique, introduced by Edward de Bono

in 1985, offers a creative thinking tool to solve problems and think differently while taking decisions. Students can break down their thoughts into six parallel areas (Process, Facts, Feelings, Creativity, Benefits, Cautious) to get the full spectrum of alternatives and help to take each viewpoint with a different discussion. As CBL teams are usually composed of around five members, this technique fits well as each member can take on a different 'hat' or role for the discussion or alternatively every member can try each role in turn. Students should evaluate the effectiveness of their chosen solution and make adjustments that will deepen their subject area knowledge. (Nichols et al., 2016). They can even return to the *Investigate* phase as the need for new guiding questions and more research emerges to consolidate the effectiveness of their solution.

Setting Up Implementation

Another important activity is to share the solution with the team's external stakeholder or CP and receive feedback from them on the feasibility. They may wish to receive informal feedback prior to a final presentation of their solution and will receive formal feedback from both CBL and subject-specific experts following their final presentation (see Chapter 3 for more details). It is important that teachers and CBL practitioners have determined at the outset of a challenge the level of involvement stakeholders should have and whether they will provide continuous feedback throughout the process or input primarily in the *Act* phase at the solution generation stage. Finally, teachers and CBL practitioners should provide guidance and mentoring to ensure that chosen solutions are thoughtful, concrete, clearly stated, and actionable in their implementation. For example, if we return one more time to the UiS example of the food waste challenge, potential solutions to some different challenges included:

- Replace disposable polystyrene food containers with cardboard alternatives.
- Increase awareness about the environmental impact of using disposable food containers and charge a fee for use.
- Create a reward system for using reusable hot drinks containers (discounts or free drinks).
- Create a compost garden on campus to show how food waste can be put to sustainable use.

In choosing one of these solutions, students had to explain the methods they would use to demonstrate the effectiveness of their solution returning to the core principles of a CBL challenge being actionable and measurable. Solutions may vary from a product to a short report or presentation, but part of the implementation process requires sharing findings with external stakeholders/CPs. Solutions should be evidence-based and assessed by an 'authentic' (real-life) audience. When this is in the form of a short presentation, as mentioned above, teachers and CBL practitioners can invite external stakeholders/CPs to provide in-person feedback. Teams should also be encouraged to give peer-to-peer feedback (see Chapter 3 for more details). Students create, organise, and execute a final 'pitch' type presentation, and they gain many useful skills including how to do public talk, manage time, and communicate subject-specific materials in an accessible and engaging manner. Finally, where appropriate, students should also be encouraged to share their findings more widely such as on their university websites or blogs or other open-source platforms. Disseminating their work to both local and wider audiences will help them feel motivated, recognised, and empowered (Loohuis & Chapel, 2021).

Sharing Evaluation

The *Act* phase should conclude with an evaluation of the CBL learning process and a reflection on their overall experiences of both working on their specific challenge and with CBL more broadly. Teachers and CBL practitioners should ensure that time is given for both individual, team, and whole class reflection, and in different forms such as through written reports or group discussions (see Chapter 3 for more details). Although reflection happens continuously throughout a CBL challenge, the end of the challenge provides the opportunity for students to share both their failures. This open approach to learning engenders a more inclusive learning environment, benefiting future learners' experiences. It promotes transparency, collaboration, and continuous improvement within the learning community (Apple, 2010; Nichols et al., 2016).

Below are reflections on the *Act* phase and the role of using new tools in testing the feasibility of solution implementation.

> If a student is very invested in finding a potential solution, CBL is highly motivating and engaging. It also allows enables students to learn about a

> variety of new tools and technologies almost in the background while they work on the challenge itself.—Dublin City - University teacher

> In the Act phase we think about the reality and limitations of implementations. We think about whether they are feasible or not. The resources you have time, money, whatever it might be, may not be feasible. It gave me a holistic and realistic view of what is possible in the real world and whether it can be implemented.—University of Stavanger - Student

We would like to encourage you to read the following resources about the CBL framework and its application:

- Implementing Challenge-Based Learning for University Teachers—The CBL landscape (Ambrosi & Hermsen, 2023).
- Challenge-Based Learning—A Comprehensive Survey of the Literature (Perna et al., 2023).
- Challenge-Based Learner User Guide (Nichols et al., 2016).

Exploring Learning Outcomes in Challenge-Based Learning: A Focus on Engagement, Motivation, Communication, Collaboration, and Teamwork

As this book argues, by using CBL, teachers and practitioners can create greater engagement opportunities for students to identify and suggest solutions to real-world problems through collaboration, inquiry, and action. This approach shows positive effects on students and teachers alike (López-Fernández et al., 2020a). Besides increasing student motivation, CBL influences learning outcomes and multidisciplinary teamwork, as illustrated by a research paper examining collaboration between applied physics (AP) and engineering (ME) students (Mesutoglu et al., 2022). Although barriers to collaboration were encountered, results showed the teamwork's benefits for student learning. AP students appeared to gain more knowledge, which indicated the potential of CBL to improve specific disciplinary insights. The paper also highlights challenges faced by multidisciplinary teams, which emphasise the role of team composition and disciplinary connections. The researchers suggest establishing a stronger link to AP concepts for improved collaboration and organising a balanced distribution of AP and ME students within teams. They also suggest that the challenges are to be adjusted and solutions need to be guided to support interdependence among students. They also emphasise that different disciplinary ways of thinking as facilitators need to be recognised in multidisciplinary collaboration. This way, each participating discipline can provide diverse perspectives during teamwork, which in turn influences the process of learning positively. The authors suggest in particular that:

- multidisciplinary teamwork enriches disciplinary practices,
- students can benefit from both diverse perspectives and interdisciplinary knowledge,
- communication across disciplines can be improved through tutor support, team presentations, and online interactions,
- coaching for problem identification needs to be allocated longer time for an optimal CBL experience.

In Chapter 1, we explored the benefits of CBL that were evidenced in research that described its first implementation in pilot studies focused on pre-higher education settings in the USA. Since those pilots were conducted, CBL has been implemented in various contexts both globally and within European higher education. The research conducted to date has highlighted many ways in which CBL affects both students and teachers as well as other stakeholders. The dimensions of impact we will explore in this section include student engagement, motivation, communication, collaboration, and teamwork and finally miscellaneous dimensions. It is important to set these out as they will be exemplified in the case studies in part two of this book which will also provide new research findings and the two will be synthesised and discussed in Chapter 8.

Student Engagement

The impact of CBL on students' engagement is a crucial dimension contributing significantly to the overall success of a CBL implementation. Research findings from various studies highlight the multi-faceted nature of engagement, including behavioural, emotional, and cognitive aspects (Fredricks et al., 2004). Yoorubsuk and Maneewan (2022) and

Chanin et al. (2018) emphasise that students tend to learn in an increasingly engage manner when they are required to integrate their experiences and personal circumstances into the learning process. CBL is addressed as an effective practical approach, as it not only encourages integration but also keeps students motivated to find answers and develop alternative solutions, which makes the learning process enjoyable and less tedious (Chanin et al., 2018; Yoorubsuk & Maneewan, 2022).

CBL is identified as a potential tool to enhance students' behavioural engagement, which is positively associated with other performance and learning outcomes (Simón-Chico et al., 2023; Skinner et al., 2008). More recently, Simón-Chico et al. (2023) found that CBL promoted students' behavioural engagement, which involves deeper engagement in listening, putting more effort into the process of learning, persevering, and participating in class activities. These processes are identified as significant predictors of student performance and learning achievement as a result of increased behavioural engagement (Reeve et al., 2004). Moreover, Ojasalo and Kaartti (2021) and Gallagher and Savage (2020) suggest that providing choice and promoting active participation among students in CBL experiences can positively influence students' engagement.

Teachers can provide choices, manage cognitive load, provoke curiosity, set appropriate challenges, clarify paths towards goal achievement, provide structure, foster a deeper understanding, enable accurate self-reflection, and offer hands-on practice for skill development. Furthermore, appreciating and encouraging students' input and initiative can create a positive feedback loop, leading to increased student engagement (Reeve et al., 2004; Simón-Chico et al., 2023; Skinner et al., 2008). However, it is also important to note that Simón-Chico et al (2023) underline certain features of the CBL approach, such as rigidly designed challenges and excessive graphical support, which may hinder agentic engagement by limiting students' autonomy and discouraging them from seeking additional help.

Motivation and Student Learning Experiences

The impact of CBL on motivation has been theoretically supported with reference to Self-determination theory (Ryan, 1995). This theory highlights these three basic needs—autonomy, relatedness, and competence—as key to motivation in learning environments (Ryan, 1995). Bombaerts et al. (2021) describe how motivation is facilitated through the pedagogical approach established by CBL. First, engaging students in real-life challenges promotes autonomy especially when students enjoy the freedom in decision making and choice of activities. Secondly, the connection with external stakeholders in CBL enhances relevance to industry by providing students with a sense of belonging and connection. Thirdly, by identifying and solving complex challenges, students develop their competence in learning and boost their confidence in completing tasks. Therefore, the influence of student engagement in CBL on their motivation is corroborated by Self-determination theory by linking the three main needs in human learning. Similarly, Padua (2020) argues that CBL has positively affected students' motivational regulations by enhancing their Basic Psychological Needs satisfaction.

There are several studies that provide evidence of how student motivation is increased through CBL. For example, López-Fernández et al. (2020b) explored the motivational orientations of master's students from ETSIAE, UPM who participated in the 2018 ESA Concurrent Engineering Challenge. The study focused on the preliminary design of a space mission using the OCDT tool developed by ESA. The authors found that CBL not only improved both intrinsic and extrinsic student motivation but also fostered the relationship between teachers and students. Swiden (2013) reported that CBL increased the participating students' engagement, facilitated their caring attitude, and enriched their learning experiences.

Furthermore, Simón-Chico et al. (2023) revealed that CBL enhanced student performance, learning achievement, and behavioural engagement, characterised by factors such as listening, striving, persistence, and participation in class activities. Supporting this, López-Fernández et al. (2020a) found that students appreciated their teachers more after participating in the challenge and developed a more collaborative and effective relationship with them. Swiden (2013) concurred with this finding, reporting that students who engaged in CBL felt more engaged with the content and more concerned about their performance in class. This is in line with the notion that active and collaborative learning methods, like CBL, result in more meaningful learning experiences**.** Teaching methods influence student motivation and CBL provides such a method by facilitating an active, collaborative, and hands-on engagement in real-work challenges in the workplaces (Swiden, 2013), while Simón-Chico et al. (2023) also emphasised the role of needs-supportive teaching in facilitating behavioural engagement, which was offered by the learning experiences during the CBL.

Table 2.1 demonstrates more specific research results that provide further evidence for how CBL could be a source of motivation and support learning experiences.

Experimental research conducted by O'Mahony et al. (2012) reveals that challenge-based instruction fosters greater interaction and knowledge sharing compared to traditional lecture-based instruction. Moreover,

Table 2.1 Impact of CBL research on motivation and engagement

References	*Description*	*Impact*
López-Fernández et al. (2020a)	CBL increases student motivation, enhances the teacher–student relationship and the overall learning process	Establishing teacher–student relationship and motivation
Wang and D'Cruze (2022)	CBL increases student participation and performance	Enhancing students' motivation and interest
Ruiz and Wever (2024)	CBL promotes the development of generic competences, teamwork skills, and problem-solving abilities	Leading to increased motivation among learners
Franco et al. (2023) and Montés et al. (2023)	CBL provides students with opportunities to interact, experiment, and apply theoretical knowledge in practical settings	Enhancing their motivation levels
Simón-Chico et al. (2023)	CBL affects basic psychological needs of students, engagement, and motivational regulations	Achieving adaptive motivational, and learning outcomes
Romero-Yesa (2023)	CBL focuses on sustainable development goals and can raise awareness and motivate students	Enhancing motivation through engagement with complex tasks
Padua (2020)	CBL provides opportunities for students to interact, collaborate, and choose tasks autonomously	Supporting the fulfilment of basic psychological needs
Bombaerts et al. (2021) and Martin et al. (2019)	CBL was more effective than the detached format in meeting educational goals	Addressing students' needs, motivation, and communication skills

the CBL group performed better in post-test items requiring integration and synthesis, showing the effectiveness of CBL in fostering deeper understanding and knowledge application.

In Table 2.1, we present an overview of the multiple ways that CBL affects student motivation and engagement in different educational contexts. For example, Simón-Chico et al. (2023) found no discernible changes in the dynamics of motivation, in contrast to López-Fernández et al. (2020a, 2020b) and Bombaerts et al. (2021) who indicate beneficial effects on motivation and communication. This difference shows that the way CBL is implemented and the specific situation in which it is employed can affect motivation. It also implies that although CBL can improve particular learning objectives and skills, its impact on motivation can differ. For example, increased participation in CBL in the context of physical education may not influence motivation as suggested by Simón-Chico et al. (2023). However, Franco et al. (2023) and Padua (2020) emphasise that CBL could influence internal motivators and instructional autonomy.

This overview highlights the applicability and effectiveness of CBL in boosting both the motivational and competency components of CBL by capturing its unique methodology, field-specific implementations, and impact dimensions across several educational disciplines.

Communication, Collaboration, and Teamwork

Team communication refers to how students adjust their communication strategies in response to CBL. CBL has a significant impact on communication and collaboration skills among students. Communication is a critical dimension of CBL, which impacts student learning outcomes and overall group effectiveness. The effective exchange of ideas and information within a CBL project team is crucial for learning outcomes, benefiting both high and low achievers. Gudonienė et al. (2021) highlight that CBL projects offer students an opportunity to practice communication strategies essential for effective group collaboration. The experiences gained in a CBL setting can prove instrumental as students prepare to work as professionals in diverse healthcare environments in the future. Early exposure to situations enhancing communication and collaboration skills can facilitate a smoother transition for students into their respective workplaces (Roehl et al., 2013).

To address challenges related to communication in CBL, recommendations include thorough orientation by the course coordinator at the beginning of a CBL course. This orientation should include sharing clearly defined purposes and expectations for each phase of the CBL process. This might help alleviate potential student frustration with this learning approach. Furthermore, Harris and Kloubec (2014) suggest that, before the initial CBL tutorial, tutors should provide training to students on effective group work, covering aspects such as role assignment, communication strategies, and conflict management.

Table 2.2 shows more specific evidence of impact on communication, collaboration, and teamwork.

Communication during CBL can also facilitate metacognitive development and the success in the application of theoretical knowledge in practical scenarios. Beyond enhancing communication skills, CBL contributes to students' overall cognitive growth and their ability to apply theoretical concepts in real-world situations. Practical experiences gained through CBL projects not only improve communication strategies but also prepare students for the collaborative demands of their future professional roles. Therefore, as teachers implement CBL, they need to pay attention to supporting the development of communication skills. This could be facilitated by providing orientation training to ensure a positive and productive learning experience for students (Gudonienė et al., 2021; Harris & Kloubec, 2014; Roehl et al., 2013).

With regard to teamwork, Mesutoglu et al. stress the dynamics of teamwork and investigate how CBL promotes multidisciplinary collaboration. In CBL context, the unique viewpoints and problem-solving strategies of students studying mechanical engineering and applied physics foster multidisciplinary teamwork. For example, Vilalta-Perdomo et al. (2022) and Lara-Prieto and Flores-Garza (2022) found that CBL significantly improves certain technical skills, like those pertaining to Industry 4.0 and IT innovation. Meanwhile, Doulougeri et al. (2021) emphasises technical learning but goes beyond it to include ethical reasoning, demonstrating how CBL not only fosters a deeper understanding of ethical issues in engineering practices but also improves practical engineering skills. When compared to the unattached format, CBL worked better at accomplishing most of the course's learning goals. This approach improved the students' fundamental needs and communication abilities in addition to supporting the instructors' educational and research objectives.

Table 2.2 Evidence of impact on communication, collaboration, and teamwork

References	*Description*	*Impact*
Tang and Chow (2021)	Participants modified communication and division of work as compared to a conventional project	Leading to greater learning of communication strategies
Yang et al. (2018)	CBL enabled students to communicate effectively within teams	Adapting team-based strategies
Bombaerts et al. (2021)	CBL supported teaching while fulfilling the students' basic needs	Enhancing communication and cultivating collaboration
Portuguez Castro and Gomez Zermeno (2020), Valentijn et al. (2023), and Vilalta-Perdomo et al. (2022)	CBL influences the communication and collaboration skills significantly	Leading to more engagement
Lara-Prieto and Flores-Garza (2022)	CBL fosters teamwork, communication, critical thinking, and creative problem-solving skills	Increasing engagement
Valentijn et al. (2023), Vilalta-Perdomo et al. (2022)	CBL enhances academic skills and cultivates a mindset that values communication and teamwork	Cultivating growth mindset
Mesutoglu et al. (2022)	CBL influences multidisciplinary teamwork and collaboration of students	Providing disciplinary perspectives to the challenge influence multidisciplinary teamwork
Keenahan and McCrum (2021)	CBL helps students enhance comprehension during team collaboration	Predicting learning as a significant factor

Portuguez Castro and Gómez Zermeño (2020) and Tang and Chow (2021) investigate the wider educational effects of CBL, including better communication skills as well as ethical reasoning. These studies emphasise the value of CBL in advancing critical thinking and teamwork, which are important in the contexts of healthcare and sustainability where knowledge of complex societal issues is essential. Mesutoglu et al. (2022) offer how CBL enhances communication and teamwork abilities in a multidisciplinary context. The emphasis is on productive collaboration between distinct academic teams, highlighting the potential of CBL to improve teamwork among a range of specialties.

Further to the dimensions explored in the previous sections, there are additional, miscellaneous dimensions of the impact of CBL on students as demonstrated in Table 2.3.

We see distinct results and applications when we compare the impact of CBL across different articles in Table 2.3. This reflects that there are different ways that CBL is adapted to different educational situations.

Table 2.3 Miscellaneous dimensions of the impact of CBL

References	*Description*	*Impact*
Horikoshi (2023)	CBL should be integrated and considered integrated with a positive education	Wellbeing and learning outcomes, aligning with positive education's impact
Helker et al. (2024)	CBL fosters engagement, ability to ask guiding questions, and promote self-directed learning	Developing transdisciplinary disciplinary and skills
Colombari et al. (2021)	CBL improved student engagement in theoretical learning during the pandemic	Informal interaction, asynchronous lecturing and time for exploration
Morselli and Orzes (2023)	CBL helps students develop collaborative skills	Supporting teamwork in the context of heterogeneous groups
Md. Khambari (2019)	CBL equips learners with skills that are beyond targeted in the course outcome	Innovativeness, building character, and encouraging teamwork
Ma (2023)	CBL develops competencies in sustainability in fashion design	Promoting creative and problem-solving skills
Hendrickx et al. (2023)	CBL granted students a sense of ownership	Developing knowledge in collaboration
Yoorubsuk and Maneewan (2022)	CBL fosters an environment where students engage in independent research to solve real-world problems	Creatively, promoting digital citizenship, problem-solving skills, and digital media creation
Christensen et al. (2021)	CBL promotes academic interdisciplinary capacity and ethos	Sustainable learning processes in collaborative and critical approach

For instance, Hendrickx et al. (2023) investigated CBL in a mechanical engineering course and finds that CBL had no appreciable positive effects on student ownership or autonomy. With an emphasis on physics and engineering students, Simon-Chico et al. (2023) notes that CBL improves relatedness pleasure, autonomy, and competence but does not significantly alter motivational rules.

Horikoshi (2023) examines the relationship between CBL and the good effects of education on wellbeing, indicating that there may be room for improvement in wellbeing but urging further empirical study. In the investigation of the effectiveness of CBL in an online environment, Colombari et al. (2021) find that appropriate challenges and unstructured interaction are essential components of successful learning outcomes. Simon-Chico (2023) and Colombari et al. (2021) reveal more conclusive benefits of CBL, such as increased learning outcomes and engagement, respectively. Hendrickx et al. (2023), in contrast, shows no benefits, emphasising that the efficiency of CBL can vary significantly depending on how it is applied.

In conclusion, these results show that although CBL has the potential for use in a range of educational contexts, it holds promise for several positive aspects such as engaging students in learning, enacting self-directed learning, motivating students to take agency and participate in teamwork and meaningful collaboration.

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CHAPTER 3

CBL Assessment, Feedback, and Evaluation

The Role of Assessment in CBL

Assessment is a key part of CBL to measure the extent to which the learners have achieved the learning outcomes that were set at the outset of a challenge. In CBL unlike traditional learning, the learners themselves can help define their learning outcomes in collaboration with the teacher(s) and peers (Vreman de Olde et al., 2021). In addition, CBL does not just focus on developing technical or academic skills to achieve a defined learning outcome but also has a strong focus on the personal learning development of individual students to realise social competencies (Perna et al., 2023). These include assessing the critical thinking, problem-solving, and collaboration and communication skills they have acquired in the context of authentic, real-world challenges. Outlining the principles for a model of self- and peer assessment known as authentic self and peer learning, Kearney and Perkins (2014) write:

> The idea of authentic and sustainable assessment is one that focusses on assessment tasks that have applicability to the world outside the classroom, and that foster autonomous learning.

This also applies to CBL, where tasks are replicated that have applicability, and require skills and competences for the 'world outside the classroom' (Nichols et al., 2016). Different forms of assessment should be distributed throughout the CBL process and not only provide feedback

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https://doi.org/10.1007/978-3-031-67011-4_3

on the final result at the end (Nichols et al., 2016). Assessment in CBL is both formal and informal, and formative and summative and so before exploring the different context in which assessment takes place (teacher, external stakeholder/challenge provider (CP), and self- and peer assessment), it is important to define the terms used throughout this chapter and in addition, provide practical examples for practitioners.

Types of Assessment

Informal Assessment

Informal assessment for practitioners can take place in different forms and at different points throughout a CBL implementation. Practical examples could include:

Teacher Observation

Teachers and/or CBL experts should observe students throughout their engagement in challenges, taking note of their teamwork and the demonstration of key skills detailed in this book. Observations help identify where specific support may be needed at both an individual and team level.

Reflection Journals

Students should be encouraged to use reflective practice throughout the CBL process. These are useful resources for students to draw on when completing formal assessments such as a final written report (see section below on formal assessment and summative assessment).

Classroom Discussions

Informal discussions are a good way to begin a challenge (see Chapter 2) and generate ideas as a whole group before dividing into smaller teams. They can also be used at each stage for the group to come together and discuss their progress and CBL experience up to that point.

Practice Presentations

Students can often be anxious at the prospect of presenting to their teacher(s), classmates, and in particular external stakeholders such as a

CP. Therefore, it is important that they can practice in an informal setting. This can be done with the teacher or CBL experts, student assistants, or as a peer-to-peer exercise with other teams.

Informal assessment in CBL is intended to gain a quick and general understanding of learners' knowledge, skills, and comprehension of the learning process. It is usually unstructured and ungraded and can be requested by the learners themselves at any point in the process to ensure they are on the right track as they move through the CBL phases. CBL is often new to students and initially confusing. They are often uncertain about its process of engagement and need to anchor themselves in the pedagogical scope through collaborative engagement, understanding of the team-based performance, and self-directed learning process. Therefore, it is important that practitioners provide immediate, timely, constructive, and continuous informal feedback from the very beginning of a challenge especially when students need more information than they could understand by themselves. Informal assessment that helps students move towards a viable solution should take place throughout the project (Nichols & Cator, 2008) in a continuous and iterative manner. Informal assessment activities are open and flexible and can be both agreed upon between the teacher and the CBL group throughout the learning process. They can be amended or added to at any point in the exploration and understanding of the challenge depending on the scope and extent of the feedback. So, since informal assessment is dependent on how students require feedback or how they identify the lack of knowledge or insights, it is regulated by them, and the teachers need to be available at those moments and deliver the feedback in the most convenient channel (online and/or face-to-face) and in the appropriate mode (written and/or verbal).

Formal Assessment

While informal assessment can provide nuanced help for the students about the challenge, formal assessments in CBL are structured, planned, and occur at specific points within the learning process (Nichols & Cator, 2008). Formal assessments in CBL provide a comprehensive evaluation of students' competencies, the impact of their solutions, and the overall effectiveness of the learning experience. They play a critical role in accountability, grading, and program evaluation. It is important to note that not all CBL experiences will have a formal assessment procedure in terms of the awarding of grades or credits such as the European Credit Transfer System (ECTS). This is particularly the case in extra-curricular challenges (see case studies in Chapter 6 for example) that are standalone and not anchored to existing bachelor's or master's programme. This does not mean, however, that there is no structure or quality in the assessment process which is still delivered by higher education professionals and experts in a field that the challenge is related to (such as a CP). Practical examples of formal assessment practices for practitioners take place at specific points in a CBL implementation and could include:

Written Assignments

Written assignments are set by the teacher, these can be at the end of each of the three phases, *Engage, Investigate, and Act* and after the challenge has been completed. A common assignment is a written report about the CBL process. This can be an individual or group assignment, if the latter is chosen, it is important to set clear instructions and expectations to ensure that all team members contribute equally to this task. If there has not been a positive collaboration in the CBL process between teammates, then this needs to be managed carefully (see section "The Role of Feedback in CBL" on feedback).

Formal Presentations

Students may be required to present their solutions or demonstrate their skills in front of the class, CBL experts, and external stakeholders/CPs. These often occur at the end of each of the three phases, and can be mixed with informal assessment, with the *Engage* and *Investigate* presentations being a 'work in progress' session to check students' understanding of the CBL process and their challenge and the *Act* presentation focusing on the team's solution(s) to the challenge. For formal presentations, it is important that the teacher sets clear requirements beforehand such as the time duration for each team's presentation (e.g., ten minutes presentation, five minutes for questions) and how strictly this will be enforced. It is also important to prepare students effectively for their audience (e.g., will they be just presenting to their teacher and classmates or to their CPs or other external stakeholders?).

External Assessment

In some cases, external experts or CPs may be involved in the formal assessment process. They bring additional perspectives and expertise, for example, on the feasibility of potential solutions in the final *Act* stage presentations.

Formative Assessment

Formative assessments in CBL can be both informal and formal but what defines formative assessments is that they occur continuously throughout the learning process. 'Formative assessments and evaluations must be oriented to develop, apply, and evaluate competencies aligned with the context of the challenge' (López-Guajardo et al., 2023). Formative assessments 'guide the decisions on the teaching strategy and the adjustments necessary to achieve the learning objectives, based on the progress and difficulties of the students during the learning process' (Membrillo-Hernández et al., 2021). Formative assessment in CBL shapes the process of students' development of new skills and competences by providing meaningful scaffold, promoting self-awareness, facilitating collaboration, and encouraging students to apply their skills and knowledge to real-world challenges in a particular work-related context (Apple, 2008). Formative assessments can be conducted by the teacher, by students, and by external stakeholders/CPs, which provide students with several opportunities to access content and context-related scaffolding that supports them in the process of learning through CBL. For example, students might provide practical insights into the nature of the thinking and creating solution, while teachers offer content-related feedback, and the CPs provide context-related nuances that support the process of learning when it is happening.

Summative Assessment

Summative assessments in CBL are made at the end of a specific learning period. The primary purpose of summative assessment is to gauge students' overall performance, measure their achievements against predefined standards, and determine the success of the learning outcomes. In CBL, summative assessment could be referred to as one where a challenge is addressed and concluded. Adapted to CBL, a summative assessment can be incorporated into the process of the completion and implementation of the solution (Nichols et al., 2016). Summative assessment is primarily

Table 3.1 Summary of assessment types

Formal • Structured, planned, and occur at specific points within the learning process • Incorporated the assessment of a learner's final grade/performance • Primarily conducted by teacher(s) but stakeholders can provide input	**Informal** • Occur continuously throughout the learning process • Open and flexible and can be agreed between teachers, learners, and other stakeholders • Can be conducted by multiple assessors
Formative • Occur continuously throughout the learning process and can be formal and informal • Guide the decisions on the teaching strategy • Can be conducted by multiple assessors	**Summative** • Made at the end of a specific learning period and usually formal • Assess students' overall performance • Primarily conducted by teacher(s) but stakeholders can provide input

conducted by the teacher(s), but they may consider assessment-related information from CPs such as their appraisal of the learner's final presentations. However, when summative assignment in CBL is aligned with already existing traditional learning assessment activities such the awards of grades, then practitioners need to plan carefully how to balance the traditional and CBL components (Table 3.1).

Assessment from Different Sources

Assessment can come from many different sources such as teacher assessment, self-assessment, peer-to-peer assessment, and assessment from external stakeholders (such as a CP). In the following sections, practical examples are provided on how each of these different groups can apply assessments to CBL.

Teacher Assessment in CBL

The primary source of assessment in CBL comes from the course teacher(s). In some contexts, the teacher is also a CBL expert (most common in extra-curricular CBL challenges) and in some cases, they have no prior experience of CBL and so will ask CBL experts to join to guide and assess the CBL parts of the course (see, for example, case study one and case study seven). Teacher assessment in CBL is essential to measure how effective their instruction to students has been during the learning process and upon completion of a challenge. Self-directed learning and taking responsibility for learning is an important part of CBL; therefore, self-assessment and peer-to-peer assessment are also key sources of assessments, which will also be included. See section "The Role of Feedback in CBL" to find out how this might work in practice.

Importance of Teacher Assessment in CBL
Tips for Effective Teacher Assessment:

Create Clear Learning Objectives and Outcomes

Teachers need to ask students to choose to develop a challenge that is actionable, feasible, measurable, and assessable, which can be aligned with the clearly and specifically formulated objectives and the expected achievable outcomes. Likewise, the learning objectives should be clear, specific, and measurable. 'To demonstrate evidence of collaborative teamwork, critical thinking and problem-solving' and 'to demonstrate an understanding of the content-specific knowledge of a course' could be good examples of such objectives.

Establish the Sequence and Type of Assessment Methods from the Outset

Teachers need to identify which methods will be used when and how they align with the CBL phases, for example, informal assessments could take place after the *Engage* and *Investigate* phases and formal assessments following the *Act* stage.

Combine Individual and Collective Assessments

Teachers need to diversify the mode of task assignments. At some points in the implementation, they can ask for individual work at another collective submissions to support the key nature of CBL where teamwork is important. Individuals can submit assignments for assessment based on their assigned roles that learners have clear expectations and can start to assign roles within their teams, while the collective assignment can be based on the CBL work process. This division of assessment is exemplified in case study twelve in part two of this book.

Agree with CP(s)' Level of Involvement in the Assessment Process

At the outset of an implementation, teachers need to agree with CPs about their commitment to and involvement in the assessment process. For example, they could be involved informally with assessment at the end of each CBL phase or more formally invited to an assessment panel for *Act* stage solution presentations.

Incorporate Formative Assessment

Teachers need to continuously check-in and assess learner progress and be flexible to adapt and amend teaching in response to the formative assessment from students and CPs alike.

Teacher assessment plays a key role in CBL since teachers can organise connected assessment practices involving multiple stakeholders including additional CBL experts and CPs. This not only provides a learner-centred assessment where students are assessed by different stakeholders and for different skills, but also requires teachers to align their assessment processes and activities with the learning objectives. For intra-curricular challenges, teachers ensure that the CBL projects align with the overall curriculum and learning goals, maintaining coherence and relevance in the learning process. This will help them develop more relevant assessment practices. Teachers can also collaborate with expert CBL trainers to develop a different process of assessment such as whether and how well the CBL goals are achieved. Teachers working with the CBL approach can also identify gaps as they conduct continuous, informal assessment when students engage in individual, and team-based learning activities and adapt their instruction to address the specific issues they observe, or they are asked to scaffold. Teachers' assessments are also important in that they can provide learning support by delivering constructive feedback which serves as a supportive resource, providing students with constructive suggestions for improvement.

External Stakeholder Assessment in CBL

Effective learning assessment with the context of CBL entails a deep collaboration and communication among teachers, students, and external stakeholders where they contribute to the assessment process in different capacities. CBL is often new to external stakeholders such as CPs as well as to students, so it is important for a CBL expert(s) to guide them through the process and agree on principles for continuous assessment. CBL can be seen as a 'bridge' between the classroom and the real world and external stakeholders play a crucial role in connecting students to real-world challenges and problems. Therefore, external stakeholders are well-placed to assess student progress in identifying and addressing the challenge and gauging the feasibility of their ideas and solutions. In some contexts, all students work with the same CP assigned to them by the teacher, while in others, CBL teams empower their own CPs by giving them greater autonomy and agency over the learning process from the outset. The case studies in part two provide real examples of different configurations of external stakeholder/CP involvement.

Importance of Stakeholder/CP Assessment in CBL

Stakeholders/CPs play a key role in observing and understanding the challenge and how students address the challenges, and they might have a deep understanding of the creativity and criticality as well as relevance of the solution to their own context. Therefore, we strongly recommend that stakeholders/CPs are to be involved in the assessment process and be key stakeholder and collaborator to the teachers. This is mainly because the suggested solutions to the challenge are potentially to be adopted and used by them and their assessment of the value and relevance might indicate students' performance which complements that of the teacher. The following list provides other perspectives of showing their importance in the assessment of student performance. Stakeholders/CPs:

- offer authentic, real-world challenges that are relevant and meaningful, aligning with current issues and needs which can be aligned with the university course content.
- give students an opportunity to apply their skills and knowledge in authentic settings, bridging the gap between theory and practice which can efficiently be established through teamwork.
- bring diverse perspectives and expertise, enriching the learning experience and broadening students' understanding of complex issues which may not be possible to problematise in the courses at university.
- Create partnerships and collaborations between educational institutions and the broader community, which can contribute to the sponsoring process of students into the industry and sector.

Tips for Effective External Stakeholder Assessment:

Create a Clear Partnership Agreement with Each CBL Team

Stakeholders/CPs should ensure a clear partnership agreement is in place with CBL teams outlining what is expected from each party, and at which points the stakeholder/CP will offer informal and formal assessment of the team's progress (in agreement with the teacher). This could even take the form of a written agreement.

Communicate Clearly

The agreement should also set out guidelines and channels so that students know from the start of the challenge the level of available support from the stakeholder/CP and the criteria in assessing their work.

Agree on Impact Assessment

Stakeholders/CPs can assess the impact of students' solutions for the challenge and evaluate the practicality and feasibility of proposed ideas. Clear rubrics for assessment should be agreed with the teacher (see section "The Role of Evaluation in CBL" on evaluation for more information).

Self-Assessment and Peer-to-Peer Assessment

Self-assessment and peer-to-peer assessment are not the primary sources of assessment but are perhaps the most important in terms of supporting the core CBL values of self-directed learning. It provides a space for informal assessment where learners can test their ideas and engage in creative and critical thinking without the pressure of an 'expert' in the form of the teacher, CBL expert, or external stakeholder/CP. Self-assessment is an important part of ensuring that learners are active participants in the learning process, that they develop metacognitive skills and a deeper understanding of their strengths and the areas for improvement in their work. Peer-to-peer assessment in CBL is another informal method of assessment that can be part of the formative assessment process and involves students appraising the work of their peers, providing feedback (see section "The Role of Feedback in CBL"), and collaborating to improve each other's solutions and ideas. Collaboration is a key part of CBL and of working within a team but also between teams and this process also develops learners' communication skills.

Benefits of Self-Assessment and Peer-to-Peer Assessment in CBL

Self-assessment can have many benefits for the learning process. One is that students can nurture their metacognition by thinking about how they learn and how their peers learn rather than only what, how much, and how well they have learnt (Medina et al., 2017; Papanthynou & Darra, 2019). Metacognitive processes can encourage students to reflect on their individual learning strategies, their strengths, and weaknesses (Winne & Hadwin, 2008). In the context of CBL, metacognitive awareness enhances students' ability to regulate their own learning and adapt to the challenge as it progresses. In addition, when students assess their own work, they take ownership of their learning experience, becoming more accountable for their progress and achieving learning outcomes. Peer-to-peer assessment also supports their ability to critically understand their performance from multiple perspectives since one of the core principles of CBL is its multidisciplinary. Peer-to-peer assessment exposes students to a wider range of diverse perspectives potentially from different disciplines, offering them insights and knowledge from their peers which they may not have been aware, or which can complement their own perspectives in different ways. Such an assessment can also provide an opportunity to learn collectively and collaboratively. Students learn from one another and can provide constructive feedback as part of the collaborative learning process.

Tips for practitioners to facilitate effective self-assessment:

- **Help** students reflect on their progress at each stage, so that they write informal journals or notes potentially in digital platforms.
- **Allow students to** set their own learning goals in addition to those set by the teacher and CP so that they have a sense of ownership of their learning. These should be realistic and manageable.
- **Model** good self-assessment techniques by demonstrating how they could better evaluate their own work and which tools they could use.
- **Show** students how to document and record all their work such as draft reports, presentations, sketches, or meeting notes which can help with formal assessments that are submitted for evaluation.

Tips for practitioners to facilitate effective peer-to-peer assessment:

- **Set** clear guidelines for peer-to-peer assessment to ensure that a constructive and respectful environment is created, and objectivity is maintained as far as possible.
- **Balance** anonymity in peer-to-peer assessment to ensure students are comfortable with providing negative opinions, though in a constructive manner.
- **Organise** multiple rounds of peer-to-peer assessment by rotating groups which can strengthen students' openness to multiple views and assessment aspects during the process.
- **Ensure** that peer-to-peer assessments have taken place, and the groups can reflect on their feedback exchange and identify overall issues to be addressed and improved.

Aligning CBL Assessment with Traditional Assessment Methods.
While there are many benefits to practitioners and learners from the CBL assessment methods as outlined in this section, aligning CBL with traditional assessment can present several difficulties and challenges for educators. This is a much greater issue in intra-curricular rather than extra-curricular contexts because their participation is mandatory rather than voluntary and contributes towards a learner's existing study programme. Practitioners therefore must think carefully as to the extent to which the CBL components of the assessment align with the traditional assessment when awarding grades and evaluating learning outcomes (see vignette at the end of this section). Below are some specific factors that practitioners may wish to consider:

1. Subjective Versus Objective Assessment Methods

Traditional assessment methods, depending on the subject in question, can often use objective methods of assessment such as standardised tests with quantifiable results (such as a correct score out of 100). However, CBL emphasises open-ended and complex problem-solving, which can be difficult to assess objectively. As discussed, it also encourages the use of self-reflective and metacognitive activities as part of assessment. Therefore, when grades are awarded, there is a high degree of subjectivity with a teacher making judgements on the effort and application of individual learners, looking at their engagement, participation, and teamwork. It is thus an evaluation of their whole learning process rather than focusing on a single summative assessment.

2. Focus on Process Versus Solutions

Although the final phase of CBL, *Act*, requires students to find innovative solutions to their challenges and may be where the majority of assessment tasks take place, this phase is not given a greater weighting than *Engage* or *Investigate*. CBL places emphasis on all parts of the learning process and the collaboration, and critical thinking involved in solving real-world challenges throughout. Traditional assessment, on the other hand, is focused on results and outcomes and the work prior to this is preparatory to this. This misalignment can make it challenging to appropriately assess and grade students' CBL efforts.

3. Focus on Competencies Versus Content

As previously discussed, CBL aims to develop a wide range of competences that students will use in real-world situations including problem-solving, communication, innovation, and critical thinking. Traditional assessment methods often focus on the acquisition of specific subject content knowledge. It is therefore easier to determine whether content knowledge acquisition has been acquired compared to the development of specific skills and competencies as nurtured throughout the engagement in CBL. The resulting competences are of course cultivated by the content knowledge acquisition in context as part of social learning experiences in CBL teams and communities. CBL does not directly focus on traditional learning approaches by repositioning students as active learners who seek and discover the targeted content knowledge in its context in collaboration with CPs.

4. Individual Versus Group Assessment

CBL is at its core a collective effort with teamwork, which is an essential component to the success of a CBL learning experience. While group work is not uncommon in traditional assessment, students are usually graded as individuals and are competing rather than collaborating with their peers for the best results. Working and being assessed as a group should in principle motivate students to support one another and take ownership of their collective failures and successes. However, it is sometimes the case that not all group members put in equal amounts of effort to their challenge (see dialogue example in this chapter) and so practitioners should carefully monitor team collaboration and take this into account if group assessment is part of a final evaluation. For example, while monitoring, they can take note of and acknowledge the individual efforts and contribution to the change identification, idea generation, and communication skills including feedback exchange and peer support that each is offering. Students' reflection on their collaboration in CBL is also another process that can be enacted through group discussions where they reassess their cooperation and the resulting performance and work. In this way, students can find opportunities to self-evaluate their working process within the process.

5. Time and Resource Constraints

As CBL involves working on real-world challenges with CPs, this can be very time-consuming in terms of establishing the stakeholder relationships, ensuring sufficient communication time with the CP, completing the investigation work, and even arranging physical meetings and visits. Again, this adds a great deal of subjectivity as some learners may put in many hours of work with their CP but with little fruitful output, whereas others may be fortunate and have a very efficient collaborative process. Therefore, we suggest that there is a time management protocol in place which students and teachers are aware of, and the distribution of responsibilities needs to be clearer to make sure resources are not wasted which includesres CPs' contribution, teachers' investment in designing, developing, and sustaining the CBL implementations.

6. Resistance to Change

Implementing CBL successfully requires engagement and commitment from all participants including teachers, students, and CPs. Aligning CBL with traditional assessment may be met with resistance from both teachers and students who are sceptical of its innovative and open-ended approach and may feel safer being anchored in traditional learning and assessment methods. This is where teachers should make best use of CBL experts who can support their integration of their existing course delivery, content, and assessment within CBL to ensure best alignment. Experts should introduce CBL in its full scale, emphasising what it entails and how it is to be implemented with a clear understanding of its:

- purpose
- procedures
- course design
- student roles and responsibilities
- potential assignments
- potential risks
- benefits
- assessment methods

This will help build trust between all parties involved in a CBL experience and facilitate a smooth implementation reducing the initially emerging resistance and turning it into an opportunity to learn in a different way. Negotiating the CBL-based course restructuring with students can also prevent all from facing negative consequences and boost maximum engagement. Any drop-out due to the misalignment between the students' expectations and what the teacher is implementing could lead to inequality in accessing opportunities. So, we need to make sure that the CBL and its corresponding requirement are best understood and accepted by the students in order not to create an environment and set of procedures that students do not want to participate.

Vignette Two

The short vignette below from an extensive interview with Associate Professor Lukasz Derdowski at the University of Stavanger gives an insight into how to use CBL experts in the assessment process, the value of their feedback, and the weighting of the CBL components of the course with the theoretical content and self-reflection:

The mandatory part of the course was that they had to deliver a short presentation in order to be allowed to take the final exam right. So that is the mandatory component and what we did was that the students presented at the end of each CBL stage and delivered a 5 to 10 minutes presentation What I really valued was the feedback that you (the CBL experts) delivered to the students. So that was an informal assessment in the way, and that *helped students to grow, to move forward with practice, with the next phases. So, we did not wait until the delivery of the final report, but they got feedback on the way and that was of great value I think to the students. To gain these learning possibilities from the experts who understand the dynamics of CBL. Then what we did, in the final exam, students were given a space for self-reflection and that was individual as well as the group self-reflection on the CBL practice. So, they could think about what worked, what did not work and reflect on the learning process itself, not only about the outcome. They also evaluated the process of learning themselves and that was of a great value for them.*

For the overall grade, I think it was 40% theory, 40% CBL, and 20% self-reflection Since my course is kind of based on a concept that is not well known and understood by the students, we needed to *grade* the theory at the level of understanding of theories, the understanding of models, frameworks, existing tools for evaluating corporate social responsibility in that context. So therefore 40% for that, then the CBL itself, which is a hands-on practice of applying corporate social responsibility. A topic in the context of either sustainability or the green transition. The CBL part was 40% because that is more kind of a practical dimension that shows and illustrates the students can use their theories in practice and then learn from that experience as well. And then the 20% for the self-reflection to see whether they actually learn from those experiences and reflect on them critically to see that that helps them to grow. It is a subjective approach that I took, which could be adapted in different courses.

I *grade*d the exams, but the CBL experts assessed as pedagogical experts. They could assess the performance of the students as well, the development of their capabilities. They provided their own evaluations, and we could also have the evaluation of the challenge provider, Overall assessment came from different sources, self-assessment, external stakeholder assessment, and so on. A combination of assessment throughout the process with the final assessment of the output to kind of balance and capture what is actually going on and which could also be informative to us, to teachers, to the educators. Because if we see that the students are struggling in some phases, we could help them to facilitate those challenges in one way or another."

For the full interview with Associate Professor Derdowski of his experiences of implementing CBL, see Chapter 9.

The Role of Feedback in CBL

In the previous section, it was important to set out the different forms of assessment and the methods and how these can vary depending on the source of the assessment. This section relating to feedback, which has already been discussed as part of informal and continuous assessment, will look closely at feedback between teachers and learners, between learners and learners, and between learners and stakeholders/ CPs giving example of feedback dialogues. Feedback is an essential part of the CBL learning process and is a continuous activity throughout rather than an addendum to the learning when a challenge has been completed. Feedback is 'one of the most influential means for students learning' (Hattie & Timperley, 2007; Wisniewski et al., 2019) and therefore it is essential that it is delivered in a constructive and helpful way.

Teacher and Learner Feedback

Feedback can be defined as 'providing information in learning, understanding, the achievement or the behaviour of the student in order to improve learning and motivation' (Voerman & Faber, 2020). As with assessment, the primary source of feedback is from teachers to learners. Learners will naturally look to their teacher to guide them through the CBL learning process and achieve their goals. Feedback is therefore an iterative process that evolves throughout a CBL challenge to meet learners' needs and from the outset, teachers should encourage learners to seek feedback whenever they require it. The feedback should be aligned with the learning objectives of the challenge and the learning outcomes for learners to help them stay on track and achieve the desired outcomes.

Effective teacher to learner feedback in CBL should be:

Timely

Providing feedback at timely intervals enables students to respond and adjust their challenge throughout the learning process.

Specific

Specific feedback addresses the strengths and weaknesses of the student's approach, allowing them to understand their progress and areas for improvement.

Constructive

Feedback should be delivered in a supportive and constructive manner, focusing on actionable steps rather than mere criticism.

Individualised

Each student is unique, and personalised feedback acknowledges their distinct learning styles, interests, and abilities.

In CBL, feedback should be a two-way process and it is important that teachers encourage learners to also provide them with continuous feedback to ensure a learner-centred environment. Continuous feedback also helps teachers to make necessary adjustments to the challenges and their instruction enhancing the overall learning process.

Benefits of Learner to Teacher Feedback:

Gaining Insights into Learners' Needs

Learners can provide insights into their learning preferences, their strengths and weaknesses, and the challenges they face allowing teachers to tailor their approach accordingly.

Reframing the Learning Process

By establishing a two-directional feedback loop, the traditional teacher–learner hierarchy is reformed to a more collaborative and equal learning process. This can contribute to the creation of an environment conducive to a mutual, non-judgemental, and constructive feedback exchange.

Identifying Areas of Improvement

Feedback helps teachers identify what needs to be further learnt, taught, and developed by also helping them adapt their teaching methods to fit the CBL process.

Empowering Teachers

Receiving feedback from learners empowers teachers to see students' learning experience from the students' perspective and design learning practices that accommodate their preferences to maximise their engagement and learning.

In the following dialogue, an example is given of a situation whereby learners have approached their teacher to ask for feedback on how to address the issue of group members not contributing sufficiently to their challenge, which has been adapted and anonymised from a real-life situation:

Teacher: How do you feel your challenge is progressing, are you encountering any specific difficulties?

Student 1: Two of our team members have not been contributing as much to the team which we feel is unfair as we are anxious this will reflect on our team's assessment.

Teacher: Thank you for sharing your concerns. Can you elaborate on how it affected your group's progress and give me some details of what happened?

Student 2: They have been missing meetings and not replying to our messages. It's created extra work for the three of us and we have had to make decisions about what to put into our presentations without them.

Teacher: I understand. Good teamworking is important for CBL and so I'm glad that you have raised this issue for me and made me aware of who has not been meeting their responsibilities. What do you think is the best way for us all to resolve this situation?

Student 3: Maybe we could set clear individual roles and responsibilities within the team. We can then message them again and say what we expect them to do for the remainder of the challenge and then if they don't do it at least at the end we can say we tried.

Teacher: That's a good idea and ensures everyone stays accountable for delivering a successful challenge. You are also showing leadership qualities by encouraging others to play their part in the team process. What else do you think you could do?

Student 1: Maybe we could say that you would like to observe our next meeting?

Teacher: Sure, I will do that and also be on hand to provide informal feedback.

Student 2: Yes, hopefully if they know you will be there, that will also make them come.

Teacher:	That's true, but we want people to participate because they want to rather than only because they know the teacher will be there.
Student 3:	What do we do if they still don't come or respond to their messages, can you contact them?
Teacher:	Yes. In the first instance it is important all groups can manage their cooperation and collaboration between themselves, but if it is really not working, I will step-in.
Student 1:	Thank you! And what about the grading process?
Teacher:	I will make a note of this conversation and hope that it can be resolved but of course my final assessment will take into account that the three of you have been proactive in trying to resolve this situation and have put in the majority of the work.

As the dialogue shows, the teacher offers timely feedback, checking in with the students as to the progress of their challenge. Once they have raised their issue, the teacher offers specific advice and constructive solutions without being critical of the students' peers. The teacher offers to observe the meeting as one of the tools they can use to deliver informal feedback. The teacher also recognises the students' concerns about their grading being affected by the issue and offers reassurance. By asking the students how they would like to resolve the situation rather than telling them what to do, they are empowered to take ownership of the situation. Finally, the students demonstrate an important metacognitive strategy for effective learning by looking forward as well as back at 'what task is next, how much time it is going to take and how to prioritise' (Voerman & Faber, 2020).

Learner-to-Learner Feedback

Learner-to-learner feedback is an integral component of good teamwork, collaboration, and communication in CBL. As discussed, learner-to-learner feedback to their peers on their progress, ideas, and solutions can form part of informal assessment. Learners can provide feedback both to their teammates and to other teams and should be encouraged to do so after informal presentations.

The benefits of learner-to-learner feedback include:

Offering Diverse Perspectives

Students bring their own unique perspectives and approaches to challenges, raising creativity and innovation. They can better relate to comments and feedback from a peer who might have a similar lens through which they seek knowledge and perceive their experiences.

Developing Communication Skills

Sharing and expressing constructive feedback also helps students develop effective communication skills. In this way, they learn to assess peers' work and performance by using non-judgemental language.

Promoting Reflection

Engaging in feedback helps students reflect on their own work by analysing others' projects and perspectives too. Reflectivity requires focused thinking on a specific aspect of the challenge and providing critical views and insights for improvement. It does not only require students to identify the weaknesses about the work but also to express how these weaknesses can be addressed. So, students will have an opportunity to think about how they can help others to improve their work, and this will have a boomerang effect on their own work.

Building a Community

The process of giving and receiving feedback promotes a supportive and collaborative learning community. Since CBL is a team-based collaborative learning process, it naturally forms a community where everyone is responsible for each other's learning and their collaborative ability will impact the depth and breadth of learning. Therefore, we need to underscore the importance and value of the working together in CBL. Students' learning to learn in communities is one of the 21st-century skills which all professional contexts are now designed and designated as.

In the second dialogue example, a student from one team is asking for feedback on their final CBL presentation from a student in a different team. Again, this has been adapted and anonymised from a real-life situation. As this is the presentation in which they present their solutions in the *Act* phase of CBL, it is important that they have shown how they worked in the *Engage* and *Investigate* phase before reaching their potential solution.

Student 1: Do you want to practice your presentation with me and then we can swap?

Student 2: Thanks! I'm a bit nervous about it, I am not sure we have included everything we need to or have explained everything clearly.

Student 1: Well, I am happy to give you some feedback! Have you thought about the structure of your presentation? Maybe we can think of ways to make it more engaging.

Student 2: Definitely, I'd appreciate that. I think we have covered all of the CBL phases, but I am not sure how I should start the presentation?

Student 1: You could start by introducing your team so that the audience know who is speaking, maybe use photos of each of you? Then for the next slide have your big idea and essential question?

Student 2: Maybe we could use photos of us working together or when we visited the challenge provider?

Student 1: Exactly. It's about telling a story from A to B, from where you started to how you came up with your solution.

Student 2: That makes sense. How many slides do you think we should use?

Student 1: That's up to you. We have decided to go for ten, roughly one for each minute of the presentation. In my opinion, less is more so that your audience are listening to you rather than focusing too much on the slides. Especially if there is lots of text, maybe try to have one idea and three bullet points on each slide? And photos always tell the story better than lots of text.

Student 1: Those are great tips thanks. How should we divide it amongst the CBL phases do you think?

Student 2: Again, it is up to you. You could have half for Engage and Investigate and half for Act if you want to spend more time showing the different solutions you came up with? But makes sure you tell the story of how you worked through these phases to get to your solution. And remember to include some of the tools you used in the CBL process like the six thinking hats, that is what we have done.

Student 1: Thanks! Can we have a practice run so that I can see how long it takes?
Student 2: Sure! Oh, and one last thing, think about how many of you are going to speak and how to makes sure you have smooth transitions between speakers. This is what we have been practising.
Student 1: Great, thanks so much for your feedback, it has been really helpful.

This dialogue demonstrates the value of learner-to-learner feedback with student 2 offering student 1 many constructive suggestions and tips communicated in a positive and friendly manner, offering their own perspective on how to present. By providing in-depth feedback, student 2 is also able to reflect on their own approach to structuring a presentation. Discussing how to ensure the presentation covers all of the CBL phases reinforces the knowledge that both students have gained from the CBL process and that they know how to correctly implement it (such as using CBL tools). Finally, by each taking in turns to give feedback and practice presentation skills, the students are creating a supportive learning environment.

Learner and Stakeholder/CP Feedback
In CBL, students have the unique opportunity to work with stakeholders/CPs who extend the learning and feedback process beyond the classroom. Stakeholders/CPs with their expertise in particular fields can offer students unique insights into real-world challenge and provide them with constructive and meaningful feedback throughout the CBL engagement process, on the feasibility of their solutions in the *Act* phase.

The benefits of stakeholder/CP to student feedback are:

Providing Clearly Phased Expectations

Stakeholders/CPs must communicate clear guidelines and expectations for the task to ensure students understand the objectives fully especially when they are developing the challenges and related suggestions for solutions. This ensures that students have a deeper understanding of the objectives of the tasks and fosters a more meaningful learning process. Clear and well-defined communication by stakeholders/CPs contributes to a more transparent learning environment, which enables students to approach challenges with a solid understanding of what is expected and discern what is not.

Establishing Real-World Work Relevance

Feedback provided by stakeholders/CPs helps students understand how their learning connects to real-world scenarios, making the learning experience more meaningful and applicable in professional contexts. Their feedback can help students understand the relational connection between academic and practical knowledge.

Maintaining Motivation Through Encouragement and Recognition

Continuous positive feedback and support from stakeholders/CPs function as powerful motivators for students. Consistent encouragement and a sense of shared endeavour between student and their CP can be strong motivational factors.

Students providing feedback to stakeholders/CPs in CBL offer several valuable benefits for both parties:

Enhanced Engagement

Student involvement in delivering feedback to stakeholders/CPs increases their engagement and investment in learning and gives them skills in how to deliver verbal or oral feedback, in some case to senior professionals.

Continuous Improvement

Delivering feedback within the context of CBL engagement improves learning experiences over time since students' comments reshape future challenges. Stakeholders/CPs can therefore look at the workplace problems from a different angle which they have not adopted before. This helps them engage in an ongoing refinement of issues that could help them increase the quality of the work they do.

Alignment with Workplace Expectations

Student feedback helps stakeholders/CPs revisit the contextual challenges and meet workplace expectations. While this gives students a more context-bound and purpose-driven learning experiences, it also helps closes the gap between university and industry by placing students as bridging individuals who work for relevance.

The case studies in part two provide practical examples of the relationships between learners and stakeholders/CPs, how each group managed their expectations of the role of the other, how feedback shaped their challenge, and what each group learned from working with the other.

The Role of Evaluation in CBL

Evaluation is an important part of the reflective learning process following a completed CBL implementation. As discussed in the assessment section, there is a higher degree of subjectivity in CBL than in traditional assessment and therefore it is important that practitioners manage expectations from learners from the outset as to how learning outcomes will be evaluated. Additionally, with the addition of CBL experts providing support and guidance, there may be multiple actors involved in evaluation (Membrillo Hernandez et al., 2022). Therefore, all stakeholders should be involved in reviewing the effectiveness of the learning experience, the relevance of solutions, and the impact on students' growth and development.

In addition, evaluation in CBL is not solely focused on assessing learning outcomes but also emphasises continuous improvement in the structure and support of an implementation. Therefore, teachers need to collect feedback from students, CBL experts, and stakeholders/CPs to identify areas for enhancement and refine their approach. The use of end of course surveys can be effective in identifying areas for continuous improvement for CBL practitioners. Through the incorporation of these evaluative findings into future iterations, CBL programs can continue to create transformative learning experiences that empower learners and support practitioners in their ongoing professional development.

An example survey for learners could be aligned to the CBL phases, for example,

Engage Phase:

1. **Defining the Challenge/Problem Engagement**
    - Sufficient opportunity for creative thinking about the challenge.

- Sufficient background information and context presented by the teacher, CBL expert, and stakeholders/CP(s).

2. **Stakeholder Identification**
   - Sufficient support for identifying key stakeholders and their role in the challenge (external and internal stakeholders).
   - Explanation of different stakeholder perspectives around the challenge.
3. **Essential Questions**
   - Sufficient support for how to write essential questions to identify gaps in understanding.
   - Sufficient support to develop essential questions into a single essential question and actionable challenge.

Investigate Phase:

1. **Effective Research**
   - Clear explanation of how to develop guiding questions to identify what research needs to be undertaken.
   - Clear explanation of different methods to gather information (quantitative, qualitative data, interviews, surveys, etc.).
2. **Problem Analysis**
   - Clear explanation of CBL tools such as the 'fishbone technique' to understand underlying causes of the challenge problem.
3. **Stakeholder Engagement**
   - Sufficient engagement with stakeholders throughout the *Investigate* phase.

Act Phase:

1. **Solution Generation**
   - Sufficient explanation of creative thinking CBL tools such as the 'six thinking hats' (see Chapter 2) to support prototyping solutions.

2. **Solution Feasibility**
    - Sufficient support for testing feasibility of solutions.
3. **Solution Implementation**
    - Sufficient preparation for final solution assessment (from teachers and CBL experts, stakeholders/CPs).
    - Sufficient support for solution implementation (where applicable).

For further practical examples of evaluation in CBL, see Chapter 9.

Vignette Three

This vignette authored by Ales Lisa and Petr Šauer presents a practical example of assessment and evaluation in two courses at Prague University of Economics and Business (PUEB).

Prague University of Economics and Business (PUEB) in the Czech Republic, has implemented CBL in two tourism study programs. The courses, namely (a) 'Sustainable Development and Tourism' and (b) 'Multi-criteria Assessment of Tourism Conditions - Field Research,' have effectively utilized the CBL approach since 2017, offering students an engaging and practical learning experience. The CBL approach adopted in these courses from the very beginning encourages students to actively participate in real-world challenges within the tourism industry. By immersing themselves in practical situations and addressing complex problems, students develop critical thinking, problem-solving, and collaboration skills, preparing them for the demands of the tourism sector.

A. Sustainable Development and Tourism (2CR 204) is a compulsory course offered within the undergraduate program of Tourism since 2017, specifically in the second semester of study. The course grants 5 ECTS credits (2.5 ECTS for the lectures and 2.5 ECTS for the research part of the course) and typically enrols approximately 50–80 students each year. About 3–4 seminar groups of 15–20 students are opened by the teacher and students register there. It comprises two hours of lectures, during which a teacher familiarizes students with important theories, hypotheses, and concepts in a 'standard' manner. The subsequent part of the course consists of a two-hour weekly seminar, led by professors and lecturers with practical experience in governmental, non-governmental, and business sectors.

The main objective of this course is to acquaint students with the fundamental principles, indicators, and practical implementation of sustainable development, with a special emphasis on its connection to the tourism industry. Notably, particular attention is given to the environmental aspect of sustainable development, along with its economic and political dimensions. In the seminar, students also become acquainted with essential field research methodologies.

Upon successful completion of the course, students should be capable of navigating the key contemporary challenges in sustainable development and comprehending the policy implications associated with them. They should possess a solid understanding of the fundamental theories and methodologies employed in sustainable development analyses. Additionally, they will enhance their skills in sourcing and utilizing relevant scholarly literature and applying basic field research methods. An integral aspect of the course entails students engaging in a practical challenge through their work on a seminar thesis, which is subsequently presented and defended. The development of this course component, including the modernization of the seminar and the creation of updated study materials, received support from a university educational grant in 2018.

B. Multi-criterial assessment of tourism conditions—Field research (2CR 420) is a mandatory course offered in the Tourism master's program since 2020. It consists of 4 hours of seminars per week and carries 6 ECTS credits. Approximately 15–25 students enrol in this course every semester.

This course primarily focuses on the practical application of multi-criteria analysis methods within the realm of assessing the quality of recreational conditions. After acquiring a foundational understanding of the theoretical and methodological background, students engage in field research. Students mostly work in a two-or three-member teams; very exceptionally only one student is working alone. The challenge topic they define themselves and then they work on developing relevant case studies. The formation of these teams is based on students' shared interests.

By the end of this course, students are expected to have a solid understanding of the theoretical foundations of multi-criteria analysis, specifically the weighted sum approach (WSA) method. They will also become familiar with selected methods of field research in the social sciences and enhance their teamwork skills within small student teams.

In both course students present their progress on the challenge development and project multiple times during seminars over the course of one semester (lasting 13 weeks) and are evaluated as part of their examination.

The feedback provided by the teacher and classmates is beneficial for both the presenting students and the other teams. These presentations serve as a way to assess their understanding, development, and implementation of challenge projects. The instructor or panel likely evaluates these presentations. This continuous assessment and feedback process throughout the seminars allows students to demonstrate their learning and engagement with the course material.

Specifically, students can earn a total of 100 points in the following manner (similarly in both cases): Each of the 3–4 interim presentations is assessed on a scale of 0–10 points, and the two highest-rated interim presentations are selected for the final evaluation. This allows students to explore multiple ideas and take risks without fear.

The final presentation, conducted in the classroom with teachers and students present, consists of approximately 12–15 minutes of speech followed by a discussion. It is evaluated based on content, form (visual presentation), the ability to engage the audience, and convey fundamental findings/results/ideas. The practical applicability of their proposals is also discussed and evaluated. This presentation is graded on a scale of 0–30 points. For the contents of the presentations see Table 3.2.

Another essential component of the assessed outputs is a written report (see Table 3.3) elaborated by the team, carrying a certain point value (0–40 points), and submitted through the university study system. This report is accessible only to the teacher to ensure confidentiality and fairness in the assessment process. The report is meticulously structured to reflect typical practices in organizations, where space for presenting results is often limited in both time and textual content. It showcases the students' research and analytical skills and provides a comprehensive overview of their work on the challenge projects.

The final component of the evaluation is an oral defence of the report and the entire challenge project in front of the teacher, graded on a scale of 0–10 points. This defence takes place individually, even for team projects, and

Table 3.2 Required contents of "step-by-step" presentations

Presentation No.	*Contents of the presentation*
1st	Topic and goals
2nd	Methodology
3rd	Weights of criteria
4th	Final presentation

Table 3.3 Suggested structure of the written report

1.	Topic and goal(s) of the analysis (50–250 words)
2.	Criteria
2.1	Description of the procedure, how the list of the criteria was created
2.2	List of criteria
3.	Making point scales
3.1	Description how this part of methodology was created
3.2	Point scales for the individual criteria
4.	Weights
4.1	Procedure description
4.2	Results and comparison of the three methods (Point scale, Fuller triangle, Saaty matrix)
5.	Description of the methodology application ("field work")
5.1	Evaluated units selection (10–50 words)
5.2	What were the data/information sources for evaluating the criteria
6.	The most important findings/results (50–500 words)
7.	Conclusion (50–100 words)
8.	Any relevant notes
9.	References (list of used literature in APA format)
Suggested attachments to the report (they could be in an electronic version):	
a. Full text of the most important papers/book chapters used for the work	
b. Printed-out interviews with "experts"	

involves discussing potential practical applications of the results, methods, communication with challenge providers and stakeholders, and possibilities for publication.

During this meeting with the teacher, there is also a personal discussion about the positives and negatives of the course. After the semester, the teacher compares the insights from these interviews with the results of the official survey conducted for all subjects taught at PUEB.

Challenge providers and other stakeholders do not participate in the presentations or defence due to technical reasons, as the work often originates from remote regions/locations.

If a student faces difficulties, they can be excused from the course without losing ECTS credits, supporting the freedom of creative expression and the acceptance of certain risks in choosing less traditional topics.

In conclusion, assessment, feedback, and evaluation are integral components of CBL. This chapter has provided practical examples of each of these components which we hope are valuable to current and future

CBL practitioners when planning and implementing CBL learning opportunities. The case studies in part two of this book provide real examples of the strategies teachers and CBL experts used for assessment, feedback, and evaluation in their individual contexts and Chapter 9 provides further in-depth, first-hand reflections from colleagues and students of their experiences of these facets of CBL.

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PART II

CBL Case Studies

CHAPTER 4

CBL Categorisation Through a Micro, Meso, Macro Framework

Why Did We Choose a Case Study Approach?

Case studies are a powerful means of uncovering contextual realities regarding experiences in particular settings. In part two of this book, we focus on real examples of CBL in educational contexts where it has been implemented, assessed, and developed as an innovative pedagogical approach. Our aim is to develop and document emerging practical knowledge which can contribute to the development of theoretical understanding in the field.

The case study approach allows for an in-depth examination of particular implementations of CBL, providing rich insights into complexities that are not visible through other methods (Yin, 2018). Each case study offers an analysis of CBL applications across different disciplines, academic contexts, and institutions, resulting in diverse perspectives on the developmental processes. This variety enhances the understanding of CBL and informs future implementations.

Moreover, case studies facilitate theory development by enabling researchers and practitioners to generate new theoretical and practical insights through systematic data analysis and comparison (Eisenhardt, 1989). They demonstrate how theoretical tenets of CBL are applied in practice, contributing to the creation of a grounded theory based on lived experiences in multiple contexts. This strengthens the triangulation and credibility of findings (Creswell, 2013). Additionally, case studies inspire

K. Dikilitaş et al., *A Practical Guide to Understanding and Implementing Challenge-Based Learning*,
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readers by highlighting unique details and offering transferable knowledge to their own contexts (Stake, 1995).

By including multiple case studies, we provide readers with resources to explore contextual challenges, achievements, and practices as they develop their own CBL implementations. These case studies add to the credibility of the knowledge generated and offer practitioners, students, industry stakeholders, and policymakers insights into how others planned, designed, and implemented their CBL practices. They serve as a source of inspiration and provide guidelines for overcoming challenges in specific contexts. Writing about CBL without these cases would result in an incomplete resource that lacks the voices and choices of CBL teachers, practitioners, and researchers.

Yin (2009) emphasises that the case study method helps practitioners understand real-life phenomena in depth, focusing on key contextual conditions. Case studies of CBL implementations promote critical reflection on the experiences of implementers and enhance readers' understanding of CBL practices. They demonstrate how CBL is applied in various courses and programmes, highlighting effective elements and necessary adaptations for emerging pedagogical needs. Additionally, they showcase how different stakeholders are involved in student learning through developing, addressing, and evaluating challenges, as well as building networks and cooperative learning patterns with different industries.

The symbiotic relationship between university and industry contexts is crucial, as each relies on the other to build relevance between knowledge acquisition and professional experiences. Case studies uncover challenge development and problem-solving processes in authentic settings, providing extensive, practical, and contextual knowledge for others to use. In the next section, we describe the overarching international setting in which CBL was implemented and the case studies were written.

CBL Implementation Within the ECIU Contexts

Through the ECIU organisation, we have a great depth of institutional knowledge related to the application of CBL in the ECIU member universities. As outlined in the introduction to this book, CBL is one of the pillars of the ECIU and is the learning approach used for all ECIU challenges. The ECIU context provides an international perspective in the implementation of CBL given that ECIU challenge teams are typically composed of students from different nationalities and backgrounds. Even in non-ECIU-hosted challenges within an ECIU partner university, such as Bachelor´s or Master´s courses, there is often a significant cohort of international students. This collection of case studies, therefore, includes institutional, cultural, national, and pedagogical perspectives in terms of diversity where inclusivity and equity are ensured. Contextual realities are richly depicted in case study, which reveals the uniqueness of each context. Nevertheless, there will also be thematic similarities which can be transferred by the readers, which can further enrich our understanding of CBL. This enables us to draw more implications for our own CBL practices. Learning about what happens in CBL contexts can best be through the voice of the authors who are also the teachers or practitioners of the CBL practice creates.

Inviting CBL Researchers to Contribute

Our book provides an opportunity for Europe-based CBL practitioners and researchers to publish their cases, including data. These case studies can also encourage them to do further research based on the challenges and questions they might have identified in their case studies.

Therefore, in early 2023, we put out a call to our ECIU colleagues, inviting expressions of interest to contribute to this book. We gave a broad outline of the desired content contributions to this book while giving colleagues as much flexibility and freedom as possible to independently develop their CBL case studies. We also encouraged contributors to collaborate with their colleagues in the development and writing of their case studies to include a wide range of perspectives. We asked for the case studies to be reflective and include the following information:

- Background and participants
- Details of the programme or practice of CBL used for
- Implementation of CBL (for each phase)
- Assessment and evaluation (details for grading student learning)
- Implications and benefits for students
- Implications and benefits for practitioners, teachers, and stakeholders
- Reflections on the implementers’ development

In terms of the design of the case studies, there is no fixed formal 'research design' as there are no research questions being explicitly addressed. The case studies are illustrative of the diversity in which the CBL framework can be implemented and provide a practical guide for teachers and practitioners seeking to implement CBL in similar context and stakeholders wishing to collaborate.

Furthermore, as set out in Chapter 1, the case studies in this book, which showcase in particular case studies from Sweden (3) and Norway (2) but also Germany, (1) Lithuania (1) and Ireland (1), provide a significant contribution to more under-represented geographies in CBL research. Three of the thirteen case studies are also co-authored between different universities (Norway and Sweden) (The Netherlands and Germany) (The Netherlands, Italy, and Norway) continuing the practice of collaboration through international co-authorship.

Classifying Case Studies

We have organised the case studies using a framework that comprises the micro, meso, and macro levels. This framework is commonly utilised in social science research as these levels are 'scales that can be mobilised in social analysis' (Serpa & Ferreira, 2019) and can be 'a useful way of studying the transition of a policy from a high-level idea to a program in action' (Caldwell & Mays, 2012). Our classification is shaped by the following layers of the units:

Chapter 5—Micro Level Frame

We categorised the case studies as micro level if they examine CBL within specific educational practices such as those within a particular academic discipline. This includes mainly the in-class CBL implementations where teachers and practitioners integrated CBL in their courses.

Chapter 6—Meso Level Frame

Case studies were categorised as meso level if they examine CBL outside specific educational contexts such as extra-curricular CBL implementation. For example, within a short, ECIU extra-curricular course driven by the needs of an external stakeholder or to assist staff working at University to tackle problems they face in their daily work.

Chapter 7—Macro Level Frame

Case studies that focus on systemic and institutional perspectives to examine global issues through CBL were categorised as macro level. These include examining long-term, multi-year CBL pathways within a university, CBL as a model for education across universities in the future and a tool to assist practitioners in assessing the level of CBL implementation required in their particular context.

In the following chapters, we present the cases studies by further explaining the specific features of the cases that are classified together. We believe this will help you understand more systematically the contextual realities, specific challenges, and the pedagogical characteristics of the learning that occur.

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CHAPTER 5

CBL Micro-Level Frame Case Studies

List of Case Studies in this Chapter

Case Study One—Implementing CBL within the Information Management and Digitalization course

Bjarte Ravndal, University of Stavanger
Masoumeh Shahverdi, University of Stavanger
Tim Marshall, University of Stavanger

Case Study Two—An inGenious way of learning

Charlotte Norrman, Linköping University,
Cia Lundvall, Linköping University,
Nelly Narges Karimi, University of Stavanger

Case Study Three—Challenge-based learning for sustainability education

Cecilia Enberg, Linköping University
Anders Jidesjö, Linköping University
Ola Leifler, Linköping University
Donatella Puglisi, Linköping University

K. Dikilitaş et al., *A Practical Guide to Understanding and Implementing Challenge-Based Learning*,
https://doi.org/10.1007/978-3-031-67011-4_5

Case Study Four—Using CBL in a master's multidisciplinary integrated project at the Universidad de Sevilla

Pedro Haro, Universidad de Sevilla
Javier González-Carbajal, Universidad de Sevilla
Rosario Chamorro-Moreno, Universidad de Sevilla
Esther Reina-Romo, Universidad de Sevilla
Bernabé Alonso-Fariñas, Universidad de Sevilla
Ignacio Alvarado-Aldea, Universidad de Sevilla

Case Study Five—Exploring and Implementing Challenge-Based Learning in Project Management and Organisation

Jeanette Engzell, Linköping University

Case Study One—Implementing CBL Within the Information Management and Digitalization Course

Bjarte Ravndal, University of Stavanger
Masoumeh Shahverdi, University of Stavanger
Tim Marshall, University of Stavanger

This case study focuses on one of the first intra-curricular implementations of CBL at the University of Stavanger (UiS) and how CBL practices have influenced both students and practitioners. We also highlight the student pedagogical challenges by providing first-hand, practical implications for those who are interested in developing CBL practices.

We first provide an example of the experiences of practitioners who collaborated during the implementation and describe the background on their respective roles and involvement in CBL with the master's level intra-curricular CBL-based course at the UiS entitled Information Management and Digitalization. We then detail the structure of this course within the CBL framework, the implementation of CBL practice, the learning experience for practitioners and students and future plans for greater use of CBL.

Background and Participants

On this course, Associate Professor Masoumeh Shahverdi, teamcher and CBL expert, Tim Marshall, teamcher assistant, and Professor Bjarte Ravndal, the course teacher, collaborated to implement a CBL approach in Bjarte's course as a joint pedagogical initiative. Two teaching assistants, Serenah and Tanzina.

Masoumeh has been implementing CBL with different tools and methods in various courses. She cooperates with students, assistants, organisations, and businesses to engage, investigate, and find innovative solutions for real-life challenges in line with the subject matter with real societal impact. Throughout these experiences, she became a learner and developed her teaching and training methods through familiarising herself with different educational contexts. She also developed her innovative skills in teaching and training methods including an efficient and effective educational framework.

Tim is a Research Assistant at the University of Stavanger who first became involved in CBL as a student himself, which gave him strong understanding of the process that students are going through as CBL participants He was therefore able to provide guidance on CBL based on his own experiences. Working on this course was of great benefit to his personal and professional development, which deepened his familiarisation with and understanding of CBL concepts such as collaboration, innovation, and teamwork as he became more involved in teaching through supporting CBL practice. He also found opportunities to learn more about different organisations and businesses within the local community and how students can engage with contemporary issues related to digitalization, which also became one of the key components on the integration of CBL in higher education.

Bjarte Ravndal is the course teacher working at UiS' Business School. He had full academic responsibility for the course, which included planning, teaching, supervising, grading, and setting up the team of supporting resources. With the introduction of the CBL method as the main teaching approach, he organised a supporting team with two teaching assistants, two teamchers, and two consultancy firms.

We as three practitioners worked together to redesign the course to implement CBL as by asking students and industry to identify 'Big Ideas' related to societal challenges, raise relevant critical questions, explore, and solve emerging challenges at stake. We negotiated how to design CBL for the course and determined the methods of the work and coursework requirement. Now we present the process of integration into the curriculum.

Course Overview

In this case study, we introduce you to the Information Management and Digitalization course referred to in the background section and contextualise it within UiS. It is a master's level course that is worth 10 ECTS (European Credit Transfer and Accumulation System), is taught in English, and is offered by the UiS Business School. Bjarte Ravndal coordinated the course requirements with Masoumeh as the CBL expert adviser. It does not require any prerequisite knowledge of technology, and it is a mandatory course for the major Leadership in a Digital Economy. It is also open for incoming exchange students and students from other majors of the MSc in Business Administration.

The course aims to provide an understanding of how firms and organisations need to adopt business practices to the ever-increasing digital economy. It has an overall management focus, and the topics, and themes that are covered are:

- Foundations to Information System (IS) Strategy and Strategizing
- Digital Transformation and Organisation
- Transformation Organising and Governing the IS Function
- Current and Emerging Challenges, including ethical challenges of digitalization.

Implementation

At the beginning of the course, teams were formed before the first meeting (see Chapter Two for a full description of team formation principles). The CBL approach encourages collaboration and teamwork and on this course, the students were asked to organise themselves into teams according to their specific interests to gain and develop a greater sense of ownership over their collaborative, challenge-based work. Following this, Bjarte Ravndal provided a foundation of theoretical knowledge and resources relevant to information management, digitalization, and other related concepts. The CBL expert then introduced and explained the three stages of CBL *Engage, Investigate,* and *Act* (See Chapter Two for a full overview of the three CBL stages). The duration of the first stage of CBL *Engage,* the second stage, *Investigate,* and the third stage, *Act* was one month, one and half months, and one month, respectively. To ensure that CBL had been implemented correctly and that each team was on track with their project, they had two presentations in each stage (in the middle and end of each stage).

Engage

In this first stage, *Engage,* the CBL experts guided students from the big idea of digitalization to an actionable challenge. First, the CBL expert provided an example case of how to write essential questions about a 'big idea' for example 'sustainability.' From the essential questions, they develop an actionable challenge. Each team was required to find their own 'Challenge Provider' (CP) to find an authentic, real-life challenge. Students could then apply their learnings from the examples that CBL expert provided to their own case. Table 5.1 details teams, challenges, and CPs.

Table 5.1 Challenges for each team in the information management and digitalization course

Team	*Challenges*	*Challenge provider '*
1	How to increase efficiency in the manufacturing processes	Aarbakke AS
2	How to increase companies' awareness of the strategic importance of digitalization and strategic IT management as a consultancy firm	Efab
3	How to optimise communication practices through digitalization to address the sudden changes due to the COVID-19 pandemic response	Stavanger Municipality
4	How to reduce the amount of food waste by using digitalization	Coop group
5	How to minimise food wastage efficiently with digital tools	IVAR
6	How to maintain employees job affiliation in home office (Digital transformation)	Bouvet
7	How to blockchain to track the carbon footprint when moving between the multiple layers from the producer and the consumer	Equinor
8	How to develop digital transformation strategies	UiS
9	How to increase the digitalization of services	SiS (student services)

At the end of this stage, Bjarte and Masoumeh asked students to present their essential questions and explain why they have chosen the final challenge. Bjarte, Masoumeh, and Tim then provided feedback to ensure they had understood this stage of CBL correctly.

Investigate

The *Investigate* stage can often be the most important and time-consuming part of a CBL project. To prepare students for this, Masoumeh practised with the students some examples of how to develop guiding questions, resources, and activities. She also provided systems thinking tools and problem-solving techniques for this stage such as the fishbone diagram which helps students create a diagram visualising the root causes of a problem by categorising relevant factors such as environmental, financial, regulatory, stakeholders, etc. These tools help students understand problems in a more holistic and in-depth way and enable them to structure their investigations. Students then developed their own guiding questions and resources to better understand their challenge. They also met key personnel from their CPs sometimes in person or remotely to conduct research and interview them to answer their guiding questions and help develop potential solutions for the Act stage. In the middle of this stage and at the end of this stage, Masoumeh asked students to present their progress, what challenges and issues they have identified so far, and what they were struggling with. This was to monitor both their progress with the challenge and their continuing engagement with the CBL process.

Act

In the *Act* stage, the Masoumeh provided students with tools and techniques to develop their potential solutions. This included the 'six thinking hats' technique which encourages each student to take a different role for developing solutions and help choose the best solution (see Chapter Two for more details). These roles can include thinking more innovatively, or more cautiously, in a more risk-averse manner or in a more bold and experimental way. This is a key part of CBL as it demonstrates how students do not have fixed roles and are able to change their roles to have different perspectives on their challenges. Students also worked closely with their CPs on developing their potential solutions to their challenges. The students presented in the middle and end of this stage and their nine potential solutions. Again, Masoumeh and Tim were looking to see evidence that the students had applied the tools we had taught them, and it was encouraging to see the use of the six thinking hats in some presentations, adapted to their own challenges. The CBL experts gave their final feedback on each team's potential solutions and their use of CBL throughout the challenge.

Monitoring Students' Progress and Providing Feedback

In addition to monitoring the students' progress during each CBL stage through their presentations, there were also weekly meetings where they could get specific feedback and advice from Bjarte, Masoumeh, and Tim, and teaching assistants who could provide more general feedback. Both the weekly meetings and presentation sessions were valuable for the CBL team as CBL practitioners as they could observe how students were adapting to this new learning model and could compare how CBL is used in different learning contexts. For example, in extra-curricular challenges, the participants usually focus on a single challenge which is given to them by the CBL expert and they work with a single CP. In this course the students developed their own challenges with the help of CP, and each worked with a different CP, so the process was more multi-faceted as it provided us with an opportunity to learn about many different organisations and how digitalization affects them.

Assessment (Process) and Evaluation (Product)

The course had a final individual take home exam, which was graded. The CBL project was a pass/fail requirement and was evaluated based on the presentations and a final report on their experience of using CBL. A central point in the literature presented by Bjarte was to discuss the various digitalization challenges that companies struggle with in their adaptation to an increasingly digital economy, and on the course, students used CBL to shape their projects as the main learning arena as discussed earlier. Therefore, students were asked to take a critical and academic reflection that combines these two approaches, and their task was to 'discuss the challenge from your CBL project with the support of academic literature.' They were instructed to include some recommendations on implementation of their team's solution, and if possible, reflect on the general advice they had received as well. This was an individual task with the expectation that it to build on the CBL report but could not just be a copy of it. Students are therefore part of evaluating their own experience with a new pedagogical model and encouraged to think about how the CBL learning approach compared and contrasted with the traditional learning approach.

Reflection

Students were also asked to add a one-page reflection note on the course. This did not influence the grading. As has been demonstrated, students were asked to focus on the challenge and dig even deeper. The whole idea is to combine the CBL approach with a standard academic discussion.

For the CBL report, this was based on students' group work in their teams and the report was to be structured to cover the three stages *Engage, Investigate* and *Act*. We recommend that students focus on the challenge, where the CBL process was an approach to help them deal with the challenge. They also need to present some evidence for the method they use referring to literature that facilitated the identification, understanding, and solving the challenge. Their assignments were graded based on the rubric in Table 5.2.

Lessons Learned: Students and Teacher Reflections

How Students Benefit from CBL

From our follow-up surveys of student experiences of this course and previous intra and extra-curricular challenges, students reported many benefits of having a CBL learning approach. First and foremost is the structure that CBL provides:

> CBL gave us an exact path and route to get to the point. We had a 'how to do' rather than a 'what to do.' This was the most significant part of our information management course.
> CBL helped us to understand the root of the problem and how we can come up with the best solution.
> The challenge was super good because in the team we chose the challenge.
> The teamwork and CBL really helped to guide us. It's a flexible methodology, like a road map or a guide but it does not say to you ok you need to do this or that.

There is also a strong sense of ownership and personal connection to the project:

Table 5.2 Grading schemata for the information and digitalization course

Grade description	*F*	*E*	*D*	*C*	*B*	*A*
Goals and fit to challenge	Goals and fit are not defined and/or unclear	Goals and fit are not clearly defined and/or not clear at all	Goals and fit are defined, but appear unclear	Goals and fit are generally defined well and clear	Goals and fit are clearly defined and easy to understand	Goals and fit are clearly defined and easy to understand
Insight into challenge and relevant theory	Has insufficient insight into the challenge and relevant theory	Has sufficient insight into the challenge and relevant theory	Displays satisfactory insight into the challenge and relevant theory	Displays good insight into the challenge and relevant theory	Displays very good insight into the challenge and relevant theory	Displays excellent insight into the challenge and relevant theory
Discussion and critical reflection	Does not show sufficient capacity for critical reflection of issues under consideration	Shows sufficient capacity for critical reflection of issues under consideration	Displays capacity for critical reflection of issues under consideration	Displays capacity for critical reflection of issues under consideration	Displays very good capacity for critical reflection of issues under consideration	Displays excellent capacity for critical reflection of issues under consideration

> I love that we can be passionate about the project and work on it and we really get the sense of, oh this is **my** project, I want to help **my** community, **my** surroundings and everything in that. I think that's what makes CBL, CBL and not like other blends of education.

On the Information and Management and Digitization course, students stated that a strong motivational factor was being given the independence to find their CPs by using their local knowledge and connections. This links to a broader benefit for students participating in CBL challenges of 'learning by doing' in terms of gaining real-world skills:

> We made a connection between our course and our materials with the CBL process and also with the real-world companies that we are working with on our challenges and the problems they're facing.
> It was a fantastic experience to meet other students and collaborate, and the potential solutions could be used as real business propositions or to generate ideas for start-up companies.

Finally, students emphasise the benefits of developing a peer-network through involvement in CBL challenges but also ensuring that challenges are relevant to their interests and educational and professional development:

> Students are motivated if the challenge is attractive in the sense that it solves a problem perceived as important for students. Word of mouth is important; students talk to each other.

> It's just really great to meet people from around the world. Different backgrounds, different experiences, different studies, different perspectives. So, you'll make friends and meet new people. Have fun and learn lots of new things. Learn how you are in this situation to learn how you react to pressure two different ways of learning with different ways of working and this really teaches you something about yourself and how you collaborate and work with people.

> Meeting other students and collaborating on a project can actually create a real business proposition for companies and you leave the challenge with all these connections and new knowledge to go and make a difference in the real world.

How Practitioners Benefit from CBL

The reflections below demonstrate that CBL was of great benefit to the practitioners as well as the students, transforming their approach to education, in enabling them to move beyond traditional didactic methods. Practitioners also benefited from mentoring the students and witnessing first-hand the energy and innovation students brought to their projects, improving their own communication and critical thinking skills in the process.

Masoumeh

> In most traditional education, the focus is on the learning recipe rather than a framework but if the concept becomes more complicated students are mostly not able to apply their knowledge that they have studied practically in a real-world problem. So, in order to develop a deeper knowledge of the subject that students are studying it is important for practitioners to build a framework to connect what students learn in the classroom to real-life challenges. CBL is a bridge between the classroom and businesses in order to making a real impact in the society. Students take ownership of all their learning process, and they learn from each other and their mistakes and, they experience unique and independence learning style. This learning style allows students to explore their own potential and get some transversal skills such as leadership, teamwork, critical thinking, communication, and collaboration skills.

Tim

> What I think is very good about CBL for practitioners is how it differentiates from more traditional models that are more didactic where the teacher has a hierarchical role, so they stand at the front of the classroom, and they just lecture, and the students do not get much of a chance to speak. In CBL it is much more of a flat structure, the teacher is part of the same collaborative team and that empowers the students to feel they have control over the project. It is amazing to be a part of it and feel the real energy and creativity in the rooms where the students are working and whenever we come back together as a group there is always such excitement, especially at the end of a project when everyone sees each other's presentations. As a practitioner, I gained the perspective of how teams are progressing and when to step in when I was needed with knowledge and guidance needed, but also to step back and observe the learning process.

Tanzina (Teaching Assistant)

We must make a connection between our course and our materials with the CBL process and also with the real-world companies that we are working with on the challenges or problems they're facing. We want to solve problems, so these things have to be connected and we as a teacher or as a teaching assistant and professors all are trying to connect these things with the students to make this an effective pedagogical model or this educational learning experience.

Serenah (Teaching Assistant)

It was an interesting journey to participate in. In the end when students could see that if they continue reading more and engaging more with their course material as well as the CBL process and to follow the guiding questions and guiding activities then they can come up with their own solutions. Of course, we could guide them to potential solutions but in the end the final decision about a solution is up to them e up with their own solutions.

Case Study Two—An InGenious Way of Learning

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Background and Participants

The roots of the inGenious course date back to 2013, when it for the first time was given at Linköping University (LiU) under the name "Demola - Cross-disciplinary project." The idea was taken from Tampere, and the first version of the course was developed in cooperation with Demola Global Oy and Tampere University. In 2016, it became clear that the LiU way of organising the course divided too much from the original Demola concept—hence LiU and Almi East Sweden AB chose to leave Demola.

Almi East Sweden AB, which is a subsidiary of Almi Företagspartner i Östergötland AB, a regional entrepreneurship support actor that provides advice and funding for SME firms in the region, is financed by public actors in Östergötland who want to support companies and promote a dynamic business climate in the region. The "mission" is to help companies and organisations to approach the university and to become more innovative and sustainable. It should be easy and free of charge for companies to collaborate with the university and get help with the challenges and problems they face. The inGenious course thus has a different concept and runs as a collaboration between Linköping University and Almi East Sweden AB and thus becomes a bridge between academia and business.

The course name changed to "inGenious cross-disciplinary project" in 2017. At the same time, we also managed to get the course accepted as a single subject course with one course code. Previously we had one course code per faculty, i.e., three course codes that were co-organised and treated as one in practice but with adjustments to the different faculty requirements.

LiU partnered with the ECIU universities of Stavanger and Twente in 2018. The inGenious concept that has since been gradually developed as part of the ECIU work and jointly by the universities of Linköping, Stavanger, and Twente. Since its start in 2012, the course adopted student-centred learning and the experiential learning approach which is described as Challenge-Based Learning (CBL) today (cf Norrman et al., 2022). In the beginning, however, the primary pedagogical approach was more similar to what is defined as project-based (PjBL), as described by Gunnarsson and Swartz (2021, 2022). As a result of the collaboration within ECIU, we became familiar with the concept of CBL and discovered that our way of doing the course also fit well in the scope of CBL. Since then, we have developed the course and are still working in line with the CBL pedagogy. Within the ECIU-related SMARTER project, the 2020 inGenious course was run as a CBL-pilot course within ECIU. Students from the Netherlands, Norway, and Sweden collaborated on a jointly developed challenge. Through all these activities and projects, we refined and developed our pedagogical approach into what is described below.

Today the course is manned and run by LiU and senior associate professor Charlotte Norrman, who was the course supervisor since 2016. Almi East Sweden AB offered the course with facilitators since the start, which has recently been offered by BSc Cia Axelsson Lundvall and Simon Boiertz.

Over the years, we at LiU have developed the inGenious course and a handful of other entrepreneurship courses where the main pedagogical approach has been transformed into CBL. During this development work, we have aimed to reflect over and spread our knowledge and learnings at conferences, such as the CDIO and RADMA conferences. Through cooperation in research and development projects such as the EU Scale up for Sustainability project, The EU SMARTER project, and the HEInnovate project BOOGIE-U project, we have had the opportunity to develop both theoretical and practical aspects further, which have resulted in some contributions to the area of CBL. References to our contributions are found in the references at the end of this chapter, and we also refer to the various papers along with where they are handled in the text.

First, through our work, we strived to develop our understanding of the concept of CBL further. Then, we reflected on our findings and tried to share them with others. Later, part of the authors, in a paper, proposed a definition of the concept of CBL, where we define CBL as being "an experiential learning approach that starts with wicked, open and sustainability-related real-life challenges that students, in cross-disciplinary teams, take on in their own way and develop into innovative and creative solutions that are presented in open forums." (Norrman et al., 2022, p. 762). We finally elaborated on the teacher role(s) in CBL courses since we found that this area was relatively underexplored. As coined within/by the consortium of ECIU, we call teachers engaged in CBL as *"teamchers"* due to the fact that running CBL courses necessitates roles beyond merely acting as a traditional teacher. According to the research findings (Eldebo et al., 2022) of part of the authors and our own practice, the CBL teamcher function can be said to include three main roles; firstly, the role of the organiser, which is challenge-oriented and includes the responsibility of finding challenging providers (CPs from here on) and together with them developing challenges. Secondly, the role of the academic teacher is oriented towards knowledge acquisition and assessment of the knowledge and skills attained—i.e., the traditional teacher role. The third role is the facilitating one, which is skills-oriented and held by the coach. These roles can, at least theoretically, be held by one single individual, but our experience shows that a multidisciplinary teamcher team solves the task better and more efficiently. Conceptually, we have defined a teamcher as "an individual that, either on its own or as a part of a team, arranges, leads, and supports CBL organiser of CBL activities" (Eldebo et al., 2022, p. 804).

The InGenious Course

The unique aspect of the inGenious course is that it is provided in cooperation between LiU and inGenious—Almi East Sweden AB. LiU is responsible for the formalities around the course and the scientific foundation. Almi East Sweden AB is mainly responsible for finding projects and CPs for the course and for the coaching of the student projects. However, as a team, we constantly work to find exciting new projects and ideas. Some of the companies and organisations that have served as challenge providers include Ericsson, Saab, FKP Scorpio, ABB, DreamHack, Ligna Energy, HiQ, Träullit, Finess Hygiene, Visual Sweden, Vreta Kluster, Civil Rights Defenders, Mjölby, Norrköping, and Linköping municipalities.

In Table 5.3, we have gathered some facts about the course:

The aim of the inGenious course is, according to its syllabus,[1] that the students, with the help of acquired knowledge and abilities, divided into cross-disciplinary teams, develop solutions to problems or challenges provided by external parties and are able to communicate the results achieved. Through the interdisciplinary project work, the students will develop skills, reflect, discuss, and grow as individuals. All projects in the course are in some way connected to the 17 global sustainability goals, Agenda 2030. During the course, the students will learn about sustainable development and responsible innovation.

The course goals can present individual and collective orientations, which complement one another from theoretical and practical perspectives. To help the students understand what to achieve to reach the grades—pass or pass with distinction, we are currently developing formative matrixes with detailed requirements for each goal. We realised that the assessment of skills poses challenges in innovation and entrepreneurship courses. To learn more, we explored the assessment processes within the above-mentioned HEInnovate BOOGIE-U project, and this has resulted in a couple of conference papers. Firstly, In Scroccaro et al. (2023), it was found (a) that skills and knowledge need to be assessed in a way that is clear, legally secure, and transparent for the students through formative matrixes, and (b) that self-directed learning is naturally inherent in CBL courses as they are student centred. Hence the learners need to take responsibility for their learning, and this process could be enhanced

[1] For course syllabus, see: https://studieinfo.liu.se/en/kurs/799G52#syllabus.

Table 5.3 Fact box-course details

Fact box—Course Details	
Course name, course code, and website	inGenious - cross-disciplinary project, code 799g52, https://studieinfo.liu.se/en/kurs/799G52#syllabus
Type and size	Single subject course, 8 ECTS
Dates given	August-December and January-May
Students	About 60 per year on average, but a maximum of 80 students per year
Requirements	All learners that have achieved 90 ECTS in whatever subject qualifies to the course. As the course is cross-disciplinary, we strive to attract students from all faculties and nationalities
Number of challenges	8–10 per year in average
Speed	25% and about 215 hours of study time
Assessment and grades	The assessment is both summative and formative and grades in case of Fail, Pass and Pass with distinction is given. Furthermore, for some parts of the course attendance is needed
Setup	The setup of the course is that students, who fulfil the requirements, apply for a challenge at the common inGenious web site; https://www.ingenious.nu They are then matched into cross-disciplinary teams based on their wish for challenge and their background. After getting a challenge they are accepted for the course
Rewards	The challenge providers are contracted and as part of this they get a first chance to buy back what the students have developed upon their challenge. The reward ranges between SEK 5000 and SEK 50.000. If the idea is not bought back, the students are free to pursue it on their own. About 25% of the ideas become acquired by the CPs. Terms are regulated in a formal contract

through reflective tools that enable them to evaluate their learnings and to reflect upon them.

Secondly, in Engzell et al. (2023), it was concluded that reflective tools such as the EntreComp framework seem to be beneficial for the students in their reflection work. This tool will therefore be implemented in the inGenious course from this autumn and onwards.

Implementation of CBL

Ahead of the course, CPs are committed, and the challenges—in the case of short briefs—are co-created by the teamchers and the CPs. The original challenge must come from the CP, who "owns the problem" and somehow needs help. Sometimes rewriting is needed to make the challenge more open, more understandable, or maybe more attractive to the students. The challenges are then announced at the website (www.ingenious.nu).

Fact box—A Challenge from Finess Hygiene AB (Autumn Semester 2020)

Finess Hygiene is a company owned by a Danish family since 1999. The location is in Kisa, Östergötland, and the production is focused on paper and plastic towards the home and healthcare sectors. We have a turnover of roughly 200 million SEK, and together with our sister company Abena AB, located in Växjö, we sell for around 500 million SEK. The Abena group total turnover is roughly 5 billion SEK. Finess produce and sells to Abena companies wherever they are as well as to export customers in countries other than Sweden. In Sweden, we also sell directly to the retail market.

Background

After many years with good profit, we have had two years with losses lately. The last 3 – 4 years have been challenging due to cheap and as we see it subsidised import from China mainly. Our main competitive edge is quality and environment, and we have worked hard to introduce environmentally friendly products on the market. We are ISO certified 9001 (quality), 14,001 (environment) and 13,485 (medical device). Together with two other companies, one in Sweden and one in Finland, we are now in the process of developing a 100% biobased and biodegradable air-laid nonwoven. We are using air-laid today as a raw material to produce some of our finished products, however then with binders that are not so good for nature.

Challenge
The products we have today with that type of raw material are mainly wipes and protective sheets. We would like to get ideas about what type of usage that could be for our new material in the home and healthcare sectors.

Result
The group that took on the challenge from Finess came up with lots of creative ideas but chose, in the end, a bag as their solution, a bag made by a new non-woven material that Finess hopefully will start producing. The bags were customized for packaging clothes but could also be reused as e.g., planting pots for gardening plants – a way for the consumer to upcycle what otherwise would have been a rest product. Another big contribution to the challenge provider was the sustainability analysis that the students provided along with their solution. The solution was bought back by Finesse, who highly appreciated what they got.

The inGenious course in Linköping starts with a kick-off, and at this event, the team members, who, ahead of the course start, brought together, were informed about their teams for the first time. The grouping was done by the personnel from AESAB and was based on the challenges the students expressed interest in participating in and on their educational background they had. Since we require 90 ECTS of previous studies in whatever subject(s), we strive to create teams that are as cross-disciplinary as possible. This implies that we also pay attention to nationality and gender. After introducing the course, the CPs provided the teams with further explanations regarding the contextual challenges, addressed questions, and scheduled the future meetings.

The first task for the students is, by use of a template, to create a so-called group contract, signed and submitted by the team members. After a couple of weeks, an event named "Shitty prototyping" (see Norrman et al., 2017, 2019) is run. Shitty prototyping is a serious play where the students, together with their CPs, create a hands-on prototype visualising the challenge using one or several possible solutions by use of crafts material and trash. The aim is to boost the group process and to create a joint cause for them to find out how to address the challenge (Photos 5.1, 5.2, and 5.3).

After that, the groups write and submit project plans describing their upcoming processes, which are then examined and graded. These are followed by oral presentations, so-called pitches, a lecture on pitching and pitch technique, along with several pitch training events, which form a vital part of the course. We use the Value Creation Forum (VCF) method that is developed by Stanford Research Institute, during our pitch training events, as a pedagogical model. VCF helps the students to give and take

Photo 5.1 Final presentation

Photo 5.2 Prototype

constructive feedback and to understand more easily what they and their project group need to improve in their pitch but also in the project itself. The first pitch event is a "one-minute pitch" seminar, which aims to make the students feel confident presenting in front of an audience but also to give them tips and tricks to develop during the course. The second is a "3-minute pitch" seminar when also CPs are present. At the third pitch event at the graduation event in the end of the course, the students deliver a 5-minute pitch in front of a bigger audience, which consists of all participating CPs, and e.g., incubators, science parks, stakeholders, teachers, and other students. In the final pitch, the solution is presented, and the students show their progress when it comes to pitch technique.

Photo 5.3 Shitty prototyping zenith

The students also get trained in sustainability-related matters, and this is done through a lecture and a workshop on responsible innovation and handed-in writings. The aim of this is to support a discussion in the final report on responsible innovation and on sustainable development. Regarding the latter, we focus on the UN's global goals, and they are asked to describe what goals they address and in what way.

Fact box—Responsible Innovation

Sustainability and responsible innovation is a core theme in the course. To enable the students work with this we use the framework of Brey (2012) "Anticipatory ethics for emerging technologies" along with the framework by Stilgoe et al (2013) on responsible innovation. The former (Brey, 2012) proposes a model named the ATE-model where ethical aspects are analysed on three levels, namely technology level, artifact level and application level. The latter framework (Stilgoe et al., 2013) regards for dimensions, namely anticipation, reflexivity, inclusion and responsiveness. Through combining these two tools the students can make rather thorough reflections regarding ethical aspects of their ideas and solutions.

Besides this we encourage them to work with the UN global sustainability goals. To enable this we use a template starting out with the overall objectives of the venture idea – i.e. the UN SDGs that describes the main targets. After this the main goals are broken down into the 1–3 main contributions of the venture and the UN SDGs targeted in each of those areas. Finally, the application area is addressed and applications that contribute to the goals stated in the previous step are specified.

During the course, they reflect on their group dynamics and revise their group contracts in case of reflections that are submitted. As reflection is vital to learning—and especially in courses based on experiential learning approaches—every student must write an individual reflection including one at the end of the course. In this assignment, they reflect upon how the course goals have been achieved and how and what they have learned throughout the course.

The final graduation event is open to the public, and on this occasion, the students also get the opportunity to create a small stand on a mini-fair where they can meet the audience after their presentations. An invited jury gives feedback and rewards the best pitch. They also write a final report describing the group work and their solution of the challenge.

To summarise, a typical course schedule, which runs over an entire semester, could be outlined as in the list below. To clarify, we have listed the compulsory milestones and put-up dates for a spring semester. We have pointed out the events in which the challenge providers are expected to participate. Besides these formal events, the students have informal contact with the challenge providers throughout the project.

Working with External Challenge Providers

Fact box—A Typical Course Schedule

To summarise the schedule of the course, which runs over an entire semester, we have listed the compulsory milestones and put up dates for a spring semester. We have pointed out the events in which the challenge providers are expected to participate. Besides these formal events, the students have informal contact with the challenge providers throughout the project.

Engage phase—defining the take of the challenge.

- Course start—January 25
- Shitty prototyping—February 8
- The art of pitching—February 20

Challenge providers participate in course start as well as in the shitty prototyping event in order to contribute to the project.

Investigate phase—digging out information and creating concept.

- 1 minute pitch—February 28
- Responsible innovation—April 5
- 3 minute pitch—April 17

Challenge providers participate in the 3-minute pitch event and give feedback.

Act phase—finalizing and communicating the solution.

- Final concept development
- Pitch training
- Graduation event—May 16

Challenge providers participate during the final presentation.

To explain how we work, we will start from the CP perspective. To illustrate this perspective, we interviewed an employee of a company that has been CP, an independent technical consultancy firm which is affiliated with a larger defence company. According to the interviewee, their first reason for participating was to deepen their relations with the university, especially with the students, who they see as a source of new knowledge in their field. They search for answers to questions such as: "Which skills are out there that we don't know about?," "What skills do they have that we don't?" In short, they want new perspectives, angles, and input to matters they struggle with. Furthermore, competence supply is a strong reason: "It gives us an opportunity to find people for the team and the company."

Regarding the challenge as such, their opinion is that there must be clear benefits, both for the students and for the CPs, and this entails that the challenge needs to address a real-life problem, not something made up. If the problem is not real, neither the students nor the staff will engage. They/We want the students to work independently and regard their own role as the one providing the prerequisites, e.g., the problem, the tools, and the necessary contacts. These findings are also supported by the literature review (see Norrman et al., 2022).

The interview also shows that the CPs expect to get something out of their engagement and develop a solution to the problem in case of sketches or information. When engaging in the process, they were fully aware that they might not get exactly what they expected when the challenge was formulated, but instead, be open-minded as new perspectives could also emerge. This has also been proved in other cases (see the fact box below) - the product as such is not always the most important, even in cases where it is bought back, instead it is the research that enlightens.

A reason why CPs might be reluctant to participate is time constraints and the fact that it is a little bit hazardous to put effort into something that you can't monitor and control.

To handle the CP expectations, to develop our work, and to make the best out of the cooperation with external CPs, we have studied this issue more closely also from a theoretical point of view. In Norrman et al. (2022), CBL with a focus on challenges and CPs were studied from a didactical perspective, we found that it is important that challenges are formulated in "a way that gives the students good chances to reach the learning goals of the course" (p. 769). From the student's perspective, it is important that the challenges give a real-life experience and work as a context for the learning process. From the CP perspective, it's about getting new perspectives and coming into contact with students and the university.

In the above-mentioned paper (Norrman et al., 2022), a checklist of what constitutes a good challenge was made. Focusing on this list, a challenge needs to be:

- wicked and open—a big idea, which is possible to break down into a comprehensible unit,
- formulated to fit and utilised by a cross-disciplinary team,
- aimed at developing a solution not obvious to the CP or to the students,
- a real-life challenge that interests external partners such as industry partners, governmental bodies, or organisations,
- encompassing a pedagogic purpose for students to acquire both knowledge and skills,
- suitable for an open innovation process,
- directed towards developing sustainable and responsible innovation.

Working with external CPs is an art in itself. It is common that external parties, including firms and organisations that have had collaborations with the university in case of master theses, expect the students to continue working upon a pre-assumed path and towards an expressed and defined outcome. This means they commonly regard the students as a group of consultants taking on a specified task. However, when it comes to CBL, this is not the best way of working. CBL aims to stimulate new ideas and innovation that can be beneficial also outside the scope of the actual CP. Hence, alignment of expectations is the first matter to ensure. This is also the reason why writing a challenge is a collaborative dialogic process which teamchers and challenge providers regulate.

Based on the above, the alignment of expectations, e.g., making clear what is expected and ensuring that the CP has time to invest and resources to provide (if this is desired), is crucial. A part of this work also includes aligning the CPs attitude to the students and making sure that they understand that their role is to act as a sounding board rather than a demanding client. Finally, an open mind towards new ideas and learning new things opens for creative solutions. CPs often value the results, validated by the number of the CPs who choose to utilise their right to buy back what the students have developed. Thus far, about 25% have either paid the students for their solution or made other types of business agreements with them. A common theme among those buying the solutions is that they—in most cases—have been rather engaged with the students and in their process. This is also a key message we communicate in the process of getting CPs on board.

Fact box—Some Voices About the Course

One of the companies that participated in the inGenious course autumn of 2020 was Finess Hygiene AB, which produces household and hygiene articles in Kisa. The company's CEO, Roger Didrick, saw the opportunity to get closer to the university and thus gain new thoughts and ideas. He liked the cross-disciplinary perspective and believed that the students' different backgrounds were positive for Finess Hygiene.

The student group, which took on the challenge from Finess Hygiene, developed a product solution that can replace cotton and thus reduce the impact on nature. Large amounts of clean water are used in cotton production, which has led to some countries now having a shortage of clean drinking water. Roger Didrick believes that the students' solution can be commercialised in the future, even if it requires some investment to be put into production.

The students who worked on Finesse's challenge felt they learned much from each other and broadened their knowledge. One of the students was right after the course applying for a job. The student realised that many companies sought employees with cross-disciplinary work experience. Everyone in the group had deep theoretical knowledge, but, as another student pointed out, by working with Finess as a challenge provider, they gained practical experience and an essential connection to reality.

When discussing the course's effects and results, the students talked about their "newfound" strength in being able to take on a challenge without being coloured or limited by looking at things in a certain way. They also believed companies could get important input and help with various analyses. By having Finess participate in the inGenious course, the students opened their eyes to the company according to themselves. Furthermore, students tend to spread their findings to others, which, according to the student group, can benefit a company's brand. Roger Didrick at Finess Hygiene agreed. "It can benefit recruitment and other projects in the future," he said. When asked if the inGenious course is something that Finess would recommend to other companies, Roger Didrick replied, "Absolutely." He pointed out that it was positive that the students actively applied for the course and a specific project because then the students will enter a project with a positive attitude, and concluded: "They take on the challenge because they are interested, not because they have to."

Assessment and Evaluation

Fact box—Formative Assessment

Formative assessment supports the learning process (Scroccaro et al. 2023). And one way to work with formal assessment is through matrixes where it is declared what students need to do in order to reach a certain grade. In the below one of the course goals are used as example.

Course goal	Requirements to reach pass	Requirements to reach pass with distinction
In group conduct a complex cross-disciplinary project based on a real life, actual challenge	*In this work the students have engaged and created their take of the challenge, they have investigated the case and they have come up with a joint solution to the challenge* *In this work, all group members have contributed*	*In this work the students have actively engaged, pinpointed essential questions, made an inventory of group competencies and out of this created their take of the challenge. The students have thoroughly investigated the case and collected data and facts from both theoretical and practical sources. The students have come up with a joint solution to the challenge* *In this work, all group members have contributed, and their competences have been utilised*

Since its delivery, the course has been adapted to the principles of experiential learning (Dewey, 1938; 1963) to foster knowledge and skills. We have also adapted the 21st-century skills, i.e., cognitive, technical, interpersonal, and intra-personal skills (Geisinger, 2016). The assessment of such skills is crucial, so we put a greater effort into developing the practice of assessment. In Scroccarro et al. (2023), we elaborated on this and found that theories on self-directed learning (cf Pilling-Cormick, 1997) can be relied on. We also learned that the assessment needs to be both formative and summative and that matrices describing grading criteria for each grade can make the requirements clearer for the students.

Formally, the course is examined through hand-in group assignments, i.e., a project plan and a final individual report, active participation in seminars and pitches, as well as an individual reflection. Besides the formal grades given, the students are also given a certificate for their successful completion of the course.

Fact box—Report Contents

1. Introduction

- Background, purpose and description of the task (or assignment/brief) that the project was supposed to solve
- External stakeholder/s (background about the firm that has provided your project challenge and any other stakeholders)
- Results of the project (description of what you have created and how it can/will be used/implemented). If possible include illustrations/pictures.

2. The Goal(s) of the Project and its Limitations

- Did your goals and your prioritisation between them remain the same or did you make adjustments during the project?
- Were your goals reached? To what extent?
- What challenges have you met during the process?
- What has been easy and what has been difficult?

3. The Project Process

- "The project triangle": i.e. "Deadlines/calendar time" vs "Work Hours/resources" vs "Functionality/Quality of end result" (how have you prioritised between these three factors, which trade-offs have you made during the project?)
- Team—your roles, communication and cooperation (use group contract and reflect upon what happened in your team)
- Relation with stakeholders (how was the collaboration with the firm and other stakeholders handled? what worked well and less well?)
- Risk management (what risks did you identify early on during the project, which of them occurred and how were they handled?)

4. Evaluation of Quality Aspects

- Business potential and customer/user benefits
- *Reflect upon what business potential your work has. Will your project partner be able to benefit from your work by means of that it makes their offer stronger or add to their value proposition in other ways. Use the NABC model as a tool.*
- Responsible innovation (e.g., social and ecological sustainability of the idea—UN SDG and RI material)

5. Recommendations and Main Lessons Learned

- Based on the project that you are about to finish; what are your main lessons learned from this process?
- *Incorporate different perspectives, i.e. both aspects related to the development of new materials/solutions and aspects of group dynamics. For the latter: Use Assignment 1A—the group contract, and Assignment 4—your reflection on group dynamics and build upon them.*
- What recommendations do you have to others, taking on similar projects? What recommendations do you have to the external stakeholder/s?
- *Be as concrete as possible and describe the circumstances in which your recommendations are useful/valid*

Outlook—InGenious at the University of Stavanger

Although the inGenious course has the same label, there are differences in how it is run at different sites. Below, we therefore made an outlook to the University of Stavanger to show their take of the inGenious course.

The InGenious programme at the University of Stavanger takes a unique approach to engage external stakeholders and students in their learning experience. The programme follows a systematic process to ensure effective engagement and collaboration with stakeholders. It starts by identifying the stakeholders and understanding their interests and contributions. A compelling case study is chosen to serve as a real-life example for engaging stakeholders and facilitating discussions. Clear learning objectives are developed to guide the engagement process and focus on desired outcomes.

To gather insights from stakeholders, interviews and brainstorming sessions are conducted, and facilitated discussions and question and answer sessions are organised to promote dialogue and exchange of ideas. The student engagement process aims to actively involve students in their learning experience. It begins by setting clear learning objectives and introducing a practical case study or challenge. Speed dating sessions allow students to interact with stakeholders and gain direct insights and feedback. Ice-breaking activities foster group formation, and whole-class discussions encourage sharing of thoughts and ideas (Photo 5.4).

Throughout the students' engagement process, guidance, feedback, and mentoring sessions are provided to students to support their learning and development. Students are encouraged to conduct self-directed research, collaborate with teammates and external advisors, and participate in various activities, including guest speaker sessions, industrial visits, group activities, soft skills sessions, design thinking sessions, pitch techniques workshops, and sustainability-related workshops and seminars.

The evaluation and delivery phase involve students delivering oral presentations to external stakeholders and faculty members, collecting

Photo 5.4 An instance from the classroom

feedback, implementing revisions and improvements, and finally submitting written assignments based on the case study and their learning journey. Overall, the InGenious programme at UiS actively engages external stakeholders and students, fosters collaboration and learning, and promotes practical exposure and skill development.

Fact box—Process of InGenious at UiS

1. External Stakeholder Engagement Process

- Identify relevant stakeholders
- Select a compelling case study
- Develop learning objectives
- Approach stakeholders for participation
- Conduct interviews and brainstorm sessions
- Facilitate discussions and Q and A sessions

2. **Student Engagement Process**

- Set learning objectives
- Introduce the case study/challenge
- Facilitate speed dating between external stakeholder and students
- Foster group formation by ice-breaking activities
- Facilitate whole-class discussions
- Provide guidance and feedback thought the semester
- Encourage self-directed research
- Encourage more interaction within the team and with external advisors
- Assess learning outcomes

3. **Activities During the Semester**

- Engaging guest speakers
- Industrial visits
- Group activities
- Soft skills sessions

- Design thinking sessions
- Pitch techniques workshop
- Sustainability related topics workshop and seminars

4. **Evaluation and Delivery**

- Oral presentation for external and internals and receive feedback
- Implement feedback
- Deliver written assignment

Conclusions and Discussions

In this case study, we described, discussed, and shared our experience from running the inGenious course in two different contexts and in two slightly different ways. We also share the implications for several stakeholders including teamchers, teachers, students, CPs, and the university's educational policies.

In the above we have shown how the course is implemented at the two sites – LiU and UiS. Regarding the setup it is rather similar, however there is a difference regarding stakeholders. In Linköping the course is run in cooperation by LiU and Almi East Sweden AB, whereas in Stavanger, it is run solely by the university. The implementation has a lot in commons. For example, we both work carefully with finding and contracting CPs and in writing the challenge briefs. At both sites we also work hard with self-directed learning and towards clear learning goals. Teambuilding and coaching activities are also a strong commonality that works as a red thread through both courses. Regarding the interaction with CPs there are some minor differences, e.g., that LiU the students work a little bit closer to the CPs than what is done at UiS. The final presentations are conducted in similar ways at both sites.

Another difference between the setup in UiS and LiU is the methodology of the programme. In UiS the programme is connected to the different stablished courses which provide 10 ECTS. Students should follow the course framework and the courses' teachers are the main decision maker about the methodology of the course. Students reach out the company's contact person couple of times during the semester. It depends on how straight forward is the case and what is the expectation of the course format and framework.

Implications

The main implications for teachers are that running CBL courses is that it is challenging, not only for the students but also for the teamchers. In Eldebo et al. (2022), two main conclusions were reached. The first was that the teacher role is different, and hence the term teamcher is a better description of what is required. To successfully run CBL courses, three leading roles are needed, (1) the one of the organiser, which is challenge oriented and sets the context for the learning process, (2) the role of the teacher, which is knowledge oriented and takes responsibility for the course from a university perspective, (3) the role of the coach which is skills-oriented and focus on helping the students developing 21st-century skills. Our experience clearly shows that a devoted teacher/teamcher team is crucial and that all included parties' benefit from having a big contact network as this helps find interesting challenges (Fig. 5.1).

From a student perspective, the course is designed to provide the students with the opportunity to gain both knowledge and skills, and especially we want them to gain experience in cross-disciplinary development work and support their ability to collaborate with people with different domain knowledge. The course also aims to give them practical experience of a sharp development process, apply theory, and gain experience in the complexity and challenges of the idea development process. Finally, it is designed to help them to acquire the ability to pack and present a first prototype or concept as a solution to the challenge they took on. Such a solution could be in the case of a product, a service, or a combination thereof.

We can also point out implications and benefits for the CPs and the surrounding trade and industry. From our experience, CBL courses are (or have the potential to become) platforms for collaborative learning—especially for SME firms without established and strong bounds to higher education institutes. This is because CBL courses can create new insights, new knowledge, and new solutions, not only for the student but also for the CPs and for the teamchers. They also enable networking and have the potential to strengthen the bounds of the knowledge triangle and the

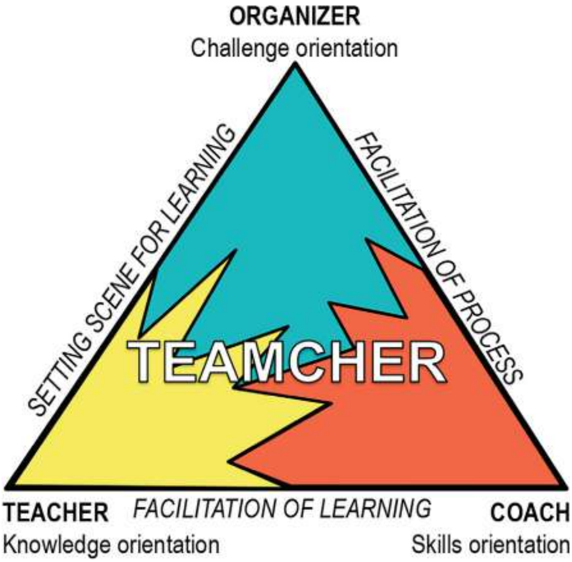

Fig. 5.1 The teamcher roles (*Source* [Eldebo et al., 2022, p. 804])

regional innovation system as a whole. For CPs, CBL courses also are an arena for the recruitment of entrepreneurial students.

Based on the above, we can conclude that even though CBL is challenging for all parties involved, it is also rewarding. For those interested in working with CBL, a good advice is to start on a small scale and improve from that. Rome was not created in one day, and neither are well-working CBL courses.

Future Development

Finally, working with a course like inGenious is an ongoing development work where we have continuously challenged ourselves. As mentioned above, our main method of solving problems and gaining deeper knowledge has been through educating ourselves and reflecting on our work through writing papers for conferences—mainly of pedagogical focus, such as the CDIO conference. We have also collaborated with colleagues around Europe.

Currently, we work hard to improve matrixes for formative assessment, such as shown in the example in the fact box above. We are also working on the development of tools for the assessment of skills, and as an example, we intend to implement the EntreComp Epic tool framework in autumn 2023 as a tool for learning reflection.

Quotes from Students from Linkoping University:

From the learning reflections, we can also tell that the students have gained skills related to group dynamic aspects—e.g., they have become more skilled in working in groups.

> For me, the two main takeaways from this module are the ability to work in interdisciplinary groups and see how everyone can contribute in different ways with their previous knowledge and experience; and learning and training how to pitch an idea.
> This type of group dynamics [the cross disciplinarity] enhanced not only critical thinking, but also contributed to a cognitive development where I got a deeper understanding of differences between disciplines and how this could be utilised to solve our challenge.

They have also improved their communication skills, both related to group communication and to communication from the stage - i.e., their pitching skills.

> I can say with certainty that this is a module that I've learned a lot from. […] I have become much better at speaking in front of people. But I have also learned a lot about group dynamics that, according to me, you miss when you work in a group consisting of only members from similar university programs.

> I really improved my oral speaking.

> I have learned to work with people with other apprehensions than me and to formulate my opinions so that others can understand what I mean.

Critical thinking and the ability to take advantage of differences in the case of competence and personality is also lifted.

> What has developed most for me is myself as a person.

> Throughout these last five months I have learned and grown personally and professionally. Becoming aware of my own skills and how to use them when working in a team.

> I was able to utilise my knowledge and sharpen my skills during this project while gaining new skills such as the art of pitch, RI analysis, and preparation of pitch deck.

Hence, we can conclude that also the students report that the inGenious course has given them what is labelled as 21st-century skills.

Case Study Three—Challenge-Based Learning for Sustainability Education

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Anders Jidesjö, Linköping University
Ola Leifler, Linköping University
Donatella Puglisi, Linköping University

Introduction

Since its inception in 2008, challenge-based learning (CBL) has been developed and included at several levels of educational systems (Johnson et al., 2009) as an innovative pedagogical approach that aims to enhance students' deeper and more meaningful learning through identification of relevant challenges and investigation of doable solutions related to real-world problems. Hercz et al. (2020) investigate effective teaching–learning processes for children based on empiric research and show why the development of social skills as well as the inclusion of sustainability contents in the study programmes starting in early education are important to support lifelong learning and help students to become responsible citizens. They argue that this is a successful way to arrange educational systems in the processes of societal change and to respect labour market necessities. Also, this approach can be embraced by higher education (HE) as a method for transformation of adult learning.

In their systematic literature review, Leijon et al. (2022) analyse the research of CBL in HE since its origin. They point out a changing society and the need for educational systems to adapt to the labour market of the twenty-first century as important drivers of the development of CBL in HE. They show how CBL draws from different educational theories and pedagogical methods, such as problem-based learning (PBL) and inquiry-based learning (IBL), where learning is active, relational, practical, and connects to entrepreneurial, self-regulated, and authentic learning due to its problem-solving nature. In the period 2009 to 2020, the authors observe that the most frequent way to use the theoretical base of CBL in HE is as background or frame for educational interventions aiming at improvement of the learning environments and processes. CBL may facilitate deeper learning and help students to feel more engaged thanks to their active involvement in self-organised activities and reflections focusing on real-world problems. The review also shows that Sweden is among the top four countries in the world where most CBL research has been reported with engineering as the dominant discipline and medicine as the second one. In relation to this, Kohn Rådberg et al. (2020) found that the educational design of CBL gives engineering students deeper skills in formulating problems and dealing with sustainability perspectives. They also develop an improved capacity to work across disciplines and with different stakeholders. Torres-Barreto et al. (2020) also point out that engineering students have mostly been educated as technical problem solvers, which leaves other skills behind. The narrow focus on linear problem-solving in engineering was a corollary of the industrialization of western societies, but today there is awareness of the need for a response to demands of trends and challenges due to our global predicaments.

In a Swedish position paper of CBL in HE, Christersson et al. (2022) further develop the theoretical background of CBL by showing its strong connection between education, research, and innovation with strong implications for sustainable societies. The educational design of CBL equips students with the skills to tackle unknown future challenges, where collaboration and reflection on different perspectives are needed, and must be suitable for the participation of students with diverse backgrounds. Furthermore, they show that such design is intricately connected to a transformative learning theory that frames our experiences, perceptions, and understanding of ourselves in relation to the complexity of our world.

The research evidence summarised in this introduction sets out several key features which inspired the development and design of the higher education sustainability course reported in this paper. A first feature is a course design that is open to students with diverse backgrounds.

Secondly, the involvement of students in real and relevant world problems where educational content, research evidence, and innovation come together to report on how an identified challenge can be treated. Thirdly, CBL is part of a frame for the course design. The course described in this case study is based on our understanding of these characteristics of CBL as they have developed over time.

Background and Participants

Many of the challenges that humanity faces are wicked, ill-defined, dynamically complex, open ended, and with no obvious solution(s). As such, they require systems thinking and a blend of different competencies which must be managed wisely and without causing new, or additional, problems. However, the ways we usually educate in our universities offer few multidisciplinary meeting places where students can interact, learn, and face challenges that require the blending of different competences and skills. Many students primarily develop abilities in applying subject knowledge in a disciplinary context with peers who know the same things. This also means that, as part of their education, they usually do not meet the range of perspectives and competences needed to manage sustainability challenges wisely, are not trained to identify and approach a problem from multiple angles, and do not learn to collaborate in multidisciplinary contexts that require the fusion of various competences and the exit from one's comfort zone. This was an important reason we developed the elective course "Sustainable development" where CBL is used to create a platform where the students can develop systems thinking and multidisciplinary teamwork skills. The course is open to undergraduate students, PhD students, and professionals irrespective of backgrounds and knowledge on sustainability.

Initially, we were five teachers who collaborated on the development of the course. Malin Bergman Jungeström, a molecular biologist who is employed at the university hospital and who took on the role of course director for the course; Cecilia Enberg, who holds a PhD in business administration and is employed as an associate professor at the Department of Behavioural Sciences and Learning; Anders Jidesjö, teacher by profession and associate professor at the Department of Thematic Studies—Environmental Change; Ola Leifler, associate professor at the Department of Computer and Information Science and Maria Lerm, who holds a PhD in biology and is professor at the Department of Biomedical and Clinical Sciences. Maria took on the role of examiner on the course. Cecilia, Anders, and Ola took on roles as mentors in the course. Hence, already from the start, we were a truly multidisciplinary team-working with course development and engaged in various parts of its execution. Already during this initiation and planning phase, additional mentors were recruited from several different disciplinary domains and more have joined over the years. One of them is also a writer of this case study, Donatella Puglisi, PhD in Physics, and associate professor at the Department of Physics, Chemistry and Biology, who started as a mentor and later took on the role of course director.

Implementing the Course

Recruitment and training of mentors

For the first implementation of this course, we all took on roles as mentors and co-mentors, together with colleagues who had been recruited when they attended a CBL course for university teachers offered by the university's centre for university pedagogics. The CBL approach to teaching was new to all mentors and co-mentors and constituted an interesting occasion for learning. To many of us, that learning included supporting a learning process within a subject area where we are not experts and to find ways of dealing with the uncertainty of a process which we had not defined beforehand, continuously adapting to new circumstances as the students worked on their challenges. The CBL course was not primarily aimed at educating mentors for the Sustainable Development course. Instead, its participants were motivated by a general interest in CBL and the merit that a course of that kind can offer for a teacher. With respect to the CBL course, it was at first structured in a traditional way including lectures, readings, and discussions. Over time, we have re-designed it to follow CBL principles and try to engage the participants in learning by means of taking on a challenge of relevance to their role as teachers. An interesting observation, however, is that many of its participants experience difficulties dealing with the uncertainty and comparable lack of structure that the CBL approach brings. The CBL course became a way of establishing and legitimising CBL as an approach to teaching and learning at the university and is still offered to university teachers twice a year.

Teachers are welcome to join the CBL course even if they are not enlisted as mentors in the specific course Sustainable Development, and this provides a means for them to try the approach of student-driven courses and open challenges in other contexts. This has led to many discussions around teacher roles and needs for control versus openness, and highlighted different ideas around the needs for detailed learning objectives and students' need to define their process of learning.

Structure and Outline of the Course

As said, this course is a single subject course that enrols students from different educational and professional backgrounds. Most of our students are already enrolled in an educational programme at the university. In some cases, they are professional workers working in Sweden. Some participants are familiar with sustainability issues and related vocabularies while others are not. The course runs during the fall semester, with groups organising their work in phases along the way so that they spend approximately four weeks on each of the main CBL phases, i.e., *Engage, Investigate and Act*. Given the diversity of student backgrounds and topics, we allow students flexibility in determining the amount of time they spend in each.

The intended learning outcomes relate to knowledge about UN's 17 sustainable development goals (SDGs) and the ways in which they are interrelated and impact each other, as well as to obtain, interpret, and compile information from scientific literature and surrounding society. We also expect them to be able to highlight their own and others' values and to understand how value conflicts may arise from different perspectives.

To draw on the students' diverse backgrounds, interests, knowledge, and skills, we start the course with a group exercise where the students explore the SDGs and identify common interests among the group members. This results in a big idea to explore with the aim of identifying and defining a challenge to take on during the course. Students decide on themes and ideas to explore without having external stakeholders providing challenges, which is a design choice made to encourage students to adopt critical perspectives on societal challenges and find their own stakeholders and ideas. At this occasion, they also write a group agreement where they decide on how they would like to take on their work, i.e., on how they would like to develop their learning process. Except for this first occasion and a seminar where the students present their challenge and proposed solution at the end of the course, there are no teacher-planned learning activities. Hence, the challenge and the group contract constitute the basis for the students' learning processes, which they structure to a considerable extent themselves as they ask questions, seek answers, and take on tasks they consider relevant to addressing their challenge. During the course, each group has a mentor and a co-mentor that they can meet for two hours per week. The students themselves set the agenda for these meetings and in this way also assume responsibility for their learning process and how it evolves. To us, this is an important part of the CBL approach, which should be student driven. Hence, what is on the agenda depends on the students' learning process and what kind of issues they are facing. The mentors and co-mentors have access to the students' shared folder which is a simple and effective way to follow the group's progress, ask questions, if needed, or give advice in between the meetings.

Assessment and Feedback

Students are assessed on a regular basis throughout the course at both the individual and group level. Every second week, they hand in a learning logbook where they reflect on their learning of the UN's 17 SDGs, their applications in real-world scenarios, and how they relate to the intended learning outcomes specified in the course syllabus (see Syllabus 8FG074 and 8FO0119). The individual assignments consist of individual reflections on the chosen challenge, a video on one of the SDGs and its interrelations with other SDGs, and a feed-forward presentation on how their learning may relate to their future professions. We use templates to help students to keep track of their progress and assess their own learning. For instance, the intended learning outcome of using digital communication tools can be easily assessed at each meeting by both mentors and the students themselves based on their experience of participating. Students can reflect on their participation and how it worked out and, based on their own experiences, they can suggest e.g., ways to improve or facilitate communication in digital meetings. By means of easy illustrations (see Fig. 5.2) we also show the students that learning is a continuous process and that we expect them to make progress on each intended learning outcome throughout the course by following up on previous reflections that they have handed in. The mentors are also responsible for giving

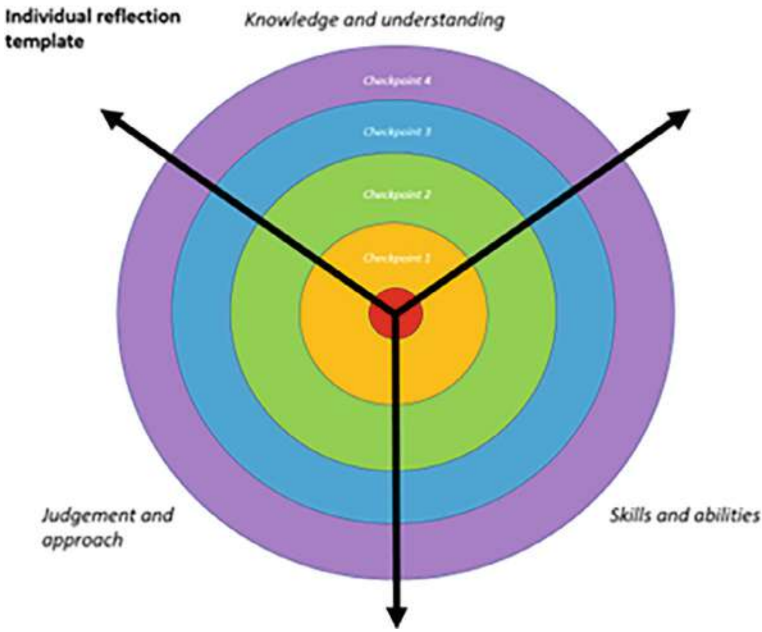

Fig. 5.2 Extract from the individual reflection template

feedback on the learning logbooks and suggest activities that the students can undertake to further deepen their learning.

At the end of the course, each group presents the results of their work at a final workshop with all groups and course instructors. The final examination task consists of an oral presentation on their joint learning process and a short movie about their challenge and the proposed solution. When presenting, they are given feedback by another group, other participants in the course and, if present, external stakeholders. Students are generally positive to this peer-to-peer feedback and particularly appreciate the feedback received. Occasions when external stakeholders are present are also appreciated as they let the students build their network.

Discussion

The lessons we have learned from teaching the course relate specifically to the characteristics of challenge-based learning: diverse student groups, the management of real-world problems and managing an open-ended process or learning. Also, as part of our own learning process, we have come to understand some of the issues relating to integrating a course such as this into degree programmes at a university that is heavily focused on professional degrees.

Student Diversity

Our student groups are diverse and multidisciplinary, from different educational as well as professional backgrounds, and with different knowledge on sustainability. While students primarily identified this as a strength of the course, we also noticed a need to manage such diversity in a way that we had not anticipated. Those with a deeper professional or educational background have sometimes experienced dissatisfaction as they have not been challenged in their understanding as much as they would have liked. Although we wanted to form diverse groups by considering different education, profession, and interests of participants, we did not explicitly manage expectations or ideas about what the course would mean for those with a solid prior knowledge on sustainability. It is, therefore, important to form groups and clarify students' expectations better, to ensure that diversity becomes a strength and not a liability.

Managing Real-World Problems

Our expectations were that students explicitly engage with real-world problems by talking to various groups of stakeholders. However, as we have allowed them to choose how they engage and find out about real-world problems, many of them preferred to use written sources, reports, or other materials to learn about issues instead of having live conversations with groups they are not naturally connected with. This may be due to the complexities and time constraints of connecting with people that would be relevant to interact with, aside from possible social issues of initiating conversations with people students have no direct connections to. The diversity of groups means there are connections to the themes explored within and beyond the groups themselves, but rarely enough to engage participants in live conversations with a broad group of stakeholders. Therefore, the course would need to actively require or support participants to engage more directly, going to locations where they can explore the issues that they focus on in the course, and talking directly to stakeholders.

CBL as a Process of Learning

The process of developing and running this course is itself a learning process for those of us involved from year to year. The ways in which student-driven education and the interaction with real-life challenges ask us for new knowledge, competence, and skills, and how this new kind of course may be integrated into the administration of the university, have required us to understand social, political, and administrative systems to ensure we can offer a meaningful experience for all involved. We had to initiate special teacher training sessions, develop new approaches to manage student groups from different backgrounds, adapt the assessment and teaching formats to both the requirements of a pandemic but also different realities regarding support for hosting final student demonstration events, and finally to understand how this kind of course challenges the dynamics of the university system in our various integration attempts. Hence, one important takeaway is that existing university structures and process have an impact on if and how CBL as a pedagogical approach to teaching and learning can be used. This has become clear to us when trying to find ways of integrating the course into existing educational programmes. For example, when the course has been pitched to degree programmes, the holistic approach of the course results in lack of a specialisation subject which is often necessary for an elective course, the flexible timeframe results in potential conflicts for students with regular schedules, the 3 ECTS need to be supplemented with different additions depending on whether degree programmes have 6 or 7.5 ECTS standard modules.

Conclusions

As students select their own challenges, come from diverse backgrounds, and adopt a more open process of inquiry, the types of questions they ask around global challenges, stakeholders, and perspectives are different than what we have come to see in other courses where challenges are "provided" by an external partner such as a company. In those other cases, we have noted that students find it more difficult to find what needs to change in relation to current practices and to formulate questions about the norms and drivers of contemporary global corporations or multinational bodies.

Case Study Four—Using CBL in a Master's Multidisciplinary Integrated Project at the Universidad de Sevilla

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Rosario Chamorro-Moreno, Universidad de Sevilla
Esther Reina, Universidad de Sevilla
Romo, Bernabé Alonso-Fariñas, Universidad de Sevilla
Ignacio Alvarado-Alde, Universidad de Sevilla

This case study focuses on how we have implemented Challenge-Based Learning (CBL) within the master's degree in plant engineering (*Ingeniería Industrial*) taught at the Higher Technical School of Engineering of our institution, including how the CBL practices have influenced both students and practitioners. We also highlight the pedagogical challenges derived from the multidisciplinary approach followed by providing first-hand, practical implications for those who are interested in developing CBL practices in similar situations (of particular interest for regulated academic programmes in Spanish universities). We first provide a description of the practitioners involved in the implementation and describe their respective roles and involvement in CBL. We then detail the structure of the integrated project within the CBL framework including the implementation of CBL practice, the practitioners' and students' learning experience as well as their instructional plans for sustained use of CBL.

Background and Participants

The Universidad de Sevilla (University of Seville) is one of the oldest universities in Spain (founded in 1505) covering most academic disciplines, including engineering programmes. The Higher Technical School of Engineering (ETSi) was founded in 1963 thanks to the sponsorship of the OECD (OCDE, 1968). The ETSi has an academic programme (bachelor + master) in plant engineering (called *Ingeniería Industrial*, according to national regulation), aiming for a multidisciplinary pedagogical approach. Plant engineers are expected to cover most aspects of the engineering practice in an industrial environment (covering a solid basis of technical aspects: chemical, electrical, electronical, and mechanical engineering, as well as of industrial engineering: optimization of processes, systems, and organisations) making them "general engineers for the industry" with special focus on supervising any kind of industries. In total, the ETSi has around 6000 students enrolled in the different engineering disciplines and levels (bachelor, master, and doctorate) (Haro et al, 2023).

The multidisciplinary nature of the plant engineering academic programme aligns well with the incorporation of CBL. In 2021, the ETSi started a pilot experience in one of the teaching groups, where three compulsory courses covering different disciplines (chemical engineering, mechanical engineering, and automation), were integrated. Such integration experience is unique in Spain.

On this pilot experience, several colleagues collaborated in different roles in order to implement a CBL approach in an integrated project for the three courses as a joint pedagogical initiative. These include:

- Pedro Haro as the coordinator of the experience and teacher for the course in chemical engineering (CBL expert);
- Javier González-Carbajal, Rosario Chamorro-Moreno, and Esther Reina-Romo as teachers for the course in mechanical engineering (CBL assistant);
- Bernabé Alonso-Fariñas as teacher for the course in chemical engineering (CBL assistant);
- Ignacio Alvarado-Aldea as teacher for the course in automation (CBL assistant).

Pedro has previous experience in CBL with different tools and methods in various courses. He has cooperated with different universities and organisations to engage, investigate, and find innovative solutions for real-life challenges in sustainable engineering design. In addition, he has been vice-dean of the ETSi, in charge of some of the innovative teaching experiences for the academic programmes. He was one of the project's supervisors and guides, coordinator of the whole pilot experience, and involved in the "classical" lecturing of the fundamentals needed to carry out the integrated project (chemical engineering).

Javier was one of the project's supervisors and guides. He had full academic responsibility for the mechanical design in the project. Working on this course was of great benefit to his personal professional development and deepened his familiarisation with and understanding of CBL concepts such as collaboration, innovation, and teamwork as he became more involved in teaching through supporting CBL practice.

Rosario and Esther were course teachers, involved in the "classical" lecturing of the fundamentals needed to carry out the integrated project. They were responsible for the fundamentals of mechanical engineering.

Bernabé was one of the project's supervisors and guides. He had full academic responsibility for the life cycle assessment in the project (economic and environmental). Working on this course was of great benefit to his personal professional development and deepened his familiarisation with and understanding of CBL concepts such as collaboration, innovation, and teamwork as he became more involved in teaching through supporting CBL practice.

Ignacio was one of the project's supervisors and guides. He had full academic responsibility for the automation in the project. In addition, he was responsible for the "classical" lecturing of the fundamentals of automation. Working on this course was of great benefit to his personal professional development and deepened his familiarisation with and understanding of CBL concepts such as collaboration, innovation, and teamwork as he became more involved in teaching through supporting CBL practice.

We worked together to redesign the three courses to implement CBL into an integrated project as by asking students to face a realistic situation of interest for the industry in our region: the valorization of a residue from the olive oil industry (*alperujo*). In doing so, we negotiated how to incorporate sustainability into the design of the valorization process. Now we present the process of integration into curriculum.

The Integrated Project (Pilot Experience)

This case study details a project integrating three courses of 5 ECTS (European Credit Transfer and Accumulation System), all taught in English and corresponding to the mandatory itinerary in the plant engineering academic programme (all corresponding to the fifth year, fall semester). It was also open for incoming exchange students.

The integrated project aims at providing a close-to-real experience and understanding of how engineers need to work in multidisciplinary teams, adopting sustainability practices into conventional process and product design. It has an overall management focus, and the topics and themes that are covered are:

- Fundamentals of the engineering disciplines needed to face the challenge.
- Conceptual design of the process for the valorisation of the *alperujo*.
- Identification of the instrumentation devices required in the process.
- Basic design of the machinery and auxiliary equipment (product design) needed in the process.
- Basic design of the automation of the process.
- Incorporation of sustainability as main driver in the selection of alternatives and evaluation of results.

By integrating teamwork and real-life examples, students gained knowledge of how theoretical knowledge in engineering can be used in real practice. In addition, this opportunity allowed both students and practitioners to identify their strengths and weaknesses in the application of theory to real problems. The duration of the course was from 10th October to 27th January 2022 and involved 12 master's level students in three teams. The background education of the students was very diverse, covering bachelor's degrees in the field of control engineering, mechanical engineering (machines), energy engineering, electronic engineering, and industrial engineering. In addition, three students participated in the course in the framework of an international exchange programme. The course used CBL as the overarching structure to bring together the three engineering disciplines and how they interface with a real engineering problem. Students were asked to identify a suitable olive oil production site (called *almazara* in Spanish), conduct research, and develop potential solutions for the valorization of *alperujo*. They were also responsible for finding necessary information (guidelines, regulations) and other materials (simulation/design software). Although the initial problem was relatively constrained, using CBL as the main learning approach gave the students a great deal of autonomy by exercising choice during their engagement in CBL. Students met to work on the project three times a week at least, but again were given autonomy to work flexibly on their projects.

Implementation

At the beginning of the semester, the fundamentals of the three courses participating in the integrated project were taught ("classical" lectures). During this period, the practitioners had the opportunity of redefining (if necessary) the lectures to provide a better starting point for the integrated project. After five weeks, team formation was initiated at the kick-off meeting for the integrated project. The principles for team formation are of special relevance in this case study, as the master's degree in plant engineering can be accessed by graduate students from other academic programmes. In addition, students in the academic programme of plant engineering have a major (automation and control, chemical, electricity, electronics, energy, industrial, machinery, materials, or structural engineering). Therefore, the background of the participating students is not homogenous, which results in a positive aspect for CBL implementation. Prior to the creation of the teams, there was an initial survey for the students to let them identify their previous experience in teamwork and soft skills (in particular, those related to CBL). Thus, students were asked to organise themselves into three teams aiming for the highest level of multidisciplinary (for instance, students with similar background education were not allowed to join the same team) and interest to gain and develop a greater sense of ownership over their collaborative, challenge-based work (for instance, team members should have different skill sets as already self-identified in the initial survey). Following this, the coordinator of the integrated project provided an open statement of the challenge to be solved (valorization of *alperujo*) and resources relevant to project management (including the use Microsoft Teams as a collaborative and communication tool).

Fundamentals (Prior to the CBL Experience)
According to the background of each student, the first five weeks differed to adapt the lectures to the need of the students. Nonetheless, the fundamentals of each course were defined to provide a strong basis for the integrated project, allowing the students/teams to follow all the stages in CBL in the integrated project.

Topics Covered in the Lectures of Chemical Engineering:

- Documentation of industrial processes.
- Mass and energy balances in systems with chemical reactions.
- Life cycle assessment.
- Industrial economy.

Topics Covered in the Lectures of Mechanical Engineering:

- Vibrations in systems with one degree of freedom.

Topics Covered in the Lectures of Automation:

- Automation of industrial processes.
- Control of discrete-event systems.

At the end of this stage, the students had an exam (written) to ensure their understanding of the fundamentals. Only pass and compensated pass were accepted to continue with the integrated project. Up to this moment, students have not started the CBL experience yet.

Integrated Project (CBL Experience)
Engage
In the first stage of the CBL experience which lasted 1 day, the challenge was presented to the students by the CBL expert as a set of three bullet points, and they were asked to discuss the relevance of the challenge and how each of them (individually) could contribute to the challenge. After an initial discussion between the CBL expert and the students, teams were formed in the same session.

The challenge:

- The olive oil sector is one of the most important economic drivers of Andalusia.
- In the production of extra virgin olive oil, a sub-product (*alperujo*) is generated, which has approx. 65% water content.
- The products from *alperujo* have different applications in the food and energy sectors.
- You are in charge of selecting an existing plant (*almazara*) in Andalusia and design a process that allows the further treatment of the *alperujo* (downstream), including the associated machinery and automation in line with the best practices in engineering.

Investigate
After the formation of the multidisciplinary teams, over the following three weeks, the students had a weekly meeting with the guides (CBL

assistants) to ask them specific questions and ad-hoc seminars (on demand) to better understand the context of *alperujo* and later to test the potential solutions being identified by each team. The teams work both in class, under the supervision of the practitioners, and remotely using Microsoft Teams. To make the experience more realistic, each team defines specific roles that were communicated to the guides using Microsoft Teams. Besides, all reports and requests were done through this platform to allow them a more immersive experience. The CBL assistants help the students in the identification of the issues within the three disciplines (e.g., treatment of wastewater from the process for chemical engineering, selection of a suitable drying trommel for mechanical engineering, and how to deal with blockages in feeders for automation). In the middle of this stage and at the end of this stage, the CBL expert asked teams to present their progress, what issues they have identified so far, and what they were struggling with. This was done to monitor both their progress with the challenge and their continuing engagement with the CBL process. The CBL expert of the integrated project gave final feedback on each team's potential solutions and their use of CBL throughout the challenge. The result of this stage was the proposed solutions to be developed by each team.

Act

After the definition of the proposed solutions for the challenge, each team worked in weekly sessions of "supervised work," where CBL assistants were available to the teams but did not perform any active role. This stage lasted 5 weeks in total. Each team was supposed to work alone in the definition of their own proposed solution (at the level of a basic engineering design). The CBL expert had weekly monitoring sessions where each team had to provide their progress. The last week was dedicated for the assessment and evaluation of integrated project.

Monitoring Students' Progress and Providing Feedback

In addition to monitoring the students' progress during each CBL stage through their presentations, there were also weekly meetings where they could get feedback and advice from the CBL assistants. Both the weekly meetings and presentation sessions were valuable for the assessment team as they could observe how students were adapting to this new learning model. Moreover, dedicated surveys were conducted to identify possible issues and measure the satisfaction of both students and practitioners.

Assessment and Evaluation (Integrated Project)

The integrated project was assessed as pass/fail for each of the three courses participating in the pilot experience. The evaluation was based on the following:

Weekly Monitoring Sessions and Final Presentation (Oral)
The checklist applied considered:

–Capacity of communicating to the public, as well as to their peers based on the evaluation by the other teams (intra-evaluation), i.e.,

- There is a logic flow of information.
- The (oral) explanations provided to support the results are appropriate.
- The media used for the presentations (e.g., slides) is appropriate and follows suitable professional standards.

–A relevant application of the "theory" to the project involving a multidisciplinary collaboration, i.e.,

- The design of the units and the processes are in line with basic engineering standards.
- The results are supported by credible calculations.

Written Individual Assessment Using Teams (At the End of the Course)
Each student had to answer specific questions from the application of the three disciplines. The checklist applied considered:

- The understanding of the disciplines new to the students (those covered in the *Fundamentals*) and their application to multidisciplinary situations.
- The application of the discipline already covered by the student in the bachelor's degree into multidisciplinary situations (e.g., in terms of the sustainability criteria).

Final Report (Written) (At the End of the Course)
The checklist applied considered:

- The information/data used both from the literature (public access) and interviews with stakeholders (e.g., producers of the *alperujo*) is appropriately cited.
- The solution provided credibly incorporates sustainability criteria (economic, environmental, and social), i.e., the results are analysed against these criteria.
- The format of the report, as well as the quality of the text are in line with the standards for technical reports.

Lessons Learned

Students' Reflections

From our follow-up surveys of student experiences of this course, students reported benefits and challenges of having a multidisciplinary integrated project using a CBL learning approach. All students participated in the surveys.

- Students highlighted teamwork and soft skills. Although some found difficulties in the realisation of the integrated project, all agreed this opportunity clearly helps them to face their professional career.
- Students faced important difficulties following the CBL approach, even when the challenge/problem was not open. This is a consequence of the traditional teaching approach in this kind of academic programmes (where "classical" lectures are the main activity). In addition, students alleged that the project should have assigned more ECTS considering the associated workload.
- The coordination between the different courses in the project was not sufficiently effective to help students incorporate a full multidisciplinary approach to the project.

Practitioners' Reflections

From our follow-up surveys of practitioner experiences of this course, practitioners reported their impressions on the integrated project and the students' performance. All practitioners participated in the surveys.

- *The performance of the students in this pilot experience was slightly above the average compared to the "as usual" situation. In general,* *the novel approach is positive, and the students can achieve the required learning outcomes even if the hours dedicated to "theory" are reduced.*

- *Practitioners agreed that a negative aspect of the pilot experience has been the lack of etiquette and active participation. Students were not used to behave in seminars, meetings and monitoring sessions, and struggle to ask questions and have effective discussions. We consider that this problem is derived from the traditional teaching approach, as already mentioned.*
- *There is some scepticism in the replicability of this pilot experience, as not only students but practitioners are not used to this approach. In particular, the integration of different courses (involving different departments) remains a challenge.*

Global Reflections

This is a first-of-a-kind experience in the integration of compulsory courses for CBL in a plant engineering master's degree in Spain. There are important challenges in the implementation of CBL into this engineering programme due to the diversity of education background of the students. However, it is possible to design a multidisciplinary CBL experience if the principles for team formation are carefully defined. We suggest that a minimum of 10 ECTS for the CBL should be allocated (i.e., excluding fundamentals). In addition, the incorporation of ad-hoc seminar to the course is very effective to overcome the generalised lack of soft skills (e.g., communication skills, teamwork, conflicts resolution) of engineering students in Spain.

Case Study Five—Exploring and Implementing Challenge-Based Learning in Project Management and Organisation

Jeanette Engzell, Linköping University, Sweden

This case study explores how challenge-based learning (CBL) can be implemented in the academic context to solve a real-world problem. The course studied is Project Management and Organisation (TEIO32) at undergraduate level at Linköping University (LiU). The course offers six ECTS, offered for engineering master's students). LiU is part of the

ECIU—the European Consortium of Innovative Universities, which has the idea to strive for cross-disciplinary teamwork among students and focus on challenges that are related to sustainability. This case study addresses the process of implementing CBL step-by-step as to how the method can be used to assess and evaluate students in a project management course as well as the benefits for students and for the university.

CBL as a pedagogical approach can be defined in several ways and there seems to be no single and common way of defining the approach or how it should be done (Gallagher & Savage, 2020; Leijon et al., 2022). In this case study, it is defined as an engaging and multidisciplinary teaching and learning approach where students work collaboratively and solve authentic problems (Apple, 2008; Nichols & Cator, 2008). CBL emphasises problem-solving, critical thinking and collaboration skills to engage students (Kolb, 2017; Kohn Rådberg et al., 2020). One of the main advantages is that students focus on designing the problem, work actively in a process to find a solution that will generate skills and knowledge that are similar to those that they will get as graduate students in any professional organisation (Kohn Rådberg et al., 2020; Pérez-Sánchez et al., 2023).

Planning and Engagement

The process of implementing CBL in the course started with the initial contact with the idea owner, namely the premises steering committee at the university. They were facing a challenge; to create and rebuild several new project rooms in one of the corridors in the main university building. Thus, the idea owner thought that this was a good challenge for the masters' students to work on. They contacted me as the course responsible due to the problem that the rooms in the C-corridor must be used more effectively. As a teacher, I considered the challenge to be suitable for the course because:

- the challenge was connected to the intended learning outcomes of the course
- it was a real-world challenge that could be observed at any university
- technical, managerial, and organisational aspects were included
- it required cross-disciplinary teamwork work and
- the challenge was related to sustainability.

The challenge presented to the students was based on the CBL approach since it was an authentic and challenging problem that motivated and engaged them more than providing predetermined lectures and cases as in traditional teaching (Hake, 1998). In total, 95 students took the course and about half of the number were exchange students.

The premises steering committee had been working for a while with the challenge but did not find an appropriate solution. The implementation of CBL in the course started with a meeting with the steering committee to understand the challenge more in depth. To protect their privacy and personal integrity, the members have been anonymized as follows:

Steve, Premises Manager, Linköping University (Sweden)
Marcus, Lecturer, Linköping University (Sweden)
Harry, Lecturer, Linköping University (Sweden)

One of the idea owners, Steve, was on the premises steering committee. He expressed that they have three main problems with corridor and the two rooms (1) they were not effectively used by the students, (2) Did not have space for storage and (3) no system for booking the rooms. Marcus expressed "At LiU, there are many courses where students work in groups focusing on design, construction and product development. In order for a group work to function well, project workplaces are needed where students can work together and store their work".

A frequently used solution for engineering programmes is to give each project group a certain workplace during a course. Marcus expressed: "students usually take several courses in parallel; the degree of utilisation is low when the rooms only are used for a few hours per week. It is also difficult to keep order in these rooms. After a few weeks, it usually no longer looks like a workplace." Therefore, the main challenge was to find a better solution for the rooms and that they should be used more efficiently.

Creating Context of the Challenge and Investigation

Together with the steering committee, I formulated and wrote down the challenge for the students. As a teacher, I got maps, pictures, and descriptions of the building, corridor, and rooms to distribute to the students.

Students got the opportunity to see and visit the place together with the idea owner. They also got written information about Linköping University, the A-building, the corridor, and the rooms. The task was formulated to the student as "*the challenge is to theoretically rebuild two project rooms in corridor C and pitch the solution for the steering committee*." The budget for the challenge was up to 330,000 SEK. They were supposed to make assumptions of costs of resources and make a budget for the renovation.

The commitment of the steering committee was important to create a relationship with the students in order to set the expectations at the right level but also to describe the context of the challenge (Gudonienė et al., 2021). The formation of student groups and group dynamics was also important in the process. From the start of the course, the students were divided into interdisciplinary groups consisting of 4–5 students per group. Students were divided based on gender, study background, and nationality. The students got to know each other during teambuilding exercises and wrote a group contract consisting of potential loyalty issues within the group. The purpose was to create commitment and respect between the group members. As a teacher, I had to make sure there was a connection between the challenge and the course learning outcomes (Membrillo-Hernández et al., 2019). I also had other parallel roles, being a teamcher. According to Eldebo et al. (2022) the teamcher role can be described as an individual who, alone or as part of a team, arranges, leads, and supports CBL activities. The teamcher takes—or alternates—between three roles and creates an environment for learning, facilitates the learning, and organise the work on the challenge. This challenge challenged me as well taking several parallel roles and facilitate students in their learning processes.

Motivating Students to Learn

As a teacher, my main goal was to motivate students to be engaged in the course and to increase their knowledge and skills within project management. To tell the students that project management is an important topic for their future careers is not giving them enough motivation. They must see a real-world problem and the relevance in order to be motivated (Conde et al., 2017). Students must realise what knowledge and skills they are missing and why this is relevant in their future professional careers. Teaching this type of course, which is practically oriented, I personally found that one effective way to tackle the problem with their lack of motivation was to use CBL to address the issue. As a teacher, I wanted to overcome the typical engineer's initial doubt about its practical relevance.

Two aspects are generally especially important for motivation: newness and reward. In this case, students were presented a new challenge that no other previous courses or students were presented before. The newness generated new stimuli and got the students' attention. Students that have completed three courses (Project management or similar, Project-based Organisation and Management and Leadership and organisational change, or similar) at Division of Project, Innovations, and Entrepreneurship, will be rewarded by a certificate of competence in project management. This diploma is one type of reward that motivates students.

Not surprisingly, sustainability itself was a key motivator for the students. They saw the opportunity to make as big a change as possible in the facilities with as few financial resources as possible. Thus, using reused materials and second hand became a motivator. The students had about 2 weeks in the engagement phase where they identified the problem and narrowed it down to meet the prerequisites of the group. The following investigation phase was about four weeks leading to the solution.

Solutions and Actions

The presented solutions were creative, contextual, and innovative. The steering committee was impressed by their sustainability focus as well as how original solutions they came up with. They based their solutions on models and tools related to project management:

- SWOT analysis
- Stakeholder analysis
- Work breakdown structure (WBS)
- Activity list
- Resource matrix
- Net plan or Gantt schedule
- Mini risk analysis
- Milestone and tollgate chart
- PENG analysis,
- NPV calculation and pay-off calculation.

One group came up with the solution to totally change the layout of the rooms and change furniture to include adjustable tables. They wanted to open up the walls and create one room instead of two rooms. Another group came up with the solution to create smaller areas within the rooms for meetings. A third group came up with the solution to build one small room within one room to create a specific room for groupwork. Generally, solutions related to hybrid and flexible work, booking systems, and storage possibilities, were included in their solutions. This act stage of CBL was one week.

Presentations and Assessment

Students presented their solutions for the steering committee, both orally and written in a report. Some presented their solution more visual than others and had pictures and drawings. A few groups had simulations of the rebuilding process. Some groups had more quantitative presentations, focusing on tables and charts to motivate their solutions. As a teacher, I encouraged students to learn from each other. Thus, I gave them roles as opponents and discussants for each presentation. This type of peer teaching activity is very useful in order to let the students interact and learn from each other.

Critical Evaluation

Course

The evaluation of the course had several components, including both formative and summative parts. First, the formative assessment was done through the course when meeting the students for coaching and assessment of their written submitted pre-study. As a teacher, I could see their progress and difficulties while working with the case. I could make necessary adjustments to achieve the learning outcomes during the course. The summative evaluation was applied when students had finished and submitted their solutions and students were assigned a grade in the course.

CBL

The evaluation of CBL itself is rather complex since it is not the solution itself that is the most important, but the process and development of student competencies towards finding a solution. In this case, the steering committee and I were responsible for evaluating the student groups' learning processes. The evaluation of the development of competences and skills was collegiate and consensual with everyone involved.

Implications and Benefits for Students

Students get the opportunity to analyse, design, develop, and execute real-life problems with CBL. Who could imagine lectures every week without any practical basis? One of the main benefits of CBL is that students get motivation and learn more than they would have done in traditional teaching in the classroom. By letting the students work with a real-life case, they will go beyond presenting the models and tools related to project management and they will also apply them in a context. Other benefits are the cross-disciplinary and multicultural groupwork. They learn how to work effectively as a diverse group and with the idea owner.

In this case, students created solutions that resulted in concrete actions; how to rebuild the university. Thus, they had a direct impact on their own university environment and for the future plans of the rebuilding process.

Implications and Benefits for Practitioners

The practitioners coach students to design and develop their solutions. CBL in this form showed a creative exchange between three different units at the university. The implications were the sustainable solutions that the students came up with.

In conclusion, CBL within the academic context worked well because of three main reasons: (1) students were motivated and saw how they could contribute to the process (2) The challenge was novel and the course rewarding, students progressing towards getting a project management diploma (3) Students were offered coaching from me as a teacher and from the steering committee. CBL as a method has great potential for both students (increased relevance, motivation, and application of knowledge), as well as teachers (better courses and new collaborations that can open up new projects) and practitioners (new solutions that can take their ideas further, contact with students who can become future employees). I therefore see great opportunities for exploring and implementing CBL in university courses.

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CHAPTER 6

CBL Meso-Level Frame Case Studies

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Alessandra Scroccaro, University of Trento

Introduction

The Challenge-Based Learning approach found a fruitful context at the University of Trento, open to innovative teaching and learning, embedded in a dynamic innovation ecosystem, and pushed to spread out stakeholders' networks. The School of Innovation (SOI) at the University of Trento (Italy) is an interdepartmental centre promoting innovation, entrepreneurship, and innovative education among students, graduates, and lifelong learners. Even before the University of Trento has become a partner of ECIU (European Consortium of Innovative Universities), the SOI has used the challenge-based learning approach through which learners are actively involved in identifying, analysing, and designing a solution that solves a challenge to current problems and real issues (Tecnologico de Monterrey, 2015).

SOI has two types of challenges: business-oriented and social-driven. The former are based upon the so-called Innovation Olympics, a 10-week programme developed by IXL Centre in Boston in collaboration with Inama Innovation-Nexus, in 2016 in Trento. The protagonists are students divided into 5 groups of 5–6 people who are incentivized to search for the most innovative solution to an actual production, managerial, or communication problem posed by a company selected among the most important ones in the country. The latter are the ECIU challenges through which students dedicate their attention to societal issues connected with UN SDG 11, "Make cities inclusive, safe, resilient, and sustainable."

In the framework of ECIU, in 2022, the SOI organised the "Alpine Smart Working: Your Office in the Mountains," a one-month challenge that involved three challenge providers, 15 participants from all over the world, and mentors from the University of Trento (Italy) and the University of Stavanger (Norway). This case study aims to show how challenge-based learning can be a tool for innovative teaching and learning, concretely benefit students, challenge providers, and the local community, and finally, be a springboard for achieving the UN SDGs. For this aim, the case study is divided into six sections. The first one introduces the challenge's background and the participants' recruitment and selection, while the second focuses on the programme and the application of the CBL. The third one explains the solutions proposed by teams to solve the challenge, whereas the fourth section explains how students were evaluated through a self-directed approach. Then, the case study dedicates a fifth section to the measurement of the impact of the challenge on participants, challenge providers, the community, and the university. Finally, the sixth section discusses critically some findings, and lessons learned and proposes some conclusions.

Background and Participants' Selection

In recent years, peripheral territories in the Trentino Region (northeast of Italy) in the middle of the mountains have often been considered a dormitory, from which people commute daily to city centres. In the worst-case scenario, people have to leave home and move close to their place of work. Small coworking spaces offer an alternative (Frigotto et al., 2022): people spend less time driving, thereby reducing traffic and pollution, and do not need to relocate to city centres, thereby improving their work-life balance. The demand from workers for a flexible way of work is steadily increasing in this period: we are observing a growth in resignations due to an insufficient life-work balance and a switch to a "remote-first" approach by more and more companies.

Developing a smart working process is also a priority project for some Public Administrations in Italy. Provincia Autonoma di Trento (the

Trentino local government) has recently approved its strategic plan (Frigotto et al., 2022). Despite these global tendencies, convincing people and companies about the benefits of remote working takes time and effort. Many organisations (and workers) are not ready for a change in general, and this could be seen as a radical transformation. In addition, before COVID-19, coworking spaces were mainly used by (and offered to) freelancers or start-up teams. Thus, they are often perceived as non-suitable to "normal office work."

The SOI started contacting three stakeholders from the cooperation sector and working on the above-mentioned topic in the Trentino Region. The three identified stakeholders were ImpactHub Trento, Trentino Social Tank, and Federazione Trentina dellaCooperazione. They aimed to tackle the issue of depopulation in the mountainous region. Impact Hub Trento is an incubator of entrepreneurial initiatives and community that offers an ecosystem of resources, inspiration, and opportunities for collaboration and works in the area to create connections between entities, associations, businesses, and freelancers that inhabit it. Trentino Social Tank was established as a business incubator that enhances and develops new ideas focusing on the welfare, personal services, and social economy sectors. Federazione Trentina della Cooperazione is the representative organisation of the Trentino cooperative movement that does assistance, protection, and auditing for more than 400 cooperative enterprises and more than 280 thousand members working in the cooperation sector.

The three entities work together in the InCooperazione project (https://incooperazione.it), funded by Provincia Autonoma di Trento. These local actors believe that small coworking spaces offer an alternative: people spend less time driving, thereby also contributing to reducing traffic and pollution, and do not need to relocate to city centres, improving their work-life balance.

In this context, the three challenge providers wanted to ask participants to develop a description of possible customer segments (e.g., residents, non-residents, private or public sector employees, students, etc.), identifying key factors useful for micro-targeting and building a better value proposition (e.g., commuting key characteristics such as distance and frequency, general interest services localization, pull/push migration factors, etc.). Once identified and defined the target segment, key characteristics, and problems to be solved, participants had to identify territorial Key Performance Indicators (KPIs) to evaluate the creation of a coworking space; and, lastly, ideate strategies to communicate smart coworking's value proposition.

Big Idea

Starting from that background, the SOI launched the Big Idea to promote smart working in remote valleys. Using the ECIU University framework for creating challenges as learning opportunities and the background idea developed by the three stakeholders SOI, started with the big idea to propose to students and some suggested questions:

- How might we promote smart working in the peripheral territory?
- How might we stick to the stakeholders' needs, such as residents (local employees, freelancers, and students) and non-residents (tourists, digital nomads)?
- How can we better meet these potential users?
- How might we propose a new business model for your target and present your idea to the challenge provider?

The SOI promoted the challenge on the ECIU online platform (www.eciu.eu) and its English website and made a communication campaign through the newsletter and social media. To participate in the Alpine Smart Working Challenge, students had to apply through the ECIU and the SOI platforms. Thanks to these communication strategies, the SOI received about 25 applications. Among these, the SOI selected 15 participants, including five ECIU students from the universities of Aveiro (Portugal), Stavanger (Norway), and Barcelona (Spain) and nine Nationalities (Italy, Russia, Pakistan, India, Algeria, Portugal, Spain, Norway, and Georgia). For the application, the SOI requested a curriculum vitae and a motivation letter or a video through which applicants had to explain their motivation for joining the challenge and in what way they could contribute to it. The selection criteria were the level of motivation, competencies, and significant past professional and personal experiences coherent with the topic of the challenge.

Selected students' backgrounds differed significantly in that they were from management, informatics, engineering, psychology, languages, and literature. Also, they belong to undergraduate and master levels. The selected participants were divided into four teams, considering diversity in terms of gender, nationality, background, and discipline (see Table 6.1) as per the guiding principles for team formation in CBL. The instructor of the challenge, the teamcher, created teams, with each participant knowing which team was the member before the start of the challenge.

The SOI involved its staff and, in particular, the challenge coordinator (Dr. Roberto Napoli), one teamcher (Dr. Alessandra Scroccaro), the Contamination Lab Chief (Professor Alessandro Rossi), and two CBL mentors from Stavanger University (Masoumeh Shahverdi and Tim Marshall).

Table 6.1 The teams' composition at the Alpine smart working challenge

Team	*Gender*	*Age (years)*	*Nationality*	*Discipline*	*ECIU Universities*
Team 1	2 males 2 females	25–26	Pakistan, Italy, Spain	Business administration, Innovation management, Management and Law	UniTrento University of Stavanger Universitat Autonoma de Barcelona University of Aveiro
Team 2	2 males 2 females	21–28	Portugal, Italy, Algeria	Civil Engineering, Innovation Management, Psychology, English Applied Linguistics	UniTrento University of Aveiro
Team 3	2 males 2 females	19–25	Pakistan, Georgia, Italy, Spain	Informatics, International Management, Contemporary History, Politics and Economics, International Studies	UniTrento Universitat Autonoma de Barcelona
Team 4	1 male 2 females	21–25	Italy, Russia, India	Innovation management, International Business and Management, Materials and production Engineering	UniTrento

The Challenge's Programme and the Three Phases

The Alpine Smart Working Challenge is an extra-curricular activity providing two European Credit Transfer System (ECTS) and a completion certificate for all students who participated in at least 80% of the activities, particularly in the final hackathon.

The challenge applied the CBL approach, dividing the programme into three phases (see Fig. 6.1): the *Engag*e phase, where students understand the Big Idea and identify the challenge; the *Investigate* phase, where they must collect information and data; and the *Act* phase, where they must focus on a sustainable solution. The Alpine Smart Working Challenge lasted one month. The first part was entirely online and included a kick-off with the presentation of the challenge. Then for almost 3 weeks, teams could investigate online or offline. The last part of the challenge was in presence. It took two days for the hackathon in a small coworking space in Mezzana, a small village in Val di Sole (Trentino Region), hosted by the Trentino Social Tank.

The choice to have a longer *Investigate* phase was made to give more time for the collection of information and data and be more effective for the *Act* phase. Before jumping to conclusions, it is better to understand and validate the problem and have a clear idea of the causes of the problem to identify the best solution that fits that specific problem. The *Act* phase in a hackathon seemed an excellent format to reunite in presence of the teams coming from different countries and make them work directly in the valleys, so they could be surrounded by the territory and community they had to work for.

Engage *Phase*

The *Engage* Phase aims to motivate participants, push them to familiarise themselves with the challenge, and stimulate them to turn the big idea into their challenge. The challenge started on the 6th of April 2022, with an online kick-off meeting that involved the SOI staff, the Stavanger University mentors, the 15 participants, and the representatives of the three challenge providers. The kick-off was initiated with an ice-breaker activity to meet one another and set an informal mood. Participants were asked to create their profile on a Miro board (the selected digital workspace), including some biographical information, competencies, and hobbies. Then, the teamcher described the context of the Big Idea, and the challenge providers introduced themselves, giving a further

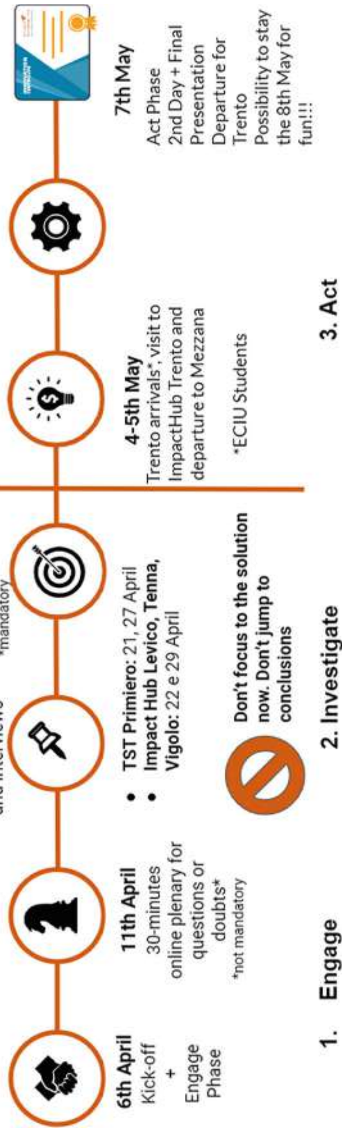

Fig. 6.1 Alpine smart working challenge program

description of the Big Idea. A time for questions and answers followed. Finally, the teamcher gave some instructions for starting the challenge, mainly how to tackle the challenge, how to set up the team and the teamwork, and the five phases of the teamwork (forming, storming, norming, performing, adjourning) (Tuckman & Jensen, 1977). The next day all teams were invited to attend an online mentorship to clarify doubts and give space to emerging questions.

Investigate *Phase*

The *Investigate* Phase aims to let participants collect as much information as possible to fully understand the problem they have to solve while encouraging them not to immediately reach for solutions. They could search for information online or in libraries, have interviews with the challenge providers, and launch online surveys. Some teams even visited the challenge providers in the Trentino Region, captured helpful information to validate the problem, and better understood the background and the context.

The teamcher also could interview the challenge providers for research she was conducting with some colleagues from the University of Trento (Frigotto et al., 2022). All these information and materials were shared with the participants during the *Investigate* phase. The CBL, in fact, can be helpful to stimulate the CBR (Challenge-based research). The teamcher in this case study is also a researcher and, thanks to this challenge, she could manage her research. In this respect, the teamcher is one of the learners in CBL and thanks to her work, she can provide contacts, documents, and data between the challenge provides and the participants.

At the end of April, all teams were invited to an online meeting to present separately what they had done the previous week. They presented their challenge and their initial ideas on how they wanted to address and solve. The teamcher and the mentors gave each team constructive feedback.

Act *Phase*

The *Act* phase is dedicated to how to develop prototypes of the solution and how to present the conclusion to the whole CBL process to the challenge providers. During the *Act* phase, all participants visited Trento to meet in person for activities that constituted the final phase. On the 4th of May, ECIU students from Stavanger, Aveiro, and Barcelona arrived in

Trento. On the 5th of May, all participants visited ImpactHub headquarters in Trento and met Ilaria Petrone, who made a tour of the organisation and presented more details about the challenge. Students had the opportunity to ask more questions and have a discussion hosted by the challenge provider. On the same day, all participants, with the mentors and the team(c)her, took the train to join Mezzana, a small town in the middle of the mountains in the Val di Sole (a valley one hour and a half by car far from Trento city). During the train trip, teams could compete in an online escape room. The winning team won the opportunity to have an extra mentorship with Dr. Alessandro Rossi. In the evening, the teamcher prepared some team-building activities to set the atmosphere for the imminent start of the hackathon the day after. The team-building activities were some get-to-know activities before and during dinner, such as answering some funny questions and sharing short stories. In addition to this, one of the participants celebrated his birthday that day, so the participants improvised a cheerful international moment. The benefits of these activities were to get people to know each other in person, since before they had to work remotely, set up an informal and safe learning environment, and motivate participants for the two-day hackathon.

All participants were hosted by a hotel near the hackathon location, a smart working managed by Trentino Social Tank.

On the 6th of May 2022, the hackathon started and was hosted in a smart working obtained from the abandoned offices of a local bank. A representative of Trentino Social Tank welcomed the participants, and the teamcher introduced the hackathon's programme (see an abstract of the programme in Fig. 6.2). The team(c)her also gave a lecture about the techniques and the appropriate attitude of communicating with peers as well as providing and receiving constructive feedback when working collaboratively. Then, a mentor delivered a lecture on developing a solution using the system thinking approach and two problem-solving techniques, such as the fish and six thinking hats tools. The second mentor gave another lecture about how to develop a compelling pitch and attractive slides.

Then, the four teams worked separately in four offices in the smart working location using the above-mentioned techniques. They had the time to focus on the solutions, and they were also supported by the mentors and experts, as well as the challenge providers and some customers working in that period in the smart working location. The teams also had the opportunity to exchange with the participants of

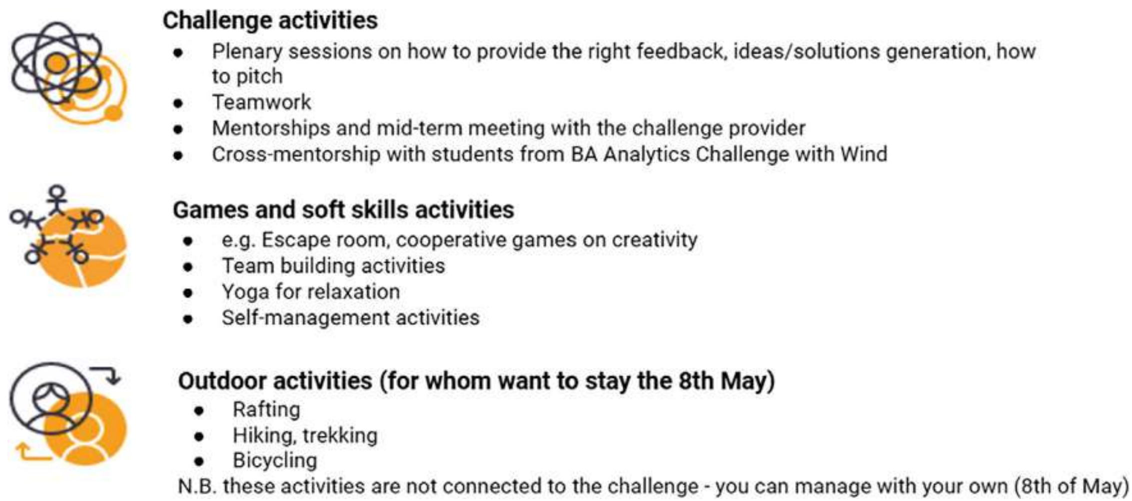

Fig. 6.2 Hackathon activities

another parallel challenge running in the exact location. This peer exchange was beneficial in gaining new perspectives and fresh feedback from peers. The teams were stimulated to present their work to others who did not know absolutely anything about the topic. This was beneficial to summarise the ideas and make clearer and shorter sentences. In addition to this, teams could receive suggestions and new questions useful to deep dive into their ideas.

Each team had to present at least two solutions to the challenge providers on the same day. The presentations were made separately so each team could receive specific feedback on the proposed solutions. The challenge provider had to choose one solution per team. Starting from that point, the teams had to focus on the chosen solution, refine it, and prepare a presentation for the next day.

The teams had all night to work on their presentations. On the 7th of May 2022, each team had a specific session through which they could present their draft slides and receive comments from the mentors and the SOI staff. Then, each team had time to rehearse and refine their presentation. Finally, each team presented its solution during the pitch session. For each presentation, the challenge providers could ask clarifications and questions. Once the presentations were finished, the jury, composed of the challenge providers, made a ranking list with four criteria: the feasibility of the proposed solution, the economic sustainability of the challenge, the quality of the presentation, and the team competencies. While the jury proclaimed the winning team, all participants received the certificate of completion. The winning team won several awards, such as free consultation on a LinkedIn profile, a voucher to be spent on a local website promoting local and genuine food, and the possibility to implement the solution through an internship hosted by Trentino Social Tank.

The Challenge Solutions

In the Alpine Smart Working challenge, the winning team proposed the concept of a 'workation,' a vacation that allows the employee to work remotely and includes training, group work, and team-building initiatives while visiting Trentino. They focused their attention on start-ups and large companies, providing a B2B service and offering an out-of-office experience that encompasses both work and leisure time. The team presented the 'workation' as an optimal solution for companies since they can increase employee loyalty, retention rate, productivity and growth, team bonding, and talent acquisition. Their roadmap includes five steps: a partnership with local service providers; a service promotion through tourism board websites; a marketing campaign for a 'workation,' offering companies one-time deals; acquisition of more customers.

The three other solutions were the following: A team dedicated the solution for 'digital nomads,' people who can work remotely: they need an online coworking space with English language functionality that helps them be productive while surrounded by attractive landscapes. The coworking space includes a relaxing and game room, opportunities to join career and tourism fairs, events for digital nomads on IT skills, coaching and web tools, and networking meetings with university students. Moreover, coworking relates to facilities and services, such as gyms and fitness clubs, local restaurants, public transportation, and tourism offices.

Another team proposed a solution for Public Administration entities since they have a large potential customer base, can afford a long-term business opportunity, and are diversified (local government administrations, universities, and educational institutions). At the same time, these organisations have a more conservative structure, rigidness towards changes, and infrastructural limitations. A coworking space is a win-win solution for both public employees and employers since, for the former, it increases networking opportunities and a better work-life balance while reducing the expenses for commuting. For the latter, it increases productivity, while renovating infrastructures and diminishing the carbon footprint.

Another team focused on smart workers proposing an all-inclusive package that provides career days, team-building activities, and services provided by partnerships activated between the coworking space and providers.

Assessment and Evaluation

The challenge was extra-curricular. Thus, students did not receive grades. Nevertheless, they achieved 2 ECTS and a certificate of completion by the SOI if they accomplished all the activities and attended at least 80% of the challenge. Since critical thinking and auto-reflection is one of the 21st Century skills and one of the most recommended capacities required by the job market (World Economic Forum, 2020), the Alpine Smart

Working Challenge proposed a new way of learning based on a self-directed approach (Deci & Ryan, 2000) and the integration between a formative (individual and team tasks during the challenge) and summative evaluation (final project presentation) (Scroccaro & Rossi, 2022).

In the framework of the self-directed approach, the students had to fill in an initial individual learning agreement (which included their learning objectives) and a final individual reflection report (Gibbs, 1988) which they reported how were the experience, weaknesses, and strong points, the achievement or not of their learning objectives, and future plans. These two tools are part of the formative assessment from an individual perspective. The team had to deliver the final presentation, which was the summative assessment tool. The learning objectives were three. The first two objectives were proposed by the Team(c)her: (1) the ability to work in an interdisciplinary and international team; (2) the capacity to communicate between peers and challenge providers, and finally, the jury. Each team member chose the third objective individually among the 15 Entrepreneurship Competence Framework (EntreComp) competencies, a tool to improve the entrepreneurial capacity of European citizens, academia, industry, and organisations (Bacigalupo et al., 2020).

In the Alpine Reflection Reports, participants confirmed that they achieved their learning objectives and recommended this experience to others. From the final reflection reports, students positively evaluated their participation in the challenge (see Figs. 6.3 and 6.4). As stated by this student, the CBL looks effective for a learning-by-doing experience "*I think the challenge was beneficial to experience a different and more practical way of learning. I believe in the importance of learning to interact with others, belonging to different backgrounds and having different languages, cultures, and perspectives*." In the final reports, students reported that they would have liked to participate in a more extended challenge hosted by the challenge providers, as mentioned by this student: "*If you plan some other events like this in future… please make it for one or two weeks at least… now I'm missing it so I wish I could be there for more time… build more connections and explore more out in the environment and also my abilities.*"

Implications and Follow-Up

Challenge-based learning can be beneficial for students (they put into practice their knowledge and skills to solve real problems), challenge

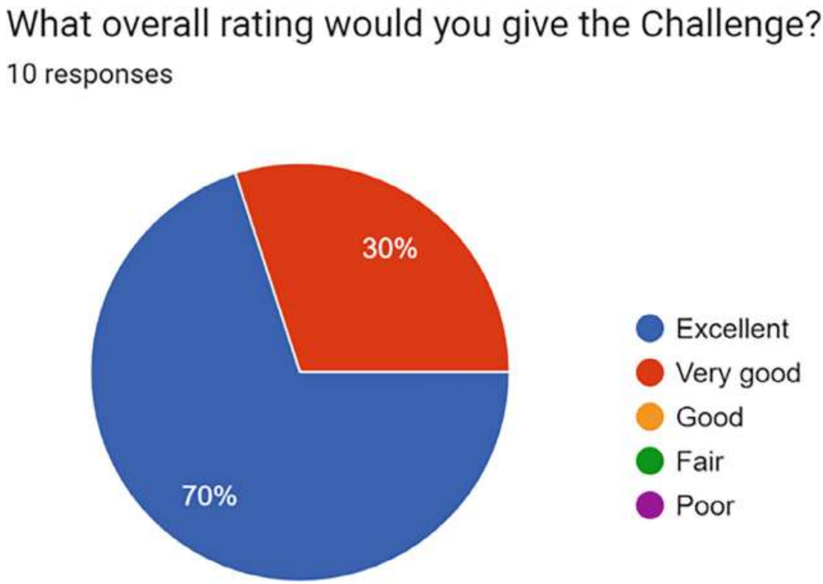

Fig. 6.3 The final evaluation of the challenge from participants

providers (they gain new perspectives and co-design news solutions), communities (they gain in the quality of the development process), and universities (they are a more and more crucial player in the innovation process in local communities and are the Innovation hub through which fosters a sustainable development).

After the end of the challenge, the teamcher interviewed the winning team of students and the challenge providers to understand the short, medium, and term impacts of that initiative. Students and challenge providers reported positive feedback regarding teamwork, soft skills, the learning environment, and reasonable solutions and ideas for solving the problem. The summary of these interviews is presented as follows:

Follow-Up with Students

Students had to evaluate from 1 to 5 (where 1 is low and 5 is high) the level of importance of each effect in the short (immediately after the end of the challenge), medium (after 6 months from the end of

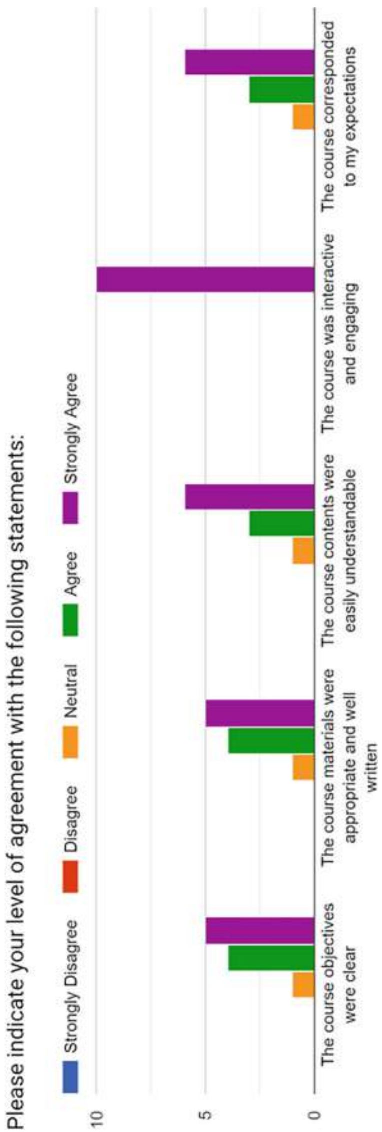

Fig. 6.4 The level of satisfaction of participants in the challenge

the challenge) and long period (in one year after the end of the challenge). See Table 6.2. The interviewed students evaluated 3,8 out 5 the level of satisfaction with the short effects of the challenge: the increasing personal network, the gaining of credits, and the acquisition of soft skills. They considered 4 out 5 the level of satisfaction for the outcomes (the medium-term effects of the challenge): the curriculum vitae development, the exposure to concrete problems and realities, the acquisition of knowledge for creating a start-up, the motivation to conduct the CBL, the possibility to do project development, the application of methodologies in real problems, and the internship opportunities. In the long term, they evaluate 4,2 out of 6. the importance of having more opportunities to start a career and to enlarge their network. They found the location positive, the modules are given by the teamcher and the mentors, the cross-peer meetings with students from the other challenge, and the international network with ECIU students. They judged the multiple challenge providers with the same challenge negatively. Finally, they suggested organising a post-challenge party and more get-to-know activities.

It seems that students evaluate the long-term effects as much more important in comparison to the short-term effects. They perhaps judged that CBL can improve their professional pathway in terms of gained experience and an enlarged network.

Table 6.2 The impact of CBL on students

	Evaluation from 1 to 5	*Identification of the effects*
Short effects	3,8 out of 5	The increasing personal network, the gaining of credits, and the acquisition of soft skills
Medium-term	4 out of 5	The curriculum vitae development, the exposure to concrete problems and realities, the acquisition of knowledge for creating a start-up, the motivation to conduct the CBL, the possibility to do project development, the application of methodologies in real problems, and the internship opportunities
Long term	4,2 out of 5	Having more opportunities to start a career and to enlarge their network

Follow-Up with Challenge Providers

Challenge providers were asked to evaluate from 1 to 5 (where 1 is low and 5 is high) the level of importance of each effect in the short (immediately after the end of the challenge), medium (after 6 months from the end of the challenge), and long period (in one year after the end of the challenge). Challenge providers were amazed by the quality of the presented solutions and the new perspectives they gained from that experience (see Table 6.3). They evaluated 4,2 out of 5 the level of satisfaction for the short-term effect of the challenge: the importance of the analysis work (the definition of the problem and the investigation process), the applicable proposed solutions, and the opportunity to contact students. They gave 4,7 out of 5 for the valuable methodologies and tools used in the CBL, the group energy, the collaboration with the University of Trento, and the SOI. They evaluated 4 out of 5 the level of satisfaction for the medium-term effect of the challenge: the development of further partnerships, the development of the winning solution proposed by the participants (the 'workation' offer), and the internship with a student. They evaluated 4,1 out of 5 the long-term effect of the challenge: the rising number of tourists in coworking spaces and new collaborations.

The positive points of the challenge were the students' energy and the 2-days hackathon in the coworking space. No parts were judged as negative or irrelevant. Finally, they suggested dedicating more time

Table 6.3 The impact of CBL on challenge providers

	Evaluation from 1 to 5	*Identification of the effects*
Short effects	4,2 out of 5	The importance of the analysis work (the definition of the problem and the investigation process), the applicable proposed solutions, and the opportunity to contact students, valuable methodologies and tools used in the CBL, the group energy, the collaboration with the University of Trento, and the SOI
Medium-term	4 out of 5	The development of further partnerships, the development of the winning solution proposed by the participants (the workation offer), and the internship with a student
Long term	4,1 out of 5	The rising number of tourists in coworking spaces and new collaborations

for problem validation for the mid-term presentation in the middle of the challenge, the preparatory work before the hackathon, and the involvement of students after the challenge for tangible action.

Challenge providers evaluate almost equally the short, medium, and long-term effects of the challenge since the importance to get in contact with the university and students and gaining new solutions.

Follow-Up with the Local Community and the University

Finally, the challenge had a resonance in the community since an article appeared on the ECIU platform, on the SOI website, and the local media. In addition, the challenge was an opportunity to foster specific research on coworking spaces in the Trentino Region (Frigotto et al., 2022). A student from the University of Stavanger created a promotional video of the challenge disseminated during ECIU events and on the SOI website.

The Alpine Smart Working Challenge became a model for ECIU and the Community of Practice of CBL, born at the University of Trento in May 2022. The Community of Practice of CBL was created with the input of FormID (the University's Teaching and Learning Centre), with the support of the SOI, it is an informal group that meets monthly to discuss issues related to this learning method, collaborate to organise or support the activation of challenges, and exchange views on "success" and/or "critical" cases. The Community of Practice of CBL stakeholders are teaching staff from multiple departments, researchers from various disciplines, administrative staff, students/staff, and stakeholders outside the academy.

Lessons Learned and Conclusions

The Alpine Smart Working Challenge was an excellent opportunity to test the CBL approach and measure its effectiveness during the learning process and also after the end of the initiative. After this experience, we can identify four main lessons learned and beneficial to create the upcoming challenges. The first lesson is that students appreciated the fact that they could work in international and intercultural teams. Students liked the mobility and the possibility of working finally in presence after two years of the COVID-19 pandemic. Mobility is essential for supporting this kind of active learning.

The second lesson is that students recognised the hackathon sponsored and hosted by the challenge provider as valuable. They had the opportunity to interact directly with people working in the coworking space, and they could work embedded in the context. The third lesson is that participants prefer to work with only one challenge provider to avoid confusion and misunderstanding.

The fourth lesson is that participants think the essential value is gathered after the challenge through improving networking opportunities, curriculum vitae deployment, exchange experiences, applying their knowledge and competencies to a real problem, and the possibility of starting an internship. They acknowledge the importance of accomplishing a challenge for further professional opportunities.

In the future, the author is willing to continue to research the implication of a challenge-based approach not only in the learning and pedagogical process but also in the university innovation processes and the implementation of the university's third mission. The challenge-based approach to innovation, particularly social innovation, is quite a recent concept. The analysis of the use of the challenge-based approach to foster an entrepreneurial university engaged in the sustainable development of local communities is relatively recent. Literature and research, for that matter, should be more explored.

Relevant Websites:

- Article at the ECIUI Website: https://www.eciu.org/news/eciu-university-challenges-at-unitrento-sustainable-telecommunications-and-remote-work-in-the-mountains
- Article at the UniTrento Website: https://webmagazine.unitn.it/internazionale/109289/soluzioni-creative-per-business-reali
- InCooperazione Website https://incooperazione.it/it
- SOI website https://www.soi.unitn.it/activities/challenges/ https://challenges.eciu.org/challenges/2473581/alpine-smart-working-your-office-in-the-mountains
- Video YouTube: https://www.youtube.com/watch?time_continue=3&v=Bzgf7t8rE24

Case Study Seven—Co-Creating the Shop "La Botiga": A First Implementation of Challenge-Based Learning at the Universitat Autònoma de Barcelona (Spain)

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Dr. Daniel Franco, Universitat Autònoma de Barcelona
Myra Ronzoni, Universitat Autònoma de Barcelona

Introduction

In recent years, universities have played a fundamental role not only as the leading institutions for creating and promoting knowledge, but also as the key players in the process of identifying and addressing the real-life societal challenges. In this context, the relationship between the university and its immediate social environment has faced several meaningful changes and is currently moving towards a deeper interaction and collaboration between involved actors, contributing decisively to the economic, social, and environmental development of society.

The Universitat Autònoma de Barcelona (UAB) is an institution that is strongly rooted in the territory, and has established a strong connection with it, to actively contribute to its development. Consequently, the institutional strategy of the UAB is framed in this firm commitment of promoting collaboration to address the main challenges of society, and to promote initiatives to share and co-create knowledge with citizens, public administration, and companies.

In this context, the UAB has been exploring and developing new ways of learning and doing research, with the goal of linking education and research to local and regional challenges: an example of these methodologies is challenge-based learning (CBL).

The exploration and the development of this innovative methodology has been done at UAB's institutional level, but it has also benefited from European Projects like the ECIU University, as one of the main goals of this project is the implementation of an ecosystem where students, teachers, and research staff collaborate with a wide range of social and economic actors, to solve real-life challenges.[1] The university has defined a framework with several components to develop its challenge-based learning strategy. These components are societal linking, stakeholder engagement, and the use of design thinking as ideation methodology. The approach followed at UAB is to merge CBL and design thinking to boost innovation and creativity in the challenge resolution process.

The following section introduces the framework and the guides and tools created, and later we describe a specific challenge process developed at UAB using the developed methodology and the available tools.

The Theoretical Framework: Challenge Development Methodology at the UAB

In order to develop challenges and provide solutions to challenge providers, we have used a methodology to guide challenge participants from challenge definition to challenge solution transfer to society and impact evaluation. This methodology is based on three pillars, as seen in Fig. 6.5, societal connection, stakeholder participation, and design thinking for CBL. A transversal axis is reflection during all development process.

For the first pillar, UAB has developed a connection strategy with the surrounding territory to connect to societal needs through societal actors like citizen associations, local cooperatives, city councils, SMEs, and industry associations. Instead of addressing a particular need from a company, this methodology allows us to gather real societal needs and representative stakeholders for challenges to address UN SDGs.[2] In the case presented in this study, UAB started contacts with *El Prat del Llobregat* city council and ABD NGO to identify the challenge to be solved. At the university, a physical challenge office has been set up to manage these relations.

[1] In this sense, both the UAB teaching and technical staff involved in the ECIU University project are contributing to the institutional implementation of CBL in the institution, providing not only their theoretical knowledge, but also their practical experience in creating and implementing a challenge-based offer.

[2] Ideally, a challenge can address any of the 17 UN SDGs. The UAB is currently focusing on SDG11 "Make cities and human settlements inclusive, safe, resilient and sustainable," in line with what is being worked in the ECIU University.

For the second pillar, we encourage stakeholders' participation during challenge development using a citizen science and open science strategy. Again, this strategy opens university to the society and citizens to improve engagement and quality of the designed solution. In our case, we had participants from the NGO, city council, researchers, students, and citizens from *El Prat de Llobregat*. From these two first pillars, the team formed by the challenge coordinator and the teamchers get a proper challenge and suitable stakeholders identified.

Finally, the third pillar is a step-to-step process based on design thinking and CBL to develop the challenge and provide a solution by challenge participants team. We start from CBL as learning methodology based in three phases*: Engage*, *Investigate*, and *Act*. Then, we merge with design thinking and challenge definition in several phases (Fig. 6.8). It is important to state that the matching between CBL and Design Thinking phases has some overlapping: for example, definition of big questions is included in CBL *Engage*, and challenge definition in part of CBL *Investigate*. Similarly, ideation and prototyping are part of the CBL *Investigate* phase (at first steps) and part of the *Act* phase (at more advanced challenge development).

For each phase, we have identified a set of tools (Fig. 6.7) to use at each phase by the challenge team. We have created a teamchers' guide where all these procedures and tools are described, so they can be used in the challenge resolution.

Design Thinking for CBL phases are shown in Fig. 6.6.

1. Challenge definition
2. Empathising
3. Definition
4. Ideation
5. Prototyping
6. Testing
7. Transfer

The first phase, challenge definition, is used to land problem definition and is based on a canvas (Fig. 6.8) that follows a series of steps to fill in carried on by the whole challenge team:

1. Current situation
2. Future vision
3. Unresolved problems
4. Challenge
5. Participants
6. SDO's
7. Next steps
8. Solutions requirements
9. Expected impact
10. Agents involved
11. Short title
12. Long title

The first phase, together with second and third ones, Empathising and Definition, matches CBL *Engage* step where you start with a big idea, then elaborate essential questions, and finally define your challenge to work into. At the *Investigate* phase, guiding questions for learner's journey are developed, guiding activities and resources are designed and, after the analysis process, a synthesis that outlines the foundations for the solution is produced, possibly including prototype or demonstrator development. This is developed at the "ideation" and "prototyping" phases in the methodology. In the *Act* phase, challenge team members develop solutions, implement, put to work, monitor, and evaluate it, and this is done in testing and transfer phases.

As mentioned, at the UAB we identified and provided a set of tools to carry on each phase (Fig. 6.7). Team members, guided by Teamcher, select the most appropriate tool for each phase based on challenge type, already used tools in previous phases, and team expertise.

In the first phase, "challenge definition," we have developed the already mentioned canvas. For the rest of phases, these are some of the suggested tools to use (Figs. 6.5, 6.6, 6.7, and 6.8):

1. Empathising: stakeholder map, dives, five why's, shadowing and user camera study, analogy for empathy, interviews and focus groups and surveys.
2. Definition: saturate and group, problem sizing, Pestel analysis, Ishikawa diagram, empathy map definition, persona map, journey map, insights selector.

3. Ideation: brain and sketch storming, benchmarking, future scan, scamper, how might we, power of ceros, 10 × 10 ideas, find your mojo.
4. Prototyping: Paper prototype, app prototype, infographic display, video prototype, manual modelling prototype, 2D and 3D print prototype, brand prototype.
5. Testing: Interviews test and focus groups, assumption learning card, feedback grid, experiment card.
6. Transfer: Interviews test and focus groups, assumption learning card, feedback grid, experiment card.

Developing CBL: Pedagogical Aspects of the Challenge "La Botiga"

The case presented in this article was developed within the framework of ECIU University, and the compromise to work towards the Sustainable Development Goals. The experience of developing CBL that we are going to present is extra-curricular, multidisciplinary, and linked to the Sustainable Goal 11: Make cities inclusive, safe, resilient, and sustainable.[3]

The first part of implementing the project was about **starting from a big idea and defining a challenge**. In order to do it, the UAB and two stakeholders, the Prat de Llobregat City Council and the ABD group (a welfare and Development Association), start working together with the UAB challenge coordinator in autumn 2020.[4] After these first contacts, an expert team of the UAB with the Challenge Coordinator organised a workshop in January 2021 with the stakeholder and other experts in the area, and worked together to define the general Challenge, that was finally defined as "Transform the free food distribution programme guaranteeing alimentary security for vulnerable groups." The goal was to discover new ways of transforming usual redistribution of food (food banks) to dignify food access and promote social cohesion, by leading local projects to reduce food waste.

[3] https://sdgs.un.org/goals/goal11.

[4] The final phase of the challenge (the public presentation of results) took place on the 23rd of November of 2021, one year after the first exploration with stakeholders was done. However, the "real work" on the challenge with the students was developed for 6 months (2nd semester of academic year 2020/21).

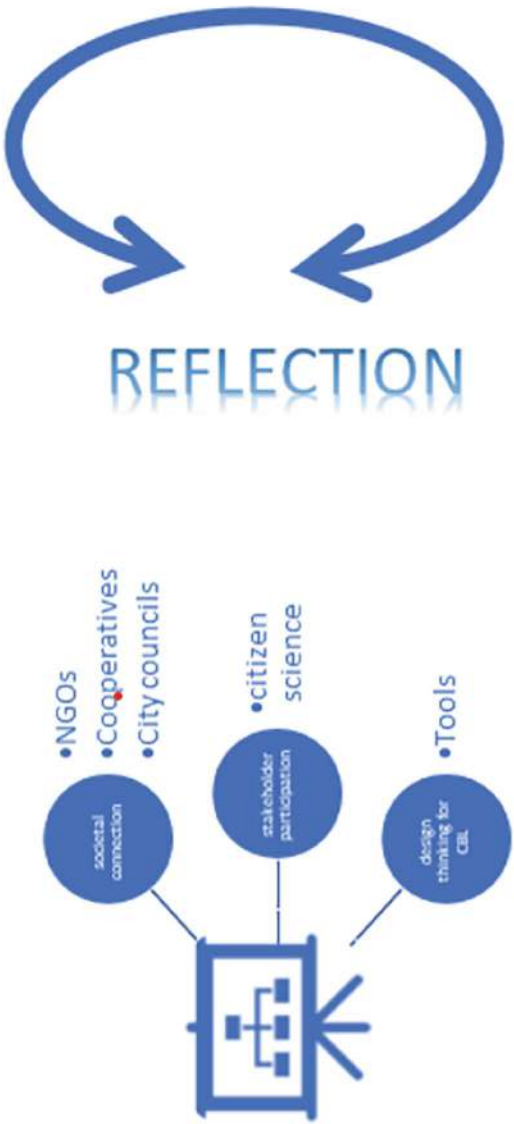

Fig. 6.5 Challenge development methodology pillars

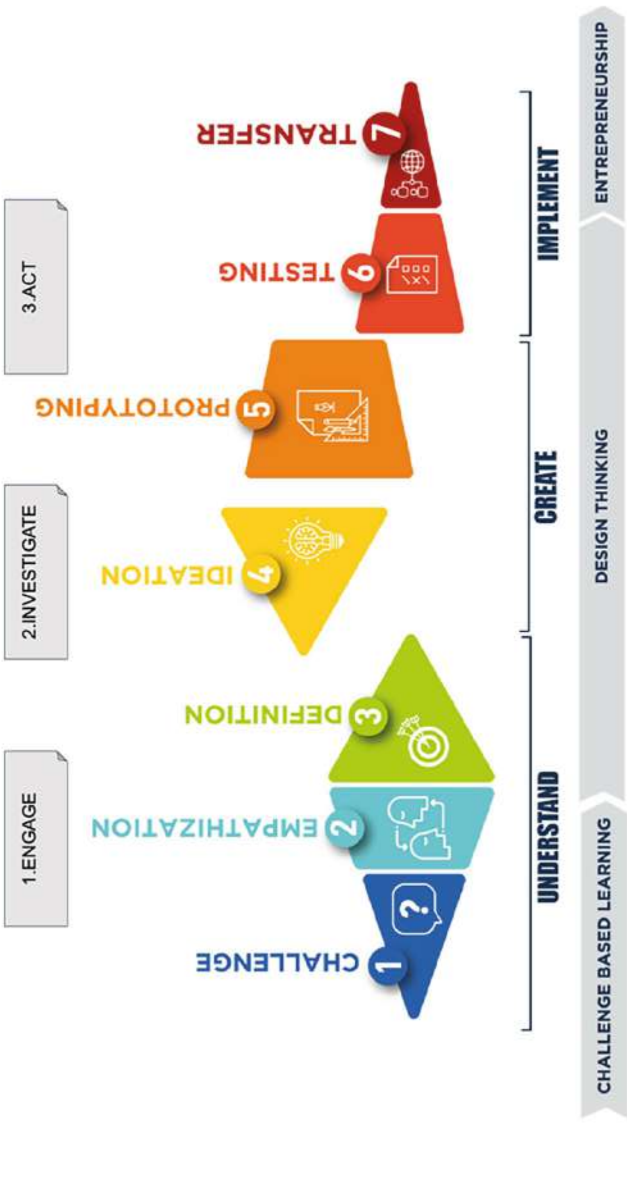

Fig. 6.6 Challenge development methodology

Fig. 6.7 Challenge development tools per phase

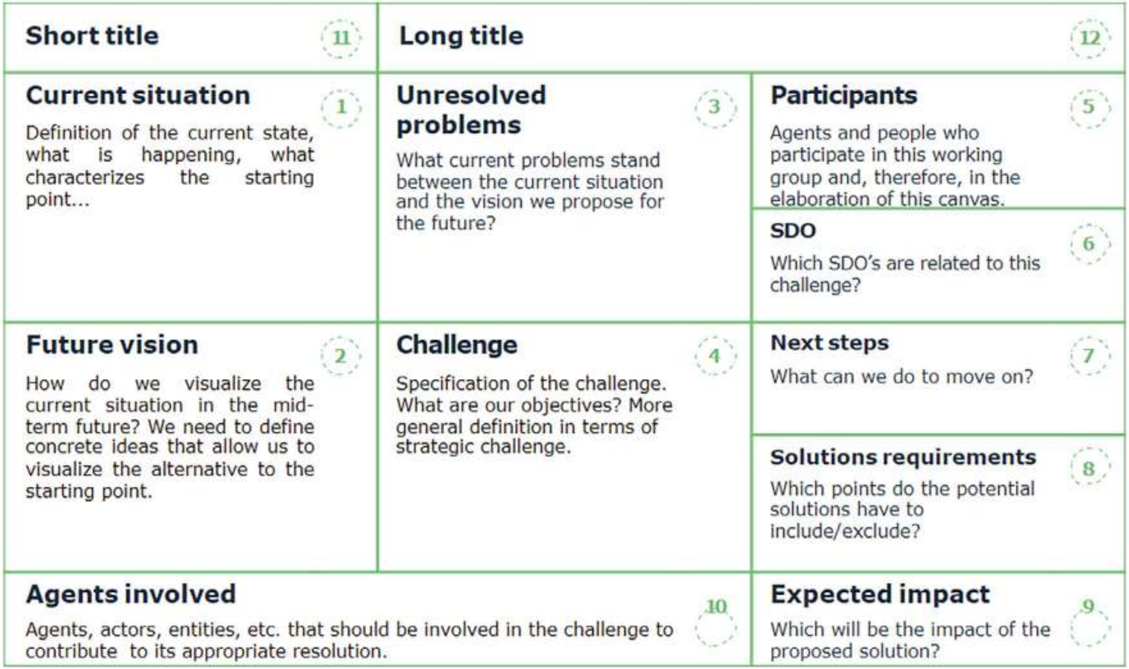

Fig. 6.8 Challenge definition canvas

In order to define the challenge, the specific methodology described in the previous section was put in place, with the help of tools such as the canvas template that guides the process previously introduced. In Fig. 6.9, the first part of the canvas presented before (Fig. 6.8), thinking about the current scenario description with one idea per post, is shown.

Once the challenge was defined, it was published on the ECIU webpage[5] and opened to the participation of the students of all the ECIU university members. 25 students enrolled voluntarily, 16 from the UAB and 9 from other ECIU universities, but only seven got to the end of the full CBL process: 4 from the UAB, 2 from Hamburg University of Technology, and 1 from the University of Trento.[6] The challenge was developed in a hybrid context, combining local face-to-face meetings and remote work.

The challenge was coordinated by three professors from the UAB, with different academic backgrounds:

– Xavier Gabarrell from the Department of Chemical, Biological, and Environmental Engineering
– José Luís Molina from the Department of Social and Cultural Anthropology
– Jordi Verdú, from the Department of Telecommunications and Systems Engineering.

They were all involved in different functions: organising, coordinating, coaching, creating materials, facilitating documentation, supporting, and evaluating the students and their work during the process.

The challenge was developed following the three main phases of the CBL methodology.

Engage *(Empathisation and Definition)*

During the first phase, the students, with the teamcher support, created the teams and got to know the stakeholders and the starting point to learn about the context, to know and learn from each other promoting

[5] https://engage.eciu.eu/browse.

[6] Some more statistical data about the 7 students who completed the challenge: 4 females and 3 males, 4 Bachelor students and 3 Master students. The fields of studies were Environmental studies, Economics and Business, European and International Studies, Food Science and Technology.

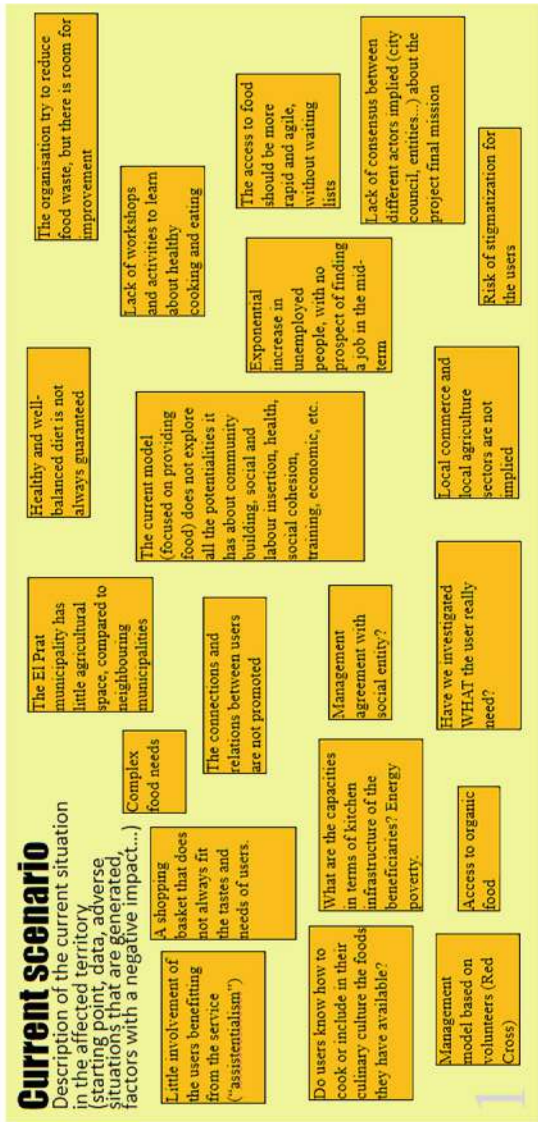

Fig. 6.9 First phase of the canvas to define the general challenge

an empathic environment.[7] Students started to generate some questions and focused to define their challenge:

- How to define an operational and sustainability model for a project that generates a new space of value and a point of reference at a territorial level?
- How can we generate an active community, committed to the project, and connected to the local/global ecosystems that can guarantee the resilience of the project?

Additionally, teams with different profiles and backgrounds are created showing high motivation.

Investigate *(Definition, Ideation, Prototyping)*
The teams shared focus on different proposals with the aim of:

- Rethinking the agro-food chain (local/global) related to the key project of the circular economy.
- Design a new disruptive, inclusive, and social empowerment food management model that can produce a positive change in the agri-food paradigm.

After different contacts with the stakeholders, the students and the Teamchers decided to propose a possible solution in creating a shop, "la Botiga," and they worked on the prototyping of the solution.

The students worked thinking about different concepts such as the target group of the Shop, sustainability, circular economy, cooperation, participation, education, communication, care, etc. They investigated on different successful models such as social gardens, food bank, city allotment, cooperatives, and legal aspects.

[7] A very important presential activity in this sense was the visit to "La Botiga," done by the teamchers and the local students, to better understand the subject and collect ideas on the development of the challenge. The students from the other universities were then informed about the outcomes of the visit.

Act *(Prototyping, Testing, Evaluation, and Transferability)*
The solution of creating a shop was presented in a special public open event in a hybrid mode, with key representatives of the stakeholder and the university (Photo 6.1).

The students, in a cooperative way, explained the process and the proposal of the shop, with a viable plan that considered the technical and economical elements. The final proposal is shown in Fig. 6.10.

The final proposal was collectively evaluated with the students, teamchers, and the stakeholders, taking into account the environmental impact (local production, 0 waist, minimum contamination, clean energy) and the social impact (equality, social inclusion, participation, and education).

The students put into value the learning process, and the transversal competences developed during the challenge, such as entrepreneur spirit, teamwork, and leadership among others. The impact on the territory has been significant, as the shop was created and it is currently working, as shown in the following image (Photo 6.2)

Photo 6.1 La Botiga

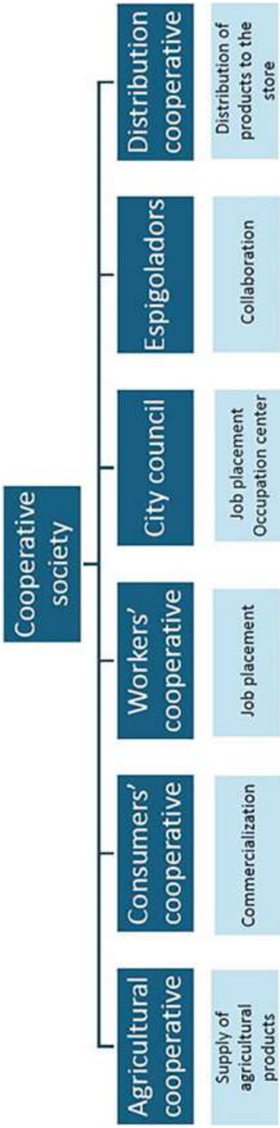

Fig. 6.10 Structure of the cooperative

Photo 6.2 Final presentation

The teamchers valued this first CBL experience very positively: there was a lot of effort and work to do, but the process and outcome were worth it. Some of the lessons learned from their first experience can be resumed it in 5 main points, that we present with their own voices:

- **Previous Training**: It is fundamental to receive training not only about CBL, but also about other strategies that need to be implemented during the challenge, such as how to create the teams and engagement at the beginning…
- **Learning Outcomes**: Quoting the teamchers, "the learning and the results obtained have being higher than our initial expectations, the students were excellent, really motivated and engaged."
- **Adequate Format**. Initially, there were some doubts regarding having to work in a hybrid format, but at the end, it was feasible, and a great way to work CBL in a both local and international level. In this sense, the fact to count with a shared online platform helps to communicate and work easily.

- **Evaluation**: It was difficult to think about a detailed evaluation process, especially about the students' skills and competences. A previous phase with the teamchers, to define the evaluation and to integrate the experience with formative modules, would have helped. The teamchers agreed on the need to create templates and rubrics to help to evaluate the three-phase process of CBL, and to reflect during the process.

  The evaluation processing focused on the active participation of the students, and lead to a pass/no pass grading. The 7 students who were evaluated positively, received an official certificate from ECIU University.[8]
- **Collaboration**: a long-term collaboration between research groups, teamchers, and institutions or businesses would help to increase the impact of the challenge. Several challenges can be concatenated to work on different phases of the same project, and this could be beneficial for the stakeholder, as well as for the learners.

Conclusions

The "La Botiga" challenge has been one of the first CBL experience developed at the UAB, and probably the first one with such a deep intercultural and interdisciplinary perspective.

The general feedback received from the several actors implied (teamchers, students, stakeholders, technical staff) has been overall very positive and enthusiastic, and it is aligned with the one collected from other challenges.[9]

The UAB is now working on the institutional implementation of the CBL methodology in several faculties: challenges are being included in subjects, bachelor thesis and master thesis. The teaching staff is being trained to get familiar with the methodology, and it is clear that students should gain the proper skills and competences to make the most out of the experience, much before being directly involved in a challenge.

[8] Additionally, in some cases, the 6 ECTS of the challenge could be recognised and included in the transcript of record of the student, as an optional academic activity.

[9] The feedback shared by teamchers, stakeholders, and students about the experience of participating in this and other challenges a the UAB can be seen here https://youtu.be/q5s9v3_u4WM and here https://youtu.be/qCcSfqR1N2E (subtitles in English).

In this sense, if the challenges are being offered starting from the 3rd year of academic career, training should start from the very beginning of the bachelor experience, as it covers many transversal skills such as autonomy at work, critical thinking, intercultural competences… all competences that require time and practice and can be applied to any learning experience.

The vision at the UAB is to keep working on the gradual implementation of this innovative teaching methodology at our institution, and to do so in a both local and international perspective, thanks to the institutional commitment, from one side, and the participation in the ECIU University, on the other side.

Case Study Eight—Combining Challenge-Based Learning with the Writing of a Master's Thesis: The Pilot of the ECIU Strategic Challenge

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Frank van den Berg, University of Twente

Introduction

This case study introduces a unique concept of combining CBL with the writing of an individual master's thesis. In this case study, we describe the original CBL-coaching process as well as the actual implementation of the thesis supervision. We reflect on our own experiences and present the participants' reflections on their engagement in this pilot study. We also provide practical implications for those who are interested in combining the supervision of the thesis writing with the coaching of an international, multidisciplinary team challenge within the framework of CBL.

Background and Participants

The ECIU is a consortium of 13 technical universities in Europe and one associate partner in Mexico, which are connected by their shared ambition to 'challenge conventional thinking.' To put this ambition into practice in education, the ECIU started the ECIU University, a real European university that would operate according to CBL. To learn about how CBL could be organised to make students learn, several projects were started in the ECIU University. One of the projects for this ambition is the Strategic Challenge, a project where students would work on their individual master's thesis while simultaneously working on a team challenge in an international and multidisciplinary team of students. The participants were students from the different member universities of the ECIU. The different student teams were coached by CBL experts from three ECIU partner universities, Hamburg University of Technology (Germany), the University of Twente (Netherlands), and Tampere University (Finland).

The Strategic Challenge—The Set Up

In the original set up of the first ECIU Strategic Challenge, the idea was that students would work in teams on a five- to six-month team challenge while simultaneously working on an individual master's thesis. As the challenge and the topic of each thesis would be linked, it was anticipated that the progress of both the challenge and the research in the theses would go together, thereby resulting in mutual benefits. In the original set up, the participating students would, as a team, define their actionable challenge they would work on, and based on that challenge, define what their individual thesis topic would be. That way each individual thesis would really contribute to the team challenge. We also imagined that all participating students would have the same timeline for their master's theses as that of the team challenge, which would last five months.

The process of coaching of the students was planned and designed at two levels. On a team level, students would be supported in all aspects of CBL and working as a team on the challenge by four coaches, all CBL experts of three ECIU partner universities. For their individual thesis, the student was supposed to be supervised by an academic advisor from the home university. Therefore, only duos of students plus academic advisors from the same university could participate in this pilot. The latter was included to ensure that the individual master's thesis would comply with the regulations of the home university, so that the student could graduate and thus would get the ECTS awarded by their home university. As the rules on the master's differed slightly per university, students could earn up to 30 ECTS for completing their thesis. They did not get any extra ECTS for participating in the challenge since the challenge and thesis were seen as one interconnected project with mutual benefits.

Implementation of CBL—Design and Implementation

The Strategic Challenge was set up according to the three phases of CBL: *Engage*, *Investigate*, *Act* (Nichols et al., 2016). Throughout the five-month period, we included several group meetings for all participating teams, for sharing information and exchange experiences. Furthermore, we included meetings for the team with their CBL-coach, for in-depth questions and support. Nine students signed up for this first edition of the Strategic Challenge, from seven different universities across Europe, namely the University of Trento (Italy), the University of Aveiro (Portugal), Dublin City University (Ireland), Kaunas University of Technology (Lithuania), the University of Stavanger (Norway), Linkoping University (Sweden), and Hamburg University of Technology (Germany). The study programmes were multidisciplinary and included Environmental Engineering, Sustainable Development, Architecture, Global and Local Studies, City and Regional Planning, and Climate Change: Policy, Media, and Society.

As the ECIU University had chosen to focus all challenges on Sustainable Development Goal 11 'Sustainable cities and communities,' in the Strategic Challenge pilot, the "Big Idea" was to develop a 'climate neutral university campus in Europe.'

To address this emerging Big Idea, we aligned the process of supervision and the CBL framework and synchronised the timeline as follows:

In the *Engage* phase (seven to eight weeks),[10] students were to form teams themselves, based on their mutual interest in a challenge. A two-day online session was organised to let the students get to know one another, explain to them about the CBL methodology, also addressing the questions as to what the students' roles are in CBL, how to formulate essential questions, how to develop an actionable challenge, who are stakeholders, and let them form teams. Furthermore, we designed some team-building activities and an informative session for all participating academic advisors, so they too were aware of what their students were doing while working on the challenge.

As many students already had a fixed idea of what their thesis topic would be, the order of challenge definition and thesis topic choice was changed: the students tried to find commonalities between the thesis topics they had already chosen, and based on this, formed teams, and

[10] The exact duration of the CBL phases varied depending on the respective team.

Table 6.4 Overview of teams and their actionable challenge

Team	*Actionable challenge*
1	CO_2 emission—scenarios towards a climate-neutral campus
2	Assessing the integrity and transparency of university climate action plans
3	Fostering sustainable travel choices of students with the use of digital technologies

defined their actionable challenge. Although this was not ideal and not completely in line with the CBL framework, in the end this worked well. The definitions of the different actionable challenges are given in Table 6.4.

Team 1, for instance, found as a shared goal in their thesis topics *"reducing CO_2 emission."* In their team challenge, the three students worked on three scenarios towards a climate-neutral campus based on the background of their thesis topics: How more *sustainable land*, *sustainable infrastructure*, and *sustainable buildings* can help reduce CO_2.

To facilitate team collaboration the three teams were provided with materials on CBL and project management and asked to specify their roles and responsibilities, guiding activities, resources, and the team's schedule in a team challenge guide.

The *Engage* phase might appear rather long. However, the students needed this time because the starting conditions in the Strategic Challenge were different as students had to consider some more or less fixed master's thesis topics when developing their actionable team challenge.

The *Investigate* phase (six to eight weeks) started with a face-to-face meeting of all participating students in one of the organising universities. The student teams were invited to share their results and experiences from the first phase, by explaining the process they went through, what the definition of their actionable challenge was, what they had learned from the previous phase and what their plans and planning was for this *Investigate* phase. In addition, we organised some practical workshops that the CBL-coaches thought to be of use. Again, all academic advisors were invited for a 1-hour online session to also hear the presentations of the different teams and give feedback.

For one of the teams, this feedback had a significant effect. The team was already struggling with their definition of their actionable challenge.

The feedback of one of the academic advisors made them rethink their challenge definition, resulting in the team redoing the *Engage* phase from the beginning. This team again asked themselves all kinds of essential questions, leading to a new definition of their Actionable Challenge. Although in regular projects and education this could be seen as the students having wasted five weeks of their time, in CBL such a step back is more common and in this specific case turned out to be a valuable learning experience for the students. They really became aware that sometimes you have to start all over again to make good progress, as one of the students indicated in her evaluation at the end of the strategic challenge: "*The main way that allowed me to fulfil my learning goals was to allow a place for failure and allow me and the team to start over from zero if our approach wasn't suitable.*"

The *Act* phase (five to six weeks) also started with an online session, milestone meeting 3. This time the student teams were invited to a regular meeting of CBL experts of the ECIU, where they explained their challenge and shared their experiences so far and plans for the coming weeks. The CBL experts were able to give valuable feedback that could help students in the last weeks of their challenge. After this meeting with the ECIU CBL experts, the student teams and the CBL-coaches continued with additional discussions and ideas for the final phase of their challenge. The *Act* phase was concluded with a closing ceremony, where all student teams presented their results for the challenge, the solution they had designed and what they had learned from working on this challenge, both individually as well as on a team level. All academic advisors were invited to join this online session. In addition, the students handed in a report on their challenge and solution, and a reflection report.

At the milestone meeting three, all teams were still struggling with their challenge and how to solve it. Some teams had some idea what the solution could be, other teams still had to do some more investigation to come to a thorough understanding of the problem. The final presentations, however, all turned out to be of very good quality. All teams designed good solutions and could explain these well; in addition, they all showed great progress and learning.

In between the different milestone meetings with the whole group, all teams had separate meetings with their CBL-coach. In the beginning of the strategic challenge, this was approximately on a weekly basis, later the meetings were biweekly or at the request of the team. No specific content was designed for these sessions, as it was seen as a coach meeting

Table 6.5 Overview of meetings in the ECIU Strategic Challenge

February		**March**		**April**		**May**		**June**	
7 + 8 Feb	**21 Feb**		**28+29 March**				**17 May**		**30 June**
Kick Off	Milestone 1		Milestone 2				Milestone 3		Closing ceremony
online	online		Face2face				online		online
Engage ---□									
			Investigate --□						
							Act ------------------------------------□		

where the CBL-coach could act according to the needs of the team at that specific moment and phase in their challenge project. This turned out to be a good approach. In addition, all teams had self-organised online meetings with their team members on a regular basis—as far as we heard, they usually met at least once a week for a real-time online meeting but also used common messenger services (such as WhatsApp) for fast and immediate team communication.

In addition to the team coach meetings, we organised several workshops on relevant professional skills, like stakeholder management, cooperation in an interdisciplinary team, etc. These workshops too turned out to have great added value for the teams, as it showed them what to pay attention to when defining their challenge and made them much more aware of their own discipline and appreciate other disciplinary points of view (Table 6.5).

Reflection by Students

Continuous reflection on one's own engagements, actions, progress, interim results, and the process of learning is an inherent part of CBL. Therefore, we encouraged our students to reflect on what they were doing by keeping a team learning diary and suggested that they do this on a biweekly basis. Also, at all milestone events, the students were to reflect on the CBL process. This means they not only presented their interim results, but also shared their experiences and lessons learned (both on content as well as on the process) and gave practical tips to the other teams. These tips were almost all on the process, e.g., their way of working and cooperating. Towards the end of the Strategic Challenge, teams as well as individuals were asked to submit a final reflection report. The teams' report included guiding questions on starting point, project management, teamwork, satisfaction with results, and tips and tricks. Individuals were asked to reflect on their personal learning goal, their role and contribution to the team, the connection of their thesis and the team challenge, and benefits and next steps.

Assessment

Assessment was comparable to the coaching, conducted at two levels. Assessment of the Master thesis was done by the academic advisor of the student. As the academic advisor was from the home university of the student, the assessment was done according to the criteria, rules, and regulations of the home university. This guaranteed that upon positive assessment, the student would gain the credits and thus could graduate from the programme of study. Assessment of the challenge was done in a different way. As CBL is all about learning, we decided to not assess but instead give the teams feedback on the result of the challenge and their respective processes. We did this in the form of tops (what is good) and tips (what can be improved and how), to make this feedback a real learning experience.

In this pilot, we made clear to all participating students that when a conflict would arise between their individual master's thesis and the team challenge, their master's thesis would prevail. This was decided because the students needed their master's thesis while the team challenge was an addition. In other CBL based programmes, this might be the opposite, where the team challenge prevails over individual tasks.

Evaluation: Students, Academic Advisors, and Coaches

The evaluation of the Strategic Challenge consisted of different sources: anonymous questionnaires from the students, both at the beginning and end of the challenge; learning diaries by the student teams; final reflection reports by the challenge teams and individual students; impressions as coaches, gathered through discussions with the students and academic supervisors.

Five out of eight students completed the entire questionnaire, which consisted of nine questions on a four-point Likert scale, four multiple-choice questions, and eleven open-ended questions. Although the results are based on a small-scale, they do offer first indications of the experiences and evaluations of all parties involved.

Benefits for Students from Participating in the Strategic Challenge

Students' Evaluation

Overall, the pilot of the strategic challenge turned out to be successful as the students had a unique learning experience and significantly enhanced their professional skills. They reported having improved their teamwork, project management skills and intercultural competencies, skills that are crucial for working on international projects.

Combining the challenge and an individual master's thesis required students to balance their efforts between two distinct yet interconnected projects. Students reported that that they found this a challenging but valuable learning experience as they learned how to better self-regulate the two processes simultaneously. And despite facing some difficulties in organising their work due to differences in thesis schedules and time zones, the students expressed their enjoyment in getting to know peers from various countries and universities. In the questionnaire they stated: "*I liked the most the intercultural aspect of the challenge*" or "*I liked that we were working in an international team and that the topic was very relevant.*"

The students were very positive about the combination of working on their individual master's thesis and a team challenge. To them, it was worthwhile and rewarding to participate in the strategic challenge, even when it took them additional time. They stated that the challenge of the group benefited from the individual thesis (e.g., "*In my thesis I ended up with results and discussion points of which I was actually able to use some as input for the challenge and this helped me to also work with the topic of the challenge more easily*") and for most of them the individual thesis benefited from the challenge. They got a better understanding of the wider context of their thesis and several students also deepened their understanding of the content of their thesis. Examples are: "*It [the challenge] helped my thesis in that some of the research led into it*" and "*In general, I think it is a great opportunity for students to explore different ways for their theses as in my case the challenge and the possibility to meet new people has* *influenced the approach of my thesis, simply said it gave me the opportunity to run comparative case study of two universities.*" and "*For my thesis, some experience shared by some ECIU advisors and colleagues was very useful, having allowed me to add and even improve important points of the thesis […].*"

The reflection reports demonstrated an increased understanding of their fellow students' study conditions and personal circumstances, along with an appreciation for the diverse expertise and approaches brought by the experiences and different disciplinary background of the other team members:

> One of the most important experiences I had for myself was being able to work in multidisciplinary and international team and understanding how different backgrounds shape different understanding, opinions, perspectives, and ideas.

The combination of the thesis and challenge allowed the students to learn that taking a step back and redoing part of the work is sometimes the best way to move forward. They acknowledged that learning from mistakes, generating new ideas, and fearlessly starting anew is part of the process. One team advised in their final reflection report:

> It is ok to start over at any stage of the project. It does not mean that you have to start from zero - you have a piece of valuable information about the aspects that did not work as a solution and that is progress on its own. […] Learn from mistakes and look for constructive feedback and critique. Do not be afraid to fail and experiment with your ideas.

In addition, students appreciated the relation to real-life problems that the challenge-based learning experience includes:

> The most important experience for me was to try to solve the real-life challenge from a practical, not only academic perspective. This kind of experience with solving real-life challenges, communicating with stakeholders, and finding compromises is something that I think will be very useful for me in the future, both in my career and beyond. I have to admit that it was a difficult but in a long term very valuable experience.

Concerning their team challenge, the students made remarkable progress in developing innovative ideas and effective solutions, including final reports of remarkable quality (ECIU, 2022, Oct 11). Regarding the coordination and implementation of the Strategic Challenge, students appreciated the support by the CBL-coaches, and the majority found it useful to regularly reflect on the teamwork and progress.

Academic Advisors' Evaluation

The academic supervisors recognised an added benefit of student involvement in the strategic challenge, as they observed that it enabled students to situate their thesis topics within a broader context. They also saw an enhanced motivation and commitment of the students to their theses.

Lessons Learned

With regard to the implementation and evaluation of the strategic challenge, we can summarise the following lessons learned:

- Combining an individual master's thesis while simultaneously working on a team challenge can be a valuable learning experience for students. Students learn to see the wider context of their thesis, while at the same time improving their intercultural teamwork skills.
- Combining students from different universities where all had their own planning and criteria for the master's theses makes the project complex but still mergeable.
- The international composition of the teams, for which students signed up, made the organisation more complex but it was found to be a great added value.
- Having an individual academic advisor for the thesis supervision and a separate CBL-coach for the team challenge was beneficial, as both projects required different processes of coaching.
- CBL-coaches played an important role in the development of students' additional competencies. Since the coaches acted as guides, they helped the teams to take over responsibility for the entire process—the team composition, the challenge, possible activities, the development of a solution—and to acquire the knowledge and skills they needed to solve the challenge.
- The CBL-coach supported students going through the CBL phases, by asking lots of questions and helped the team diverge in the first half of a phase, and then converge in the second half of the phase.

Also, the coach encouraged students not to think about and focus directly on solutions in the first two phases.
- CBL is a flexible methodology that can be adapted in different contexts, even in combination with the writing of master's theses. It is possible to have already fixed thesis topics and based on that define a group challenge. Even if this means the link between the thesis topic and the challenge becomes indirect.
- Working on CBL provided more room for failure, which should be seen as a learning opportunity, thereby leading to greater learning in the thesis as well.

All in all, this pilot proved to be very valuable for the students and gave many new insights into learning from the CBL methodology and planning innovative ways of master supervision. This innovative approach of the ECIU strategic challenge holds great potential for advancing education and preparing students more effectively for requirements in the professional world, now and in the future.

Our Basic Guidelines for Future Implementations

Below an overview is given of basic guidelines for educators, teachers, and academics who are interested in implementing a strategic challenge that combines individual theses with team-based challenges:

- **Timelines**: Strive to align the timelines of individual theses as best as possible, ensuring that the start and finish dates of the different theses are synchronised as much as possible. This alignment helps create a cohesive and coordinated approach, allowing for better integration between the individual thesis work and the team challenge.
- **University Procedures**: Be aware of the different procedures from different Universities and countries. Inform about differences before you start.
- **Two Level Coaching**: Involve a CBL-coach in addition to a thesis supervisor. The CBL-coach can support during the stages of CBL and support team progress.

- **Regularly Coach Meetings with the Team**: Meet regularly. We recommend weekly meetings in the *Engage* phase and biweekly meetings in the *Investigate* and *Act* phase.
- **Team Composition**: Consider diversity in the composition of teams (students from different countries, different disciplines). This adds to the unique learning experience (different perspectives, additional data, etc.)—although it also adds to complexity of the teamwork.
- **Skills Improvement**: Incorporate workshops focused on cooperation and project management to enhance the effectiveness of (international) collaboration. Be flexible in offering additional workshops based on students' indicated interests and needs.
- **Reflection**: Make sure that students continuously reflect what they do and share their reflection.
- **Room for Failure**: Encourage students to fail and let them learn from mistakes, especially in the beginning of the project. Let student reflect on their mistakes and failures, as this will greatly enhance their learning.
- **Feedback**: Make sure that students collect feedback at different stages of their work, from different stakeholders, teachers, coaches, and peers.
- **Exchange and Networking**: Provide room for brief exchanges between academic supervisors and coaches.

Case Study Nine: Using CBL in a Specific Extra-Curricular Model

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Challenge-based learning (CBL) can be seen as a new learning approach that helps students to develop skills needed to solve the challenges of modern society in today's VUCA world (VUCA is an acronym standing for volatility, uncertainty, complexity, and ambiguity, characteristics that make a situation or condition difficult to analyse, respond to, or plan for) (Gallagher & Savage, 2023; Swain-Oropeza & Renteria-Salcedo, 2019). In order to introduce CBL into the learning and teaching practice at

Kaunas University of Technology (KTU), a CBL ecosystem was developed, which includes the strategic vision and priorities of the university, the framework for developing the competences of teachers and team members, and the development of the practice community, as well as the implementation of CBL in the curricular and extra-curricular modules.

The aim of this case study is to present this ecosystem, which has been developed as an example of the application of CBL in a specific extra-curricular module, and to identify the lessons learnt. The module is called "Development of Challenge-Based Innovation" (6 ECTS). The aim is to enable students to solve complex real-life challenges in an innovative way, using the CBL approach and working in interdisciplinary and intercultural teams.

KTU Course Implementation Team

To ensure that the course runs smoothly, the University has a Course Implementation Team (CIT) whose members have different roles and responsibilities. This team is mainly responsible for 3 key areas: administration, external communication, and team teachers (teamchers).

Administrative functions include student registration, student verification, formal enrolment in the university as a student, and recognition of skills at the end of the course. External communication covers all communication with external partners during the course. The invitation of guest speakers and experts to the course is also covered. Internal and external promotion of the course is managed by the external communication sub-team but receives input from the whole team.

In line with the CBL philosophy, teamchers spend most of their time with the students, managing the teams and their progress, organising consultations, providing initial communication platforms, implementing CBL directly with the students.

All members of the CIT are involved in the selection of challenges, the formation of teams, and the presentation of students' progress. The CIT communicates through digital platforms throughout the course, allowing the whole team to monitor the progress of the students and any problems/questions that may arise, which are addressed immediately.

Constructive Alignment of the Course

To achieve the objective of the course, five intended learning outcomes have been identified that relate to the application of the CBL approach in the study process. After this course, students will be able to:

- Formulate a research question using interdisciplinary knowledge and skills.
- Solve complex real-world challenges in an innovative way, based on the key principles of challenge-based learning.
- Apply the principles of effective teamwork and leadership in interdisciplinary and multicultural teams.
- Create innovative ideas according to the needs and characteristics of the audience.
- Present developed prototypes effectively to different audiences.

These five main intended learning outcomes correlate well with the three main phases of CBL, where the *Engage* phase involves the formulation of questions and possible research directions; the *Investigate* phase involves information gathering and research, while teamwork becomes essential in the creation of innovative ideas. The *Ac*t phase of CBL covers aspects of clearly presenting new ideas to different audiences and developing actual solutions to complex problems.

The learning outcomes are achieved through the use of the CBL method as well as complementary activities such as creativity workshops, guest speakers, seminars, and specific techniques such as idea mapping, short team presentations on the ongoing process, framing potential risk map.

The assessment strategy consists of a formative and summative assessment. Formative assessment is used to assess student progress and anticipate future development. The summative assessment aims at the final evaluation of the solution. Phase 1 assessment items are the challenge proposal, the essential questions, and the justification of the importance of the challenge. Phase 2 assessment includes: research design and primary solution. Phase 3 assessment focusses on solution implementation, evaluation, and dissemination. The assessment includes peer assessment, reflection on action, oral presentation, and a report. Peer assessment and reflection on action are used for formative assessment of the course. An oral presentation and a report are used for the final assessment of the course.

Preparation for the Course

The beginning of the course consists of two main processes that come together during the first meeting of the CIT. One is the development of the challenges with the challenge providers. The other is the registration/selection/assessment of the course participants and the formation of teams.

Challenge Providers. The course is run every semester, so communication with challenge providers continues throughout the academic year. Several discussion sessions are arranged outside of the actual course to evaluate possible ideas for the students and to present general course information for a smooth running of the semester. During these meetings, Challenge Providers are also presented with the formal schedule for the semester to facilitate their planning. Their participation is required on no less than 3 occasions: at the beginning of the course, at the presentation after the *Investigate* phase, and at the final presentation.

Some Examples of Key Points: Presentation for the challenge providers on the context of the course, possible benefits they could receive in the form of unique ideas from students, and that it is an added value such as participating in the challenge solving process, collaborating with students and course teachers, and sharing best practices. Technicalities such as presentation duration, formats, and availability (for presentation dates) are also agreed.

Student Selection. Student registration/selection takes place in the first few weeks of the term, before the actual course delivery begins. When registering for the course, students can choose which challenge they would like to undertake from those offered by the challenge providers. The teams are formed by the CIT. The composition of the teams is based on the students' backgrounds, skills, and the possible solutions to the challenge that can be foreseen, with a team size of 4–6 students.

Some Examples of Key Points: The aim is to have multicultural and multi-background groups for a more diverse pool of ideas. Having students from the same field in a team leads to predictable outcomes, which defeats the purpose of CBL. Experience shows that smaller teams tend to struggle, while larger teams tend to have a lower level of engagement from team members. Typically, there are 2–4 teams per course with 2–3 different challenges.

Intellectual Property. Intellectual property issues related to the challenge solution are discussed with the challenge provider before the challenge is published. Social partners/stakeholders submitting a challenge are often invited to sign a cooperation agreement with the university. The agreement outlines responsibilities, obligations, the extent of the social partner's involvement, intellectual property arrangements, opportunities for commercialisation of the challenge solution, and other relevant matters.

Some Examples of Key Points: If there are no issues with this matter, the best course of action is to follow the university's internal policies.

Course Design

In this application of CBL, the first phase, *Engage*, usually lasts 4 weeks, the second phase, *Investigate*, 6 weeks, and the third phase, *Act*, 5 weeks. Each week there is a scheduled session with the team leaders where the student teams are given specific tasks as per the CBL process. In addition, there is an option for teams to use a teamcher consultation, which is more dedicated to the implementation of the teams' challenge solution. Teams are assumed to have one or more informal meetings each week on their own. The detailed course design and activities are shown in Table 6.6.

To ensure that CBL is implemented correctly and that each team is on track with their progress, there is an oral presentation at the end of each CBL phase, as well as short check-ins during each weekly meeting with the team leaders, where the teams present their progress since the last meeting.

It is important to note that this CBL is exclusively delivered through distance learning tools and the delivery process has been enriched with various technologies. For example, the Zoom platform was employed for the weekly meetings and the Miro board served dual purposes, i.e. assigning to give students specific tasks related to solving challenges and to collect information in a board. Moodle was also used in the course so that students had all the study courses available. Mentimeter and Google

Table 6.6 Course design and main activities

Phase	*Time period*	*Teamchers activities*	*Students Activities*
Engage	1–4 week	• Introduction of CBL • Team-building activities • Big idea/Challenge introduction • Presentation about the aim of phase 1 and expected results • Consultations • Assessment of 1st phase progress;	• Active discussions about big idea/challenge • Prepared list with essentials questions • Defining actionable challenge;
Investigate	5–10 weeks	• Presentation about the 2-phase aim and expected results • Consultations • Organised meeting with big idea/challenge provider • Evaluation of the phase progress	• Prepared list with guiding questions • Identified guiding resources • Conducted research • Synthesis of the results • Primary concept of solution • Consultations with a big idea/challenge provider
Act	11–15 weeks	• Presentation about the objective of 3 phases and expected results • Consultations • Organised final assessment event	• Validation of the final concept of the challenge solution and development of a prototype solution • Developed a plan for the implementation of the challenge solution • Test the prototype and improve it after collecting feedback • Implement the challenge solution and analysis of the effectiveness, success, impact • Presentation of the results

Forms were also some of the examples of online tools that helped to increase student interaction throughout the course.

The Start

The first session of the course was attended by all CITs, Challenge Providers, and invited guests. Challenge providers give presentations on how and why their challenges were important and provide the context of their organisation for a possible higher impact of the solution. The CBL concept process was presented, and the course formalities were discussed. Students were introduced and teams established their communication methods outside the course. Some examples of previous challenges are given in Table 6.7.

Some Examples of Key Points: The first meeting time and date was given by the CIT, the rest of the schedule was discussed with the students to adapt the schedule as much as possible to their own, as the students come from different universities, time zones, and continents. The Doodle polling platform worked well for the task of setting the meeting schedule for the course. Dynamic adjustments were possible during the course, especially with regard to additional consultations with teamchers.

Table 6.7 List of challenges with challenge providers

Team	*Big ideas/challenges*	*Big idea/challenge provider*
1	Transition of a City towards Circular Economy	Kaunas City Municipality
2	Transforming a Municipality into a Digital City	Kaunas City Municipality
3	Changing the Game in Household Waste Sorting	Kaunas Region Waste Management Centre
4	Increasing Energy Sustainability among Consumers	Group Ignitis
5	Creating an environmentally friendly community for pets, pet parents, and cities	Mars pet nutrition
6	Energy Consumption and CO_2 Footprint Reduction in the Offices of Lithuanian Business Companies	Scania
7	School Education on Conscious Consumption and Waste Disposal	Kaunas Region Waste Management Centre
8	Consumer Digital Engagement for Energy Sustainability	Group Ignitis

Engage

In this first phase, *Engage*, teamchers guided students from the big idea to an actionable challenge. It was very important to assure that students from different fields of study and different cultural contexts start working together as a team. This required additional tasks and activities such as having a short talk with a team and offering some tools for the team formation.

In each session with the teamchers, there were team-building exercises with the slogan "from group to team." For example, the first exercise "from group to team" was used to fill the team agreement (Fig. 6.11).

In this phase, the concept of essential questions was presented to the students. Digital collaboration platforms were used for the collection and grouping of essential questions. Figure 6.12 presents an example of how essential questions, and their grouping were performed on the Miro board.

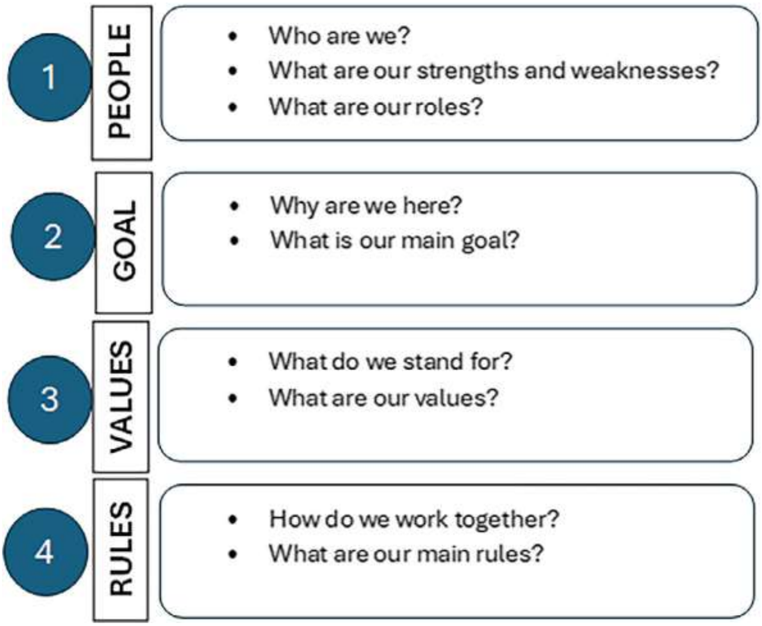

Fig. 6.11 The team agreement

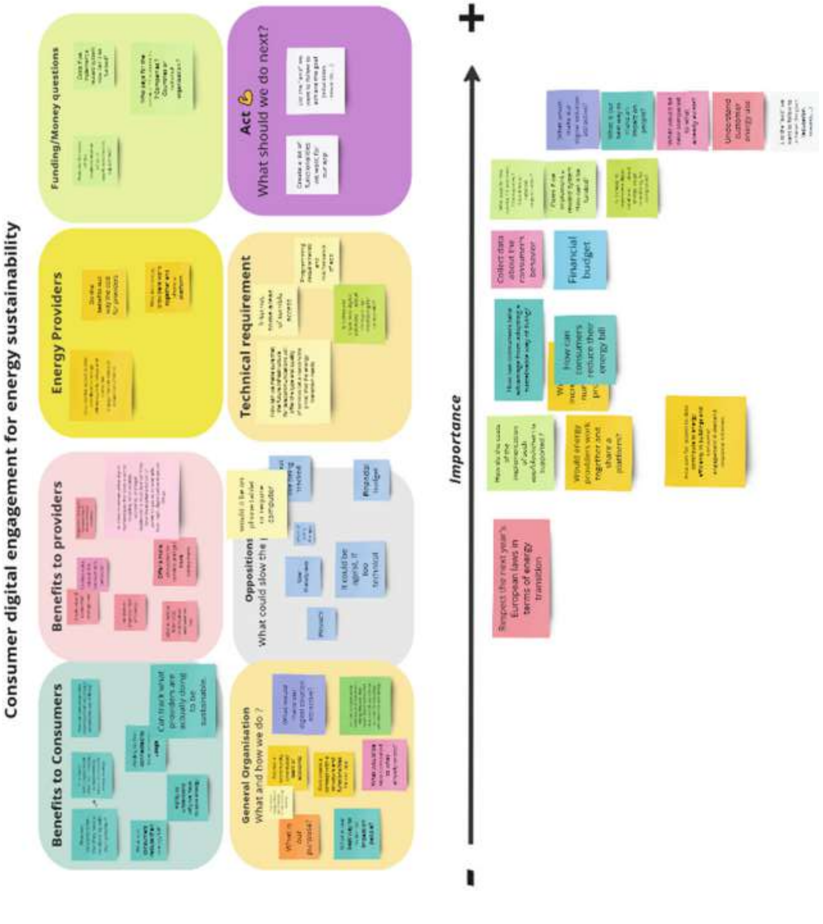

Fig. 6.12 Generating and grouping essential questions

At the end of this phase, the students presented their key questions and explained why they had chosen the specific final formulation of the challenge that they would solve. The whole CIT attended this presentation and gave feedback to the students.

Some examples of key points: It should be noted that after this phase, teamwork starts to emerge from the group of students. If the team exercises mentioned above indicate slow progress in team building, a small intervention by the teamchers with additional exercises (short creative tasks, such as provocative questions (how to measure the speed of light with a piece of chocolate?) as a nano challenge) is beneficial.

Investigate

The *Investigate* phase is the most important and time-consuming part of a CBL project. In addition to the specific tasks to help students with their real actions, teachers were invited (depending on the challenge the students are solving) to give a theoretical background. As an example, the teachers were helping students with the design thinking methodology, artificial intelligence skills, or how to pitch a presentation.

During the first meeting, the *investigate* phase teamchers provided examples of how to develop guiding questions, resources, and activities. A work plan was devised during the second meeting of this phase, where the teams established their responsibilities for the specific areas of research required. During this phase, teams were encouraged to revise their initial challenge formulation, based on the research undertaken.

An additional meeting with challenge providers was also held or a set of inquiries was passed on by the CIT. The format of such meetings is discussed between teamchers and students. It was either one meeting or a set of questions for the big idea/challenge providers, to be answered by email.

During this phase, the progress of the teams was also constantly monitored by the teamchers. The teams presented their progress and received feedback. Invited teachers were asked to provide expert comments in the field of the possible challenge solution. The teams were highly encouraged to use scientific and official statistical data for the decision making in this phase.

At the end of this phase, the students presented their potential solution and provided evidence and rationale for their choice. The entire CIT and the big idea/challenge providers participated in this presentation and gave feedback to the students.

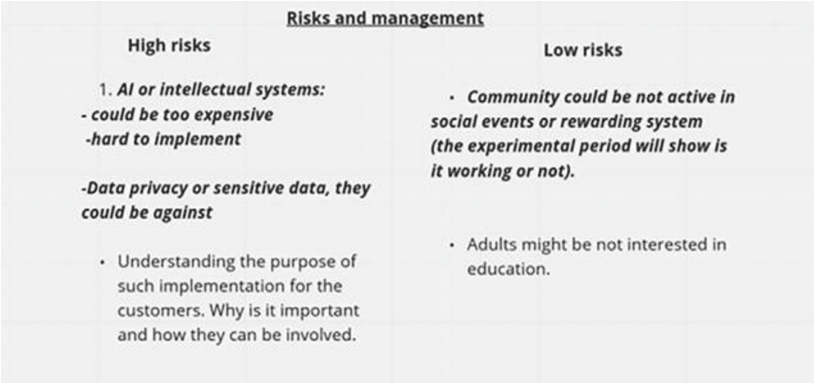

Fig. 6.13 Example of evaluation of actual solution

Act

In the *Act* phase, the actual solution was implemented by the student teams. As this course was given as a distance learning course, physical prototypes of the solutions were not options; thus, they were mainly digital solutions (apps, algorithms, etc.), guidelines (examples, use cases, etc.), or digital content (videos, cartoon characters, learning material). Teams were encouraged to follow the slogan 'have something to deliver.' Teams usually develop a draft solution and then further to test it and to improve. During this phase, teamchers provided guidance on project resource management, risk management, and teamwork management. More consultations with teamchers and, if necessary, with challenge providers were scheduled for teams during this phase. Intensity of consultations was mainly set by the teams themselves in consultations with the teamchers (Fig. 6.13).

At the end of this phase, the students presented their final implemented solution. The entire CIT and the big idea/challenge providers participated in this presentation and gave feedback to the students. Big idea/challenge providers received deliverables the teams produced.

Assessment of Learning Outcomes

The course was designed as extra-curriculum; thus, the assessment outcome was formulated as pass/fail. Students had to make presentations two times per semester and provide a report at the end of the course. The course was formalised as 6 ECTS and was recognised as such as an entry in the diploma supplement for full-time Kaunas University of Technology students, or as ECTS passing certificate for the students from different institutions.

A report was comprised of two main parts: process reflection and solution description. The first part of the report covered team progress throughout the CBL process and team-building process. The second part of the report described the technicalities of the solution itself, deliverables, and possible further improvements after implementation. There was an agreement that the implementation plan was a mandatory part of the report if the team's results did not contain any deliverables.

In addition to the report, additional feedback/assessment was collected from different parties. This practice is usual during the final presentation of the solutions, where all the course team members and guest experts (when applicable) are participating on the defence.

Students assess their performance in the team and performance of the team. The assessment form consists of two parts. In the first part, students are invited to evaluate statements on teamwork. A five-point response scale is used to answer each item (Fully agree/Rather agree/Neither agree nor disagree/Rather disagree/Totally disagree). Students evaluate such statements as:

- *I think our team approached the challenge in a structured and focused way.*
- *I know the tasks of my role in this team, and I think it is useful and important.*
- *The discussions in our team were mostly effective and based on the subject matter.*
- *In our team we helped each other and focused on solution rather than problems.*
- *Everyone tried to resolve conflicts in the group constructively.*
- *The process of decision making is transparent and fair.*
- *Important decisions were made together.*
- *The difficulty level of this teamwork is appropriate.*
- *I know my responsibilities and have no problems fulfilling my tasks.*
- *I am satisfied with the process of our teamwork.*

The second part consists of 4 open questions such as:

- *What do you like most about this teamwork?*
- *What would you like to change?*
- *What could be improved in communication with peers, teacher, team leader, big idea/ challenge provider, other stakeholders?*
- *What is still bothering you? What could help to overcome this hurdle?*

Teamchers and invited experts focus on the presentation of the teams and the solution itself. The big idea/challenge provider assessment looks at the solution from their own perspective of implementability and added value. They also evaluate the solution using these questions:

- *Is the solution founded on hard proof and a social context?*
- *Is the solution implementable in the short term?*
- *How relevant would the final solution be to stakeholders?*
- *Were expectations met?*

Due to the nature of providing this course through online platforms, a Google form is used to perform feedback collection. The results of all assessments are provided to the students and insights are provided for further development of the solution from different perspectives. This is technically provided as a short presentation (up to 10 min.) by the Teamchers based on the feedback collected. The content of this presentation is adjusted considering the context of the teams, challenge providers, and overall course dynamics.

Furthermore, in a situation where more than 5 teams of students are enrolled, a final presentation is turned into a friendly competition, where the assessments of the mentioned parties are used to select the 'best solution' of the course.

Lessons Learned: Student and Teamchers Reflections

In addition to the added value of the CBL, it is important to mention three main aspects particularly in the context of a technology-integrated university:

- real-world relevance.
- active participation of students.
- resilience and adaptability.

Enhanced Real-world Relevance: CBL focuses on real-world problems and scenarios, which helps students to experience practical application of acquired competencies during their studies. The CBL process helps to connect your learning through hands-on experience with the world outside the classroom, making it more meaningful and engaging.
Amplified Active Engagement: Challenges inherently require active participation and engagement. Students are encouraged to think critically, analyse situations, brainstorm ideas, and collaborate with each other and with different stakeholders solving the challenge. This active engagement promotes deep learning and helps to develop problem-solving and critical thinking skills.

Fostering Resilience and Adaptability: Challenges often involve encountering obstacles, setbacks, or unexpected situations. By participating in the CBL process, students develop resilience and the ability to persevere in the face of challenges. These qualities are essential for navigating the complexities of real life and preparing students for future projects and professional endeavours.

It is important to acknowledge that CBL is a two-way road. Big idea/challenge providers gain a unique opportunity to network. Students establish connections and build relationships with industry experts and professionals. This networking aspect not only opens the doors to internships, job opportunities, or future collaborations. Students can benefit from the expertise, guidance, and potential support of industry experts as they progress in their careers.

Case Study Ten—Implementing CBL in a Professional Context at the University of Stavanger

Masoumeh Shahverdi, University of Stavanger
Tim Marshall, University of Stavanger

Introduction

This case study explores a unique CBL implementation in a non-education context at the University of Stavanger with administrative communication staff over a six-month period. This has been the first implementation of its kind at our institution. The project involved 23 staff across for their department and communication advisors from the different faculties, including the Museum of Archaeology. Following the completion of this implementation, the authors conducted two in-person focus group sessions held to gather in-depth reflections from the participants on their experiences of the CBL process. We include direct quotations from this focus group sessions throughout our case study to offer participants' reflective voices on their experience of CBL and the insights gained.

Background

The Department of Communication and Public Affairs at the University of Stavanger led by Director Vibecke Lykke Olsen requested for CBL expert Masoumeh Shahverdi and Tim Marshall to design and implement a CBL learning project for their department project. The thinking behind this exercise was to bring together members of staff who work in the field of marketing and communications but in different departments across the university to choose a '*wicked problem*' that they face in their daily work. By dedicating time to specific CBL sessions, this took participants out of their usual working environment to address the problem with a different way of thinking and arrive at solutions that will be practically implemented in their daily work. It was important for the director to bring together her team and create dedicated sessions to think with a different perspective on their daily challenges as her reflections below illustrate.

> For me as a leader, I think it was a really useful experience a because we needed to pull the extended team closer. I have worked with similar methods with students before, but never with colleagues like this, and it was so lovely to see the potential that this unleashed when we actually got out of the normal 'admin;' mode that we're in all the time.—Vibecke Lykke Olsen

> It was a great opportunity to experience the new method of working, and for me at first it was a bit challenging literally, but it was a great help when you (MS) first launched the steps in the method.—Vibecke Lykke Olsen

Implementation Strategy

Masoumeh as the CBL expert in consultation with Vibecke, the Director of Communications created an implementation plan/programme over the course of six months from November 2022 to April 2023. The project duration lasted from 24th November 2022 to 2nd June 2023 with ten in-person sessions, three for each phase (see Table 6.8). This is an unusually long implementation period compared to typical CBL implementation in an educational context (with the exception of using CBL for a master's thesis—see case study seven). However, it needed to be scheduled around the availability of busy professionals. Masoumeh introduced each phase with an overview of the framework and detailed examples of the respective tasks such as how to devise essential questions. She also presented tools to use in the later stage such as the fishbone and six thinking hats technique. The participants were divided into five teams to ensure they were working across departments with people that they did not usually work with on a day-to-day basis. This aligns with the multidisciplinary nature of CBL teams that we see in student implementation and encourages participants to step outside of their comfort zone and think differently. The teams used the online collaborative platform Miro to work through the CBL phases, which enabled them to have a space they could return to outside of the fixed sessions whenever they wished to add contributions to the discussions. Table 6.8 details the specific dates for the course programme.

Engage *Phase*

Team Formation

As is common in CBL implementations, the *Engage* phase started with the team formation process on the 24th of November 2022. Vibecke formed teams by mixing employees based on where they work. Each group had a mix of members from the Department for Communication and Public Affairs (AKS) and the faculties or museum and their field of work and competence. The aim was to put together teams with mixed backgrounds, i.e. people that normally work with different subjects and

Table 6.8 Implementation programme

Date	*Activities*	*Phase*
24th November 2022	Team-building game and team formation Introduction to the *Engage* phase	*Engage*
24th November to 10th January 2023	Teamwork on Miro	
10th January 2023	Outcomes of the *Engage* phase	
13th January 2023	Team pitching sessions	
17th January 2023	Introduction to the *Investigate* Phase	*Investigate*
17th January to 9th March 2023	Teamwork on Miro	
14th February 2023	Outcome of the *Investigate* phase	
14th March 2023	Team pitching sessions	
18th April 2023	Introduction to the Act phase	*Act*
9th March to 14th April 2023	Teamwork on Miro	
14th April and 12th May 2023	Outcomes *Act* phase	
2nd June 2023	Team pitching sessions	

different areas. A team could for instance have a communication advisor from AKS, a communication advisor from a faculty, a member from the marketing team in AKS, an event coordinator from AKS, a member of the web team, the social media team, a public affairs advisor, etc. Each team had four to five members in total. This, therefore, aligned with CBL team formation principles to aim for a multidisciplinary orientation. Once teams were formed, Masoumeh and Tim initiated team-building games and activities including collaboration and communication skills in an informal setting.

Establishing the Big Idea

Also, on the 24th of November 2022, Masoumeh presented the *Engage* phase which participants learned how to develop a challenge from a Big Idea in their five teams, with each team's challenge detailed in Table 6.8 As detailed elsewhere in this book, a Big Idea is often a singular concept like '*Digitalization*' or '*Sustainability*' to link a global issue to a local problem for CBL participants. In this case, it needed to be adapted to be more concrete and relatable to the work of the UiS staff. The teams identified '*brand awareness*' as the Big Idea. It was decided by Vibecke and emerged from a brand awareness survey that had previously been conducted. Participants still thought globally in the sense of contextualising and comparing the challenges faced by their university to others both in Norway and beyond.

Masoumeh explained the concept of the Big Idea using the examples above to foreground the participants in CBL and to get them to start thinking about problem-solving and thinking through a problem holistically and thoroughly without jumping quickly to solutions. Masoumeh also guided them through the process of developing essential questions using examples from other CBL implementations. This allowed participants time to understand how to apply it to their own context and reflect on the process.

Developing Essential Questions and Creating a Challenge

After this introduction to CBL, participants began to brainstorm on and develop their essential questions and identify their challenge using the Miro board. This phase lasted about two months. During this time, participants worked on the Miro board to continue the process of refining and adjusting their essential questions and seek constructive feedback from CBL experts. Like students in the *Engage* phase, this process led them to revisiting, reflecting, and refining their questions into a single essential question. Table 6.9 shows the final essential question that each team decided upon and their challenge:

On the 10th of January, the participants met in person- for the second time for initiating teamworking, sharing progress in their challenge, and seeking feedback from Masoumeh and Tim as CBL experts. The *Engage* phase concluded on the 13th of January 2023, when the participants met physically to present their challenges in five-minute 'pitch-sessions.' Here they received further feedback on their understanding of the CBL from their colleagues as the content experts. Below are some reflective quotes from participants on what they gained most from the *Engage* phase:

> It was valuable, the strong focus on the big idea how, how important it is to question things, to come up with lots of questions in the beginning of this process. I that is very useful and something I will try to take with me.—Participant - Team 2

Table 6.9 Essential questions and challenges per team

Team	*Essential question*	*Challenge*
Team 1	How does UiS contribute to the region (Norway and beyond?	Increasing visibility and sharing success stories at UiS
Team 2	How can we increase the external visibility of UiS to add value to our brand?	Increasing visibility and awareness, broadening collaboration between UiS, the society, and professional working life
Team 3	How can we increase the involvement of UiS staff in brand awareness?	Strengthening the involvement of ambassadors among employees at UiS in the reputation work
Team 4	How can we motivate students to continue with further education at UiS?	Creating a good user experience from the first course inductions at UiS
Team 5	How can we improve the reputation of UiS by showing that we are an attractive workplace?	Improving the attractiveness of our job advertisements for positions at UiS (Measurement: Reach of the advertisements on Finn and Job Norge)

> It became very clear how much we all work in silos and how it is important to find who will be a part of the project to find a solution.—Participant - Team 5

Investigate *Phase*

On the 17 of January 2023, the participants began the *Investigate* phase and Masoumeh delivered another presentation on the key components of CBL theory in this phase. This included examples of how to identify knowledge about the challenge by asking guiding questions. It also included an overview of the resources to organise CBL research and collect data through this phase. Finally, she demonstrated and practised problem-solving tools such as the fishbone technique, fish technique, and system thinking. The purpose was to help them understand the causes of a problem and map out relevant stakeholders and factors (see Chapter 2 for more details). It was helpful for participants to look at the problem in the system and zooming out and see all the factors that effect on the challenge or influence by the challenge. Between the 17th of January and 14th of March, the teams could continue to work on the challenge in their own time and to consult the CBL experts for feedback and advice. Examples of these guiding questions included:

- How do we define a success story?
- In what way should the success stories support our strategy?
- How do we identify the fields that are important for building a good reputation?

On the 14th of March there was a dedicated session for teamwork and attention to the outcomes of the *Investigate* phase as per the process for *Engage*. A month later on the 14th of March 2023, the *Investigate* phase concluded with another in-person pitch-presentation session, following the same process in the previous phase. The reflective quotes from participants below illustrate their experiences of the *Investigate* phase and what they found most beneficial:

> It's about really investigating what is our goal and what should we do to achieve the goals we have and that is something we have to work through again and again because it's so easy to just jump to conclusions. You have to work really hard to get very good and to get the good results.—Participant - Team 1

> The fishbone technique was interesting, and you can call it innovation as well, but it's mostly what you get from working with the CBL method in itself, that's the learning.—Participant - Team 5

> I really appreciate the fishbone technique. The people in the group were really engaged in that and it that we got a result.—Participant - Team 1

Act *Phase*

The *Act* phase began on the 18th of April 2023 and Masoumeh presented an overview of how the process of working towards the completion of this challenge. As discussed, in this CBL implementation, the solutions would be practically implemented in the participants day-to-day work-. It was crucial to rigorously test their feasibility according to a range of factors such as resource intensiveness (including personnel), financial constraints, time constraints, and compatibility with the department's existing work plans. Each team, therefore, worked towards solutions that contained one or more measures with one or more sub goals, unlike the single solution that students traditionally work towards in CBL. The final solutions are included at the end of this section.

To assist the teams in this process, Masoumeh introduced them to the creative thinking tool the ‘six thinking hats’ (see Chapter 2 for more details) to evaluate potential solutions from different perspectives in brainstorming sessions. After this session in April, the teams had two further in-person meetings on the 14th of April and 12th of May to accommodate staff availability. These sessions reiterated the outcomes process described in the first two phases and were an opportunity to seek final comments, feedback, and input from Masoumeh and Tim.

The project concluded with the final pitch-presentation session on the 2nd of June 2023. Each team shared their results with the whole team, the CBL expert, and Vibecke, the head of the department. This was followed by questions for feedback from their colleagues and a final group discussion of the CBL experience. Below are some reflections from participants on what they liked best about the *Act* phase, and we then listed each team’s solutions/action points with their own additional commentary.

> I like the six thinking hats technique where you looked at thing from different angles and you know everyone should try one hat because often, you’re very positive about your own solution and you see others are not so positive to your own solution, but I think then to have this practice, seeing it from different angles and you know finding the positive and the negative and the doubts etc.—Participant - Team 2

> I also wanted to mention the six thinking hats, I thought it was very good. It took some time to do it properly so maybe some tips or shortcuts on how to do it quicker.—Participant - Team 1

Solutions (Measures and Goals)

Team 1

Team 1 developed two solutions and formulated three goals to address the challenges they identified.

Solution 1: Establish an editorial team for green transition composed of communication advisors and cross-disciplinary researchers led by a communication advisor, emphasising outreach and dissemination of research.
Solution 2: Create a landing page for research communication/ success stories where issues regarding energy and green transition are gathered.
Goal 1: To convey more success stories about what we contribute to society
Goal 2: To increase the number of success stories; what UiS contributes to society in terms of energy and green transition
Goal 3: To enhance the visibility and presence of our researchers in the public discourse on green transition.

Team 2

Team 2 came up with one solution and one goal that could help them address their challenge.

Solution: An information hub for external collaboration at uis.no—all information gathered/available in one place.
Goal: to create a solid foundation for further development. The first step to highlight existing collaborations and foster new ones is to make information accessible from one location—it should be easy to navigate.

Team 3

Team 3 also formulated one solution and one related goal that could help them address their challenge.

Solution: The Reputation Box, a box with instructions and questions to work on collaboratively including at internal seminars.
Goal: The goal is to raise awareness of UiS, and aid connection to individual departments and their work. The leadership has a responsibility to follow up on this work. The aim is for everyone

to contribute so that, collectively, the outcome will significantly enhance the reputation of UiS.

Team 4

Team 4 came up with two solutions and one goal that could help them address their challenge.

> *Solutions 1:* Further develop a really good landing page (uis.no) that provides the most important information students need before the start of their studies. The website is strategically designed and will be included in emails sent to all students before the start of their studies. It will also be diligently distributed on social media and be visible on information screens during the period after the start of studies until September 1st.
> *Solutions 2*: An academic festival where students can find out and learn everything they need before they start their studies in earnest. The festival will utilise and unite resources, courses, and offerings that are already available from the library and student organisations, as well as using scientific and administrative staff and third-year students/master's students."
> *Goal*: The goal is to provide targeted information, contribute to relationship building, foster a sense of security, aid in developing a feeling of accomplishment, and facilitate a smooth start for students in their studies.

Team 5

Team 5 came up with one solution and four goals that could help them address their challenge.

> *Solution*: Improve the reputation of UiS by showing that we are an attractive workplace via four goals.
> *Goal 1*: Create new standard texts and a photo bank for job advertisements.

Goal 2: Test these out on new announcements for administrative positions starting from August.
Goal 3: Measure the results in terms of the number of views on advertisements on JobbNorge and Finn Norwegian job websites)—compare with 'before data.'
Goal 4: Evaluate the effect.

In summary, the participants came up with a diverse range of measures to their challenges and set out further goals to consider different factors required for successful implementation and follow-up.

Benefits and Skills Gained by Participants

As detailed in this book and the other case studies, CBL is usually implemented in an educational setting. However, we want to demonstrate that CBL can also be beneficial for other groups, in this case, professionals working in a university as administrative staff. Therefore, this case study presented a unique implementation of CBL in a different context in which some similarities but also many differences can be noticed in terms of the way the participants experienced CBL. For example, the solutions listed above would be implemented in the participants' daily tasks unlike an educational context where solutions to real-world issues can also be conceptual. The reflective quotes below demonstrate that participants highlighted the role of the transversal skills of teamworking, collaboration and communicating, problem-solving, and innovative thinking.

> I think that the collaboration with other colleagues was nice and kind of new for us because we know each other but it is very rare that we work together in the way that we did this time across the, the faculty and centres bringing us together as a team.—Participant - Team 3

> Collaborating with other communication advisors at the faculties and at the centres, it's very nice to meet with them and to talk about issues connected to our field of work.—Participant - Team 4

> It was nice to work together for a common goal and to ask and get information from other departments as well. So, it was a nice practice in how the whole university is connected and how we are working on different parts of a common goal.—Participant—Team 2

> I think the best part was well, the teamwork in general. Getting to collaborate with different departments and centres.—Participant—Team 1

> Through it all I found a very good process with a group that I was in, and I will say that one of the best side effects is how we communicate across about this.—Participant—Team 1

> I would definitely say problem solving and collaboration and innovation too, it was kind of an innovative project. The whole mindset to keep asking the questions that I tell my colleagues to always ask, of course, too, why do we do this?—Participant—Team 1

> The best part was actually learning how to work in an innovative process and seeing how difficult that is to do in a big organisation.—Participant—Team 5

> I think it was very interesting. I think we need methods to work in a more innovative way, so maybe CBL is such a method.—Participant—Team 5

Challenges and Lessons Learned

One of the main challenges that participants raised in the focus group was the length of the programme, which extended to more than six months and created a number of disadvantages, in particular, that momentum and progress were sometimes lost with such long gaps between sessions This longevity has a secondary issue which is that if the problem addressed by the team changed significantly during the project it then required a lot of extra time and resources which pressurised busy professionals. They would like to revisit the methods, but with more specific challenges and narrow down the project period to gain more momentum. This would obviously need a bit more planning before starting such an exercise.

However, they also mentioned positive aspects to engaging in the programme over a long period as it allowed for flexibility for participants to work on Miro between sessions or that they could approach the CBL experts either in person or via email for feedback and guidance. It also gave participants time for reflection, reconsideration, and critical idea generation. They had enough time to revisit early CBL phases and one team even changed their challenge altogether during the *Engage* phase, which is common practice in CBL as it encourages learning from failure (see Chapter 8).

Another challenge was that absence of some participants in some teams throughout the challenge. There were also participants who either left after the first phase or joined mid-way through the project, which created imbalance in the team dynamics. The final challenge was that CBL was challenging for participants since the focus on the application was too broad which hid very specific issues that needed to be solved in their daily work. Below are some reflective quotes that illustrate these challenges:

> It was hard to gather the whole group each time, so we were never the same people who met each time. To do it better we must ensure that everyone who participates in each group is dedicated over the time and can be at all those meetings. It is good if we get the whole timeline from the start and we know all the meetings, we can schedule it if we have two months, we can schedule it properly.—Participant—Team 1

> Perhaps it would have been better if the topic was a bit narrower than the university's reputation.—Participant—Team 2

> A better way to do it would been if it was more concentrated and with just one day in between each part of the task for instance. We forgot a lot between the gaps, and it took a lot of time to recapture what we have learned.—Participant—Team 4

> One of the things that was bit frustrating was that we did this over a long period of time. In one way it was good because you can think about it for a long time and you get new ideas and new perspectives instead of working one week and then everything you think about after that, you can't use. A shorter period of time and then have more days, maybe a whole day in between to work with the question and then the challenge could have helped.—Participant—Team 2

Future Implementation

The Department for Communications and Public Affairs has decided to use the insights gained from their CBL implementation in several ways. This includes welcoming new students and strengthening their research for building better communication with the students and other stakeholders. They also started working more as smaller teams across the department and expanded the communication network at the university by forming social media team and a communication research team. The reflective quotes below show an enthusiasm from participants to use CBL again, indicating how the challenges turned into lessons learned:

> I think it's important that we use this method again because if we know this method better than we can use this in a better way to solve different task and different challenges.—Participant—Team 2

> I would like to emphasize that I hope we can do it again because it really is an interesting and good method, I believe.—Participant—Team 2

> It was a very efficient way of highlighting some of the more structural or organisational issues and how we're working.—Participant—Team 5

Conclusion

The key findings of this case study demonstrate that CBL can be applied in administrative communication departments as a tool to help tackle problems they face in their day-to-day work. There was some initial hesitation and confusion as to how CBL could be adapted where CBL could be relevant to their tasks. Many of the participants found they felt empowered once they had overcome the challenges they invited and addressed. As the feedback from the focus groups demonstrate, participants gained knowledge of new tools (*systems thinking, fishbone technique, six thinking hats*) and frequently mentioned the benefits of collaborative teamworking outside of their usual working context. They also enjoyed the creative and innovative approach to problem-solving and solution-generation that CBL encourages.

For us as practitioners, it was also a new learning experience to implementing CBL in an administrative communication department. It required different planning and organisation strategies and to adjust and adapt our existing CBL materials to this new audience. These include different presentation and facilitation techniques, and more collegial interaction, and more self-assessment and peer review among the teams. As discussed in this book, as practitioners we took on different roles throughout the challenge as mentors, guides, and facilitators. However, we also took on the role of learners in gaining a lot of knowledge about the individual specialisations within this administrative context.

These insights and the comparative experiences to other CBL contexts will enhance our future CBL implementations with both students and professional stakeholders in higher education.

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CHAPTER 7

CBL Macro Level Frame Case Studies

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K. Dikilitaş et al., *A Practical Guide to Understanding and Implementing Challenge-Based Learning*,
https://doi.org/10.1007/978-3-031-67011-4_7

Case Study Eleven—Challenge-Based Learning Pathways at Dublin City University: A Case Study on Supporting University Teachers

Clare Gormley, Dublin City University
Fiona O'Riordan, CCT College Dublin.

Introduction

Challenge-Based Learning (CBL) is considered a 'trending educational concept' (Doulougeri et al., 2022, p.35), increasingly making its way into reports intended to guide teachers and policymakers in educational innovation (Kukulska-Hulme et al., 2023). Higher Education Institutions (HEIs) are being asked to develop future-focused skills and competencies that will help students tackle the urgent societal issues of our time (Kotsiou et al., 2022). There is a growing emphasis on transformative pedagogies that will help students engage in a process of collaboration and problem-solving that can be applied in the many unpredictable contexts they are likely to face (Perna et al., 2023). Challenge-based learning has been suggested as one such pedagogy, one that may form part of a 'pedagogical toolkit to meet future trends in HE' (Gallagher & Savage, 2022, p. 391).

However, as it stands today, understandings of CBL and its core purpose as a pedagogy remain mixed. While many papers refer to the definition from Apple Inc. (Nichols & Cator, 2008), there is no fixed definition of CBL, some seeing it as an innovative pedagogy (Vilalta-Perdomo et al., 2022) while others put more emphasis on its sustainability and societal remit to address the important challenges of our time (Malmqvist et al., 2015). Furthermore, some schools of thought would see CBL as an extension of Problem-Based, Project-Based, and/or Service Learning (Cruger, 2018) while others would see it as a very distinctive, emerging pedagogy in its own right (Membrillo-Hernández et al., 2019). All of this has led to what has been called 'definitional muddying' (van den Beemt et al., 2022, p. 2) and challenges in terms of research to develop a robust evidence base around CBL.

The reality is that many institutions and educators are interpreting CBL and adapting it for their own context. Frameworks of common characteristics of CBL are being developed (Gallagher & Savage, 2020;

Van den Beemt et al., 2022) which may make research and indeed a shared language somewhat easier. However, it is the view of these authors that something further is needed to explain practically what CBL might look like at various levels, how it might work in practice, and what kind of examples from various disciplines might inspire potential challenges. Rather than focusing on the student experience, this guidance needs to explore matters from an implementation perspective and address the kinds of issues and questions that university teachers will have as they attempt to navigate this potentially transformative approach.

This case study will describe how academic developers leading professional development activities at DCU have been supporting teaching staff to implement CBL in various ways in their practice. It will outline the range of supports that are currently in place, focusing in particular on the development of the *Guide to Challenge-Based Learning Pathways at DCU*. It will explain how that guide was co-designed and developed and the literature it was based on.

First, we will explore how CBL has grown from a relatively niche pedagogy to a core element of teaching and learning strategy at DCU.

The Growth of CBL at Dublin City University

DCU is a young, dynamic university with a distinctive mission to transform lives and societies through education, research, and innovation. A key project designed to deliver this mission is DCU Futures. It is 'the most ambitious innovation in teaching and learning in the history of Dublin City University (DCU). Operating as a blueprint for the University and funded by the Human Capital Initiative, this €19.9 million project is an unprecedented commitment to radically re-imagine undergraduate education for the 21st century to meet the challenge of empowering students to be future-capable and thrive in an increasingly unscripted world defined by volatility, uncertainty, complexity, and ambiguity' (DCU Futures: Reimagining Undergraduate Education for an Unscripted World, 2023). Ten new innovative multidisciplinary programs were launched in September 2021, with CBL as a central pillar of educational innovation.

DCU is a member of the ECIU, the background to which is set out in the introduction to this book. The current ECIUn+ project (2022–2027) is rolling out and scaling the work done in the pilot (ECIU

Project). Through co-creation across the consortium, and with societal and industry stakeholders, ECIU brings together stakeholders from member universities, such as learners, educators, and researchers, to work with society and industry to solve real-life challenges. Other key components of this innovative work are the use of micro-modules to support CBL, and mobility to enhance and expand the learner experience. At the time of writing, there are ninety-seven ECIU Learning Opportunities (ELO) on the Engage Platform. DCU has four ELOs on the ECIU Engage Platform, with more in the pipeline. Upon completion of each ELO, learners will receive an official ECIU Micro-Credential.

These are not the only cases of CBL at the university: prior to the existence of these projects, CBL was being used in the Engineering and Business faculties (e.g., DCU Business School, Hack4Change project). However, the DCU Futures and ECIU major strategic projects have provided an impetus to grow CBL at scale at DCU. Unsurprisingly, concerns were raised about institutional support for implementing CBL and conversations with staff involved in these projects highlighted that certain questions needed to be answered if CBL was to take root. Staff had many questions, such as:

1. What is the core difference between CBL and PBL?
2. Is CBL really feasible with large class sizes or only with relatively small groups of students?
3. How can relationships with stakeholders be managed, given limited resources and time?
4. How should CBL evolve over time?
5. Can CBL be used in non-STEM disciplines?

How should CBL be assessed? As academic developers, it is part of our purpose to support staff in developing their teaching practice to enhance student learning (Popovic & Baume, 2016) and as such, provide guidance to support staff implementing CBL. With CBL being a relatively new pedagogy at DCU, it became clear that these were not going to be easy questions to answer and would require a multi-faceted approach involving synchronous and asynchronous professional learning support at a range of levels. Working closely with the Dean of Strategic Learning Innovation, the central unit for academic development at the university—the Teaching Enhancement Unit (TEU)—developed a range of supports including:

- A centralised online CBL hub on the DCU Virtual Learning Environment hosting design and assessment-related resources for CBL (including implementation guidance, case studies, and glossary of terminology);
- Professional learning events such as a hackathon experience for academics and workshops to share practice in CBL (O'Riordan & Gormley, 2023);
- On-demand faculty supports to explain what the different phases of CBL mean, share experiences in running CBL activities such as hackathons, and provide advice on rubrics and general assessment of CBL such as through acting as 'judges' on request;
- Visits to institutions with more experience in CBL such as Tec de Monterrey (Mexico) and the University of Twente (The Netherlands) followed by sharing of lessons learned in the form of reports and presentations to DCU staff;
- Chairing a university-wide CBL working group called DCU who developed a working definition of CBL in, 2022, curated support guidance for students and staff, and provided feedback on the development of the CBL Learning Pathway (discussed later). Developments that emerge from the DCU working group are brought to the DCU Education Committee for formal approval.

A high-level overview of this approach is documented in Van den Beemt et al. (2023) who outline a schematic flowchart of the CBL implementation process at DCU. This process highlights the criticality of the adopted CBL framework and the fact that multiple stakeholders (teaching staff, students, senior management, and those involved in setting challenges) can influence implementation to an enormous extent. The diagram also highlights the iterative process involved: the role the TEU plays in planning, supporting, and resource development around CBL is ongoing and feedback from Teaching and Learning events and committees (such as hackathons and working groups) is continuously fed back into the work carried out. For example, a case study on the experiences of running a hackathon for academic staff was written and published with the aim of informing similar ventures that may be introduced by staff (O'Riordan & Gormley, 2023) (Fig. 7.1).

For the remainder of this case study, we will focus on one particularly significant support that will be used to inform future practice and

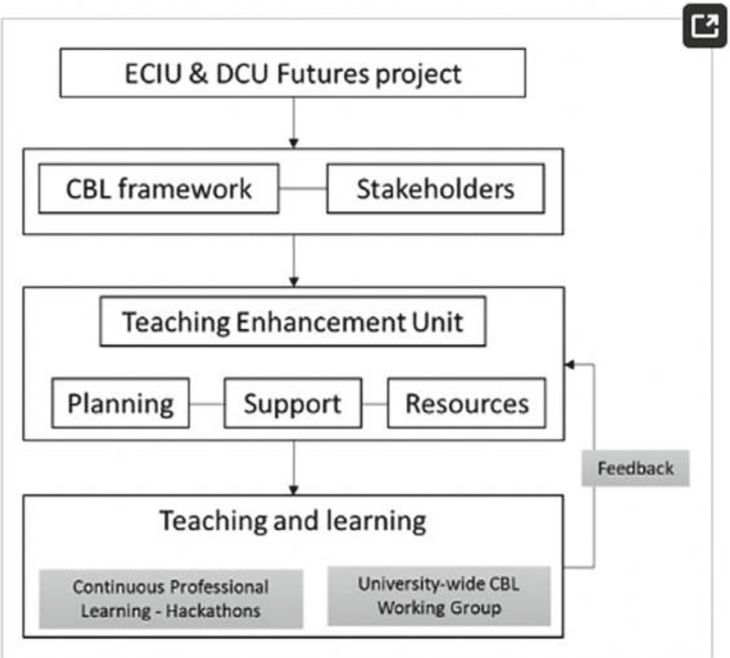

Fig. 7.1 Schematic of CBL implementation process at DCU

research into CBL implementation at DCU: the *Guide to Challenge-Based Learning Pathways at DCU*.

Development of the Guide to CBL Learning Pathways

In response to numerous requests for further guidance on implementing CBL, a co-design sprint was held in November 2022 to capture experience, expertise, and advice from staff who have already engaged with CBL in teaching. The objectives of this process were to:

- Co-design a CBL Learning Pathway framework representing DCU staff perspectives on ways of designing and implementing CBL at different stages.

- Incorporate evidence-based best practice into CBL development and implementation.
- Create a set of co-designed guidelines and gather specific examples of what First & Final Year CBL at DCU might look like in practice.

To create this pathway framework, academic teams were invited to participate in a two-hour in-person session similar to a fast-paced design sprint where the assembled group focused on teasing out a picture of what CBL might look like in different contexts over time. The groups were arranged in multidisciplinary teams at tables to ensure a mix of staff perspectives and levels of experience with CBL. Each table was presented with poster-sized worksheets listing various possibilities for characteristics of CBL in students' First and Final Years at university. The goal here was to avoid the intimidating 'empty page' and instead provide examples that might prompt ideas or further thinking. These initial prompts were created by the academic development team, based on their engagement with the literature, experience with previous projects, and feedback received from various parties. The groups were asked to work collaboratively, starting with the Final Year vision, to articulate what they saw as key characteristics and examples of CBL. Table 7.1 outlines the prompt questions that were posed (Table 7.2).

Eleven groups attended on the day, comprising a mixture of DCU Futures and academic staff from various faculties interested in CBL. A further four DCU Futures teams provided feedback afterwards. All data from the session was reviewed. Following an agreed protocol, all data (in the form of written responses to question prompts) from the worksheets were digitised.

Basic content analysis was then carried out. As per Holsti (1969, p. 14), 'Content analysis is any technique for making inferences by objectively and systematically identifying specified characteristics of messages.' The feedback on the suggested CBL characteristics for Final and First Year was coded in accordance with the following five categories:

- Agreed
- Disagreed
- Mixed Views
- General Comment
- To be clarified/followed up

Table 7.1 Prompt questions for CBL in final year

Suggested CBL characteristics (What?)	*CBL characteristics in practice (How?)*	*Challenge examples (across disciplines)*
• Larger challenge, approx. equivalent to 5–10 ECTS credits • Challenge is typically open-ended, a complex or 'wicked' type of problem • Less definition of the dimensions of the challenge • Develops more sophisticated transversal skills, e.g., critical thinking, advanced data literacy, personal agility, leadership • Strong relationship with stakeholders • Detailed implementation plan considered and produced • Strong focus on reflection throughout and afterwards • Multidisciplinary and multicultural perspectives within the team • Comprehensive evaluation of solution • Solutions shared both internally and with the wider community Do you agree with these characteristics? What would you add, remove, or adapt?	• What type of weighting should be attached to the challenge, e.g., 30%, 50%, 100% of the module? • Do you see potential to share a challenge with other modules/ programmes? • What level of input do you see yourselves having in helping students to define the challenge? • What type of guidance and support with CBL do the students need at this point in their studies? • How will you accommodate evaluation and reflection throughout the process?	• What ideas for possible challenges might work in your context? • What kind of outputs/ solutions might be appropriate in your discipline? • How might you make good use of external stakeholders such as industry partners in your context? e.g., As a mentor at student presentations

Our next challenge was for the academic development team to distil this multi-perspective feedback from the sprint into a format that would be accessible to staff approaching CBL for the first time.

Table 7.2 Prompt questions for CBL in first year

Suggested CBL characteristics (What?)	*CBL characteristics in practice (How?)*	*Challenge examples (across disciplines)*
• Small challenge, usually part of a module • CBL is used as a mechanism to contextualise the LOs of the module • Tightly defined dimensions/boundaries of the challenge • Develops some transversal skills expected from early on in degree programmes, e.g., communication, sustainability literacy, collaboration, and some digital literacy • Often no external stakeholders • Often involves only one discipline • Light touch implementation/ recommendations • Light touch reflection, sometimes post challenge • Limited evaluation of proposed solution • Solutions usually shared internally Do you agree with these characteristics? What would you add, remove, or adapt?	• What type of weighting should be attached to the challenge, e.g., 30%, 50%, 100% of the module? • Do you see potential to share a challenge with other modules/ programmes? • What level of input do you see yourselves having in helping students to define the challenge? • What type of guidance and support do the students need in year one, e.g., for group work, communication, sourcing information, etc. • How will you accommodate some light touch evaluation and reflection throughout the process?	• What types of challenges might work for first years in your context? • What kind of outputs might be appropriate for first years in your discipline? • How might guest speakers contribute to the students' CBL learning experience?

Drawing on the CBL Literature

This learning pathway resource needed to address the questions that frequently arose through a comprehensive and clear set of guidelines for those at the forefront of teaching. But as well as drawing on the experience and insights of those attending the design sprint, we needed to ensure that we considered researchers who had already explored this topic.

Three recent publications were highly influential in determining the next steps:

1. The conceptual framework of eight literature-based characteristics of CBL developed by Gallagher and Savage (2020). These are: Global themes, Real-world challenges, Collaboration, Technology, Flexibility, Multidisciplinarity, Innovation and Creativity, and Challenge Definition.
2. The CBL compass instrument and indicators described in van den Beemt et al. (2022). These authors have developed the CBL compass as a tool for representing the key characteristics of CBL and capturing the variety of CBL implementations that may occur. However, their interpretation is that not every characteristic may be evident in every CBL interpretation. This perspective 'implies a variety in CBL characteristics across study components, ranging from small-scale to full-fledged versions of challenges and their implementation' (p. 2). Based on reviews of the literature and discussions with thought leaders and CBL practitioners at the University of Eindhoven, the CBL compass identifies a framework of 12 dimensions or characteristics of CBL. These dimensions are: Real-life open-ended challenges, Global themes, Involvement of stakeholders, T-shaped professionals, Self-directed learning, Assessment, Teaching, Interdisciplinarity, Collaborative learning, Learning Technology, Facilities, Teacher Support. The dimensions of stakeholder involvement, self-directed learning, assessment and facilities, and teacher support were deemed necessary additions to the Gallagher and Savage model for the purposes of both research and educational design decisions.
3. Design principles and practical advice on how to develop CBL courses within an overall curriculum described in Doulougeri et al. (2022).

Together, these documents helped to inform our pathway by identifying key dimensions or characteristics of CBL. These theory-driven dimensions provided an anchoring framework for us to work with and extend further with examples from DCU. See Fig. 7.2 for further details on the 12 CBL dimensions identified, which are underpinned by two more dimensions of Teacher Support and Facilities.

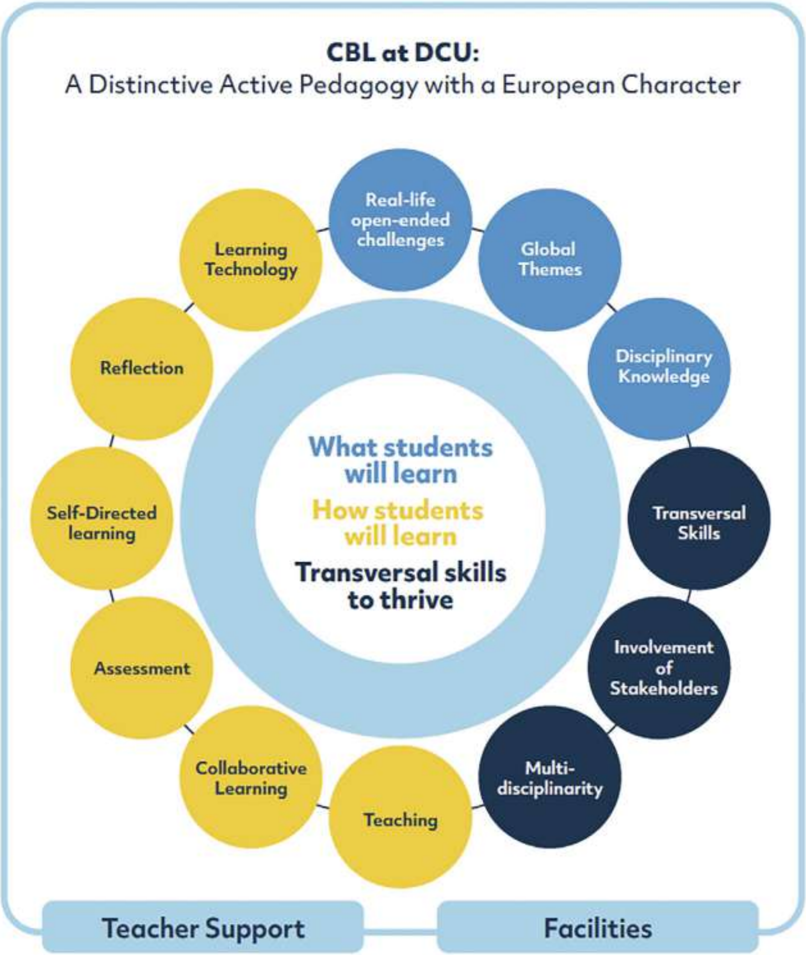

Fig. 7.2 CBL dimensions

Because so many questions had been asked about specific dimensions (e.g., how deeply should stakeholders be involved? What do we mean by multidisciplinarity? What is meant by real-life challenges?), further details were added to explain the 14 dimensions identified. A short description of each dimension was developed, as shown in Table 7.3.

Table 7.3 CBL dimensions descriptions

CBL dimensions	*Description*
Real-life open-ended challenges	Challenges should be rooted in real-world, authentic problems. The problems are authentic in the sense that they relate to tasks and activities relevant to the future profession. Challenges are open in that they require a solution for which there is not an existing, pre-made response. An open-ended challenge is one where an effective solution is not already available, or where the challenge itself lacks sufficient information/definition in order to transition to an effective solution. Challenges are therefore not fictionalised or simplistic—they should literally challenge the student to tackle a problem in a way that leads them to learn and apply that knowledge in order to develop a tangible solution. Solution outputs will vary (e.g., prototype, presentation, report with recommendations) to address the selected problem. Depending on the context, there may be sharing of solutions/recommendations with the wider community
Global themes	Challenges should relate to social, technological, environmental, and economic challenges of urgency and significance. Challenges should derive from globally significant themes—the UN Sustainable Development Goals (SDGs) may play a prominent role—and could have impact at individual, local, and/or community level. Such impact may be short, medium, or long term
Disciplinary knowledge	Challenges should provide an opportunity to develop and apply disciplinary knowledge. The challenge will need to be clearly structured to satisfy professional bodies and strong technical/disciplinary learning outcomes may be needed to satisfy accreditation requirements. Resources and learning activities to support the learner in acquiring disciplinary knowledge should be clear, relevant to the challenge, and appropriate for the level of the learner

Furthermore, in recognition of the fact that CBL is implemented on a continuum and is influenced by factors such as educator confidence, class size, student level, and available resources, the pathway also draws on the indicators in the CBL compass (Van den Beemt et al., 2022).

These indicators provide reflective prompts highlighting some of the practical aspects related to each dimension. For example, the indicators for multidisciplinarity ask educators to think about:

- The extent to which challenges require multidisciplinary teamwork, e.g., for first year, multidisciplinarity could be manifested in a small-scale way such as sharing an aspect of challenge (rather than a full challenge) with students from another discipline. For final year, it should be possible to run challenges where everyone works on something from start to finish but different disciplines 'break out' to work on specific aspects at different points.
- The extent to which challenges support combinations of individual and teamwork, e.g., in first year, teamwork is likely to be highly scaffolded, helping students to develop their abilities to work in teams. In final year, opportunities for both group and individual assessment should be considered.
- The extent to which learning activities support the development of multidisciplinary professional skills and competencies, e.g., in first year, if the challenge is not multidisciplinary in practice, the challenge should be explored through a multidisciplinary lens, especially during the *Investigate* phase. By final year, students should have a substantial bank of knowledge and professional skills to draw on—the ability to communicate/translate between disciplines is a critical skill to develop and apply as they engage with the challenge.

Finally, in recognition of requests, for example, of challenges that might inspire thinking in other disciplines, a crowdsourced list of examples from multiple disciplines was created. A set of FAQs and resources was also developed to enable quick scanning of answers to common questions that arise (see Appendix of Case Study Eleven). The final product was a 28-page booklet with the following key sections:

- 'What is CBL?' explains what CBL is, highlighting the approved working definition developed for DCU.
- 'What is a CBL Learning Pathway at DCU?' introduces the CBL Learning Pathway. It explains potential dimensions of CBL (in graphic and text form) to provide a sense of the key characteristics to consider when designing and implementing CBL over time.

- 'Are there examples of typical CBL challenges?' lists a range of potential CBL challenges that may act as a starting point or source of inspiration for various disciplines.
- 'FAQs & Responses' provides a set of Frequently Asked Questions (FAQs) and answers to common and specific questions that arise.

Where We Go From Here

The resulting *Guide to Challenge-Based Learning Pathways at DCU* is an attempt to explain how CBL might be implemented in various ways and provide an insight into the different types of CBL Learning Pathways that are emerging at DCU. It should be noted that this document is not a recipe or a prescription for CBL of any sort. Rather it respects the autonomy of professional educators to make decisions about whether or not CBL is appropriate for their teaching and if so, how it can be tailored to the circumstances and the discipline to develop the desired knowledge, skills, and competencies. This document is not being proposed as a definitive guide to CBL but instead, we hope will be looked on as a useful resource for anyone designing or considering CBL to refer to as needed. Above all, we hope it explains the fundamentals of CBL relatively clearly and will act as a usable framework for CBL implementation and empirical research using commonly accepted characteristics.

As this is a recently released resource (May 2023), apart from a positive reception at certain in-house workshops, we do not yet have data on how it is being used in practice. However, it is being used by DCU academic developers as a key resource in CBL events/workshops and it will underpin a CBL evaluation process in 2024. Copies of the pathway are available on request by emailing teaching.enhancement@dcu.ie.

Case Study Twelve—'Building the university of the future'—Citizenship Education Through Challenge-Based Learning

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Introduction

Democracy is currently facing significant challenges, leading to concerns about human rights, the rule of law, free speech, and other public values. The rise of populism and extremist ideologies has raised questions about the stability of democracy worldwide, including in Europe. To attempt to counter these developments, one of the initiatives of the European Union (EU) is to encourage its citizens to engage in democratic participation (Deplano, 2011). Enshrined in the Lisbon Treaty of 2009, the EU has encouraged its citizens to actively participate in democracy through various initiatives, including the European Citizens Initiative and the 'WeMove' platform.[1] To counter these threats, the European Union encourages citizen engagement in democratic participation through initiatives like The European Citizens Initiative (ECI) to promote values such as human dignity, freedom, democracy, equality, rule of law, and human rights. Some of the core skills and competencies citizens require to participate in bottom-up policymaking include:

1. Critical thinking skills: Citizens need to be able to critically analyse information and arguments presented in public debates, to make informed decisions. (Council of Europe, 2019)
2. Communication skills: Effective communication skills are essential for citizens to participate in discussions and debates, present their ideas, and express their opinions. (UNESCO, 2023)
3. Collaboration skills: Participatory democracy requires citizens to work together to achieve common goals, so it is important to have good collaboration skills. (Council of Europe, 2019)
4. Conflict resolution skills: Citizens need to be able to resolve conflicts and find solutions that work for everyone involved, to reach decisions that are fair and just. (Council of Europe, 2019)
5. Research and information gathering skills: Citizens need to be able to gather information from a variety of sources, analyse it, and use it to inform their decision making. (OECD, 2016)

[1] https://www.consilium.europa.eu/en/documents-publications/library/library-blog/posts/citizen-participation-in-democratic-europe-what-next-for-the-eu-edited-by-by-james-organ-alberto-alemanno/.

6. Leadership skills: Effective leaders can help guide discussions, facilitate decision making processes, and inspire others to participate in democratic processes. (Council of Europe, 2019)
7. Digital literacy skills: In an increasingly digital world, citizens need to be able to use technology to access information, communicate with others, and participate in online discussions and debates. (Council of Europe, 2019)
8. Cultural competency: Citizens need to be able to understand and respect the diverse perspectives and experiences of others, in order to work together effectively and make decisions that are inclusive and equitable. (UNESCO, 2023)

These are also some of the skills and competencies that students can develop through participating in a challenge-based learning (CBL) course, like the ones offered by the ECIU. One such challenge was 'Building towards the university of the future' (UoTF) offered by the University of Twente (UT) which will be discussed in this multifactorial case study. First, it will describe the structure and detail the implementation of the challenge and the skills and competences the participants learnt and include their reflections throughout. It will then assess and evaluate the learning process about the concept of citizen education before concluding with a discussion on implications and benefits for students and practitioners in relation to future implementations of such a challenge.

Background and Participants

The aim of the UoTF challenge was to involve students in the co-creation of educational concepts from the outset to address the problem that 'students usually experience education but are rarely involved in its design.' The challenge was originally scheduled for just one month from November to December 2021 but it was extended to June 2022 to test how the challenge could be developed further. The challenge provider (CP) was the UT itself, represented by Marike Boertien, Challenge Coordinator for ECIU and Leonie Chapel, Educational Consultant. Usually, the CP is an external organisation, so this arrangement presented its own advantages and disadvantages which are explored later in this case study.

The challenge was extra-curricular, with only a single team participating, but as per CBL team formation principles, the team was highly diverse in terms of age, educational background, and nationality. Six students from six different ECIU universities participated in UoTF, guided by a teamcher from the UT. These were:

- Hamburg University of Technology, Germany,
- Universitat Autònoma de Barcelona, Spain,
- University of Linköping, Sweden,
- University of Stavanger, Norway,
- University of Trento, Italy,
- University of Twente, The Netherlands.

As for all ECIU challenges, students were required to write a motivational letter when applying to the challenge which helped the teamcher select participants and have some understanding of the individual characteristics of her team. The challenge required collaborative and interdisciplinary work to address the future-oriented education design. The estimated study time investment was 28 hours, and credits (ECTS) were awarded based on the students' effort as assessed by the teamcher.

Implementing the Challenge and Participants' Learning Experience

Prior to the challenge, students' expectations to develop new skills and grow their knowledge through collaborative and interdisciplinary exchange were evaluated. This could support the students' team to remain focused on their personal challenge and growth goals. Furthermore, understanding how each of the members works and prefers to interact with each other, as well as how the coordination of the activities would develop and be planned were also discussed at this phase. Setting up those goals could support the construction-specific skillset goals regarding the **collaboration, cultural, communication,** and **leadership skills** development of each of the team members.

The team began to tackle the challenge by employing a foundational approach, adopting a comprehensive and methodical perspective to building the UoTF. It did so by using the CBL framework and thus follows a summary of activities for each of the three CBL phases.

In the *Engage* phase, the team worked collaboratively using the online platform Padlet. The use of this collaborative tool supported them in creating a mental mind map of their thoughts and maintaining a structure for this intercultural and transdisciplinary collaboration, while also developing **digital literacy** and **collaboration skills**. According to the demands of this phase, the students were meant to start as broadly as possible with the 'big idea' of the university of the future, to generate many essential questions about the concept of the university of the future and decide on the most important to focus on. This supported the improvement of their **research and information gathering skills**, and their **critical thinking skills**. To those ends, the team generated a series of essential questions such as:

- *How can we make the university of the future more rewarding and accessible?*
- *How can we design a university that promotes lifelong learning and is flexible and affordable to all?*
- *How can learning be more interdisciplinary?*

As per the CBL process of distillation and refinement of essential questions, this led to the single essential question:

- ***How can the University of the Future (use challenge-based learning to) support interdisciplinary learning?***

Thereby, the concept of CBL itself and its current and future implementation within higher education was placed at the centre of the challenge.

In the *Investigate* phase, the team divided into two groups, with two participants undertaking research for a policy-based report using qualitative interviews with CBL practitioners and policymakers; and the other four designing a questionnaire regarding students' experiences with CBL. In terms of mentoring and feedback, this was also divided with the teamcher reviewing drafts of the policy report and the CPs providing feedback on the questionnaire. However, the team also had to work collectively to present its interim progress on the challenge to a group of ECIU stakeholders, including the CPs, who provided feedback on the challenge. This required agreeing on the composition of a presentation and agreed roles on presentation of content. Taking initiative on these tasks and delegating work among teammates supported the further development of the students' **leadership, conflict management, critical thinking, as well as their research and information skills**. It also gave those who wished to take the opportunity a chance to develop their **public speaking skills** in presenting in a formal setting and answering questions from stakeholders.

In the *Act* phase, the two sub-teams completed their respective tasks with the policy team writing up their interviews and analysing the implications for the UoTF; and the questionnaire team refining the design for their questionnaire. To complete the challenge, the team offered a final online presentation to the CPs and several ECIU stakeholders from different universities and again received feedback on their recommendations. The result of this process led to the completion of the challenge report, where the students offered their acquired knowledge and recommendations regarding the university of the future. As an addendum, there were two days of physical visit at the University of Twente in May 2022. During this meeting, the participants met in person among themselves as well as with their teamcher, challenge providers, and ECIU representatives from the University of Twente. During several workshops and meetings, the students could share their knowledge and reflect on their experience with other students who participated in CBL challenges and courses, as well as to create some promotional material about this learning opportunity. This experience promoted even further their **interpersonal, leadership, collaboration, communication**, and **public speaking skills**.

Finally, CBL is strongly focused on the development of soft skills for its learners and stakeholder engagement. Hence, contact reflection and evaluation of the personal and learning-related path of its stakeholders is of high importance. To complete the learning circle, the group completed an individual reflection activity, where individual students evaluated their learning experience with CBL, the collaboration with the team as well as the extent to which they achieved their original goals. The teamcher of the group evaluated their process and offered to the students the relevant ECs.

The Challenge Outputs

The challenge had two main outputs. The first one was related to a policy report regarding the utilisation of CBL as a teaching and learning method along a variety of European universities that collaborate under the ECIU. The second was the development of a questionnaire that could be used to evaluate the learning experience of students that participated in CBL challenges across different universities. The two documents together could cover the whole spectrum of CBL experiences among stakeholders involved in CBL challenges.

Writing a Policy Report

Background to the Report

To collect the relevant information on the CBL applications at different universities, interviews were conducted among relevant stakeholders from the ECIU universities participating in the current challenge, and how they utilised CBL in their intra- and extra-curricular activities. These were with educational practitioners responsible for CBL implementation (both on internal and external curricula) at five universities: Alborg University of Denmark, University of Twente Netherlands, University of Stavanger, Hamburg University of Technology, and the University of Trento. The interviews provided insights into the current level of CBL implementation and the planned level of future implementation in CBL, as well as information on where each partner university saw the future direction of the ECIU.

Results

The sub-team responsible for the policy report conducted the interview on the original material of the CBL implementation and analysed the results of the interviews. The result was a strengths, weaknesses, opportunities, and threats (SWOT) analysis of the CBL implementation at different ECIU universities and some future directions regarding the UoTF concept, quoting the partner universities interviewed and the team's own potential solutions. This analysis provided that ensuring **interdisciplinarity**, **challenging conventional thinking**, **engaging higher education students,** and **engagement with popular topics** are the most important strengths of the CBL application. These strengths align with the skills that participants in the UoTF challenge gained.

Producing the report was a detailed undertaking that provided many insights in terms of CBL application and their prospects at the different universities within the ECIU network. The report could be utilised by the challenge providers and involved ECIU stakeholders as a foundation for future practice, and a basis for an advised decision regarding their future CBL endeavours. Furthermore, given the crucial character that this challenge topic provided to all related stakeholders, the outputs of this report were aimed to be utilised as a solid foundation for a future UoTF challenge team. For an overview of the outcomes, see Table 7.4.

Of particular interest was the timing of application, i.e., at what point of study CBL is introduced. Most universities applied CBL only at the highest levels of education, in the final years of bachelor's and at the master's programs. Only a few utilised it at all levels of study and others not at all. The rationale behind this approach was two-fold: Firstly, academics perceived students to not be ready for the CBL approach at the early stages of their studies, before they even had received a base level of tuition on their specific subjects. Fundamental content knowledge and simplified project-like applications could be utilised as a springboard to accelerate towards the 'wicked problems' of industry. Secondly, because the organisation and coordination of CBL are by nature more complicated for the professors, only the students that were already familiar with the subject could cope and appreciate more complicated learning structures.

The interviews also revealed some CBL weaknesses. These include the lack of applicability at all levels and topics, high workload for both

Table 7.4 SWOT analysis

SWOT	*Positive factors*	*Negative factors*
External origin	**Strengths** • Popular topics usually • Topics allow interdisciplinary cooperation • Positive experience for students and teachers • Richer assessing approaches • Challenge conventional thinking/grading/educating	**Weaknesses** • Not applicable for all topics • Not applicable at all levels • Participants must have a lot of engagement • Can be overwhelming for teachers • Law/Bologna contradiction • Mismatch between initial challenge and reality
Internal origin	**Opportunities** • Opening up new topics • New insights on topics • Learning opportunities for teachers	**Threats** • No input from the students who did not complete the challenges • No teaching staff available • Not enough motivation for students

teachers and students and practical implications such as the Bologna process contradictions, as well as the departing away from the original challenge. Overall, there appeared to exist a consensus among the university representatives interviewed that the CBL implementation maintains room for improvement, especially regarding opening new topics and learning opportunities for teachers, while at the same time ensuring both students and teachers remained engaged.

Reflections on the Report Writing Process

Although reports are often part of intra-curricular CBL outputs (that are formally assessed—see Writing a Policy Report), the time commitment required to produce this went beyond the usual expected outputs for an extra-curricular challenge. Researching, conducting the interviews, and analysing the results, structuring and editing the report required a much higher workload than anticipated at the outset of the challenge, which supports one of the report's findings in the weakness section of the SWOT analysis. The two students participating in this process enjoyed many benefits, such as developing information **gathering and processing skills, collaboration and presentation skills.**

Developing a questionnaire

Background

The second output for the UoTF challenge was the creation of a questionnaire, which aimed to identify challenges in higher education and propose solutions to meet the evolving expectations and needs of students, industry, society, and policymakers. The process of designing such questionnaire involved several stages and iterations. The subgroup team working on the questionnaire in partnership with the CP changed the questionnaire's structure multiple times and the scope was narrowed to focus just on students.

Results

The questionnaire was originally based on items from the Motivated Strategies for Learning Questionnaire (MSLQ) aiming to measure students' learning experiences and their skills in academic contexts. The tool was designed to compare students who participated in CBL with those who did not. The final goal was to evaluate the extent to which CBL could be considered of added value in comparison to traditional didactic approaches regarding approaching 'wicked problems.' The questionnaire was developed around multiple activities of the student learning engagement, such as study program, group work, team engagement, problem-solving, teacher's guidance, problem identification and engagement, time management, intrinsic motivation, and general questions about CBL.

The final version of the questionnaire covered topics such as preparation for university life, support systems, soft skills development, teaching methods, multidisciplinary and interdisciplinarity, and personal experiences and expectations. The methodology employed a self-administered questionnaire with multiple-choice questions, Likert scale items, and open-ended questions to collect both qualitative and quantitative data.

Reflections on the questionnaire process

The overall process of developing this questionnaire was long and complex. The team revised the questionnaire several times, readily accepting many suggestions offered by the CP. The challenge took part over several months, with the result of losing focus and even forgetting part of what had been done previously. Finally, the lack of clear deadlines and a variable number of hours allocated for the challenge made it impossible to carefully plan all the work and, therefore, the questionnaire was not administered. While this is not a significant issue in terms of CBL goals, it was frustrating for students that the work would probably be of no use for the UT or the next students working on the UoTF challenge. Despite the difficulties, the students gained many skills from this undertaking, such as **qualitative and quantitative research, questionnaire design, and collaboration**. Those who took the lead on this process developed **stakeholder management and communication skills** in navigating the feedback process with the CP.

Assessment

As set out in the introductory section, there was no formal assessment and grading process for the UoTF challenge as a whole or for the constituent outputs. Assessment and award of ECs were made by the teamcher in terms of engagement with the CBL process and the resulting tasks. Throughout the learning process, the teamcher also informally assessed behaviours relating to citizenship education (and how they interacted with fellow participants, the CP, and the teamcher).

Students were introduced to this challenge in a multi-faceted and open-ended way that allowed them to engage with the challenge on a personal level and explore the specific dimensions of the challenge which they would like to tackle. This was especially because UoTF required learners to (1) take ownership over the challenge, (2) accept responsibility for their own learning, and (3) make choices and compromises. Therefore, the two outputs described were chosen by the team itself rather than being teacher-directed requirements. Putting power in the hands of students flips educational planning and design on its head and opens a space for bottom-up and participatory educational design. The process was explicitly student-centred, which is one of the core principles of CBL. Learning to take ownership over and responsibility for a collective process is an important civic skill and the participants of the UoTF achieved this outcome. Splitting into two smaller teams was also an effective strategy for both time and resource management allowing the overall team to reach higher achievements.

In terms of assessment of the two outputs that formed the *Investigate* and *Act* phases of the CBL process, informal feedback from the teamcher and CPs recognised the effort and engagement that both sub-teams had applied to their respective tasks. To give critical feedback on the report, it was superficial in the introductory sections and did not demonstrate a sufficient engagement with the various dimensions of the essential question laid out by the students in the *Engage* phase of the challenge. However, as previously mentioned, the report was still of sufficient rigour and quality for an ECIU coordinator to recommend further study and research on this topic.

Regarding the questionnaire, students appeared to face many struggles regarding the requirements of the challenge from the challenge providers. They initially failed to perceive the CP as a problem owner and involve them in the *Investigate* phase. However, to the credit of the team, as the challenge progressed, they understood the value of building a relationship with the CP who eventually offered them a much-needed direction when they requested information on CBL efficacy. The students consequently demonstrated resilience and perseverance when it was tempting to abandon the project, especially as it was an extra-curricular project on the side of their core studies.

Turning to assessment of the skills and behaviours related to citizenship education that should be demonstrated by all participants, it should be noted that challenges including governance involve ‘collective action’ dilemmas. This means that certain behaviours such as free-riding and other shirking behaviours constantly threaten to upend a joint endeavour. Overcoming collective action dilemmas requires the institution of collective rules and norms, which in turn require citizens to reach common ground using their **communication, collaboration, and conflict resolution skills**. These were all qualities that the students developed or enhanced during the UoTF challenge. Arriving at a common understanding regarding the common challenge was not always easy, but the participants made space for diverse approaches and opinions within the internal group dynamic while also managing the external expectations, opinions, and approaches of the teamcher, CPs, and hosting educational institution.

Reflections on the Learning Process

As central part of the CBL learning process, reflection should occur repeatedly during all different stages of any project and should have an equally personal and team-related nature. This was the case in this challenge as well. Throughout the process, the students reflected on their progress in a non-hierarchical manner, noting their successes and failures, and redirecting their actions towards the next steps that needed to be obtained. Characteristically, the students displayed deep appraisal of both the positive and negative aspects of self-directed learning. Quoting the students:

> I think CBL is a great way to free one’s intrinsic motivations, promoting individual responsibility and pleasure in learning. CBL constantly reminds students that what really matters in the learning process is the process itself, not the grades or the final outputs.

> The ambiguity of CBL demands came to me as a great surprise. What left me really perplexed in the beginning, but that I came to value subsequently, was the fact that we had to set goals for ourselves, and no clear

> schedule or plan was initially in place. Students need to take the initiative: I especially appreciated that in this challenge, we have even been encouraged to go beyond CBL if we found it limiting in some ways. This experience let me learn that in the end students have to shape independently their own education and find meaning in what they study, without hoping that institutions like universities will provide them with everything. At the same time, universities have to let students express themselves more freely, planning more non-evaluative moments.

The collaborative process was both a challenge and a reward of UoTF. In their reflections, many of the students made note of the **communication and intercultural skills** they needed to develop in order to work together with teammates from different cultures, disciplines, and with different ways of working and how these evolved as the challenge progressed:

> One such surprise was the final connection that we had with all of my colleagues once we met all together. Even though the cooperation and interaction process was not flowing that nicely during the pre-meeting period, that changed completely once we physically met. During these two days and all the period proceeding afterwards, everything in our cooperation was different. It felt as is my fellow students felt a stronger need for responsibility towards the project, just because they met us personally.

In terms of the fluid nature of roles within a team that the CBL model promotes, all team members had to learn when to take initiative and show leadership skills, as well as when to accept a more following role. Students who were already familiar with CBL were introduced to new ways of being supportive to their team member. And students with less experience in project based or CBL learning were also practicing cooperation in a team for a common goal, as well as taking action and being in a guiding role, when needed:

> Even though, I had already acquired most of those skills from my previous experiences with project-based learning and teamwork, the specific learning experience requested a higher-level acquisition. More specifically, since many members of my team were not familiar with the initiative-taking expectations of my university, I needed to guide them more into this direction.

Finally, CBL is in its core a real-world problem learning method. Through UoTF, the learners gained distinct skills regarding approaching and solving those type of problems, as skill that will be of high relevance in their future careers:

> I am proud that we tackled such a big challenge 'Building the University of the Future' in both a creative and methodological way. There are so many different ways to approach such a challenge but by focusing on multidisciplinary and CBL this gave us a good structure and I am proud that we have started a foundational piece of work that other challenge tams can build on.

Reflecting on Stakeholder's Engagement

To maintain the equal ratio in the cooperation between CPs and educational institutions on the one hand, and the students/learners on the other hand, an evaluation of the cooperation of both parties was conducted. To those ends, interviews with representatives of both institutional bodies were conducted a year after the completion of the challenge to assess the challenge's impact.

The educational institution (in this case, the UT) considers this challenge to have been a success, since the students appeared to obtain large amounts of knowledge. From the educational point of view, this was the main goal. However, the representative of the institution would propose a different approach should the challenge be offered again in order to provide higher connection to the local community. More specifically, it appears that guidance towards the students from the CP at the first stages of the challenge would be of great added value. Defining the actual problem premises that bridge the needs between science and society is more informative rather than coming up with a solution for a well predefined problem. Early on, the involvement of the stakeholders would be of crucial importance, as they could support the students to understand what the impact of their actions is at every stage of the challenge, as well as what their final output would be for the society. However, defining the challenges is a challenge on its own.

Finding teamchers that are already experienced with the CBL process and know how to guide the students during the different phases is another. As CBL is a new teaching method, not many teacher and university professors are experienced with it. Their strong motivation is of high value, however, CBL requires different teaching and guiding approaches that diverge from the traditional methods. ECIU is on a good path to creating learning databases to cover the instructional needs of the educational institutions. The premises of a short teaching challenge comprise, however, another issue that often arises; the actual evaluation of the implementation of the challenge solution is not covered in the evaluation. In other words, the impact that the challenge has on the society is unclear, even a year after the completion of the challenge. Solid action should be undertaken to ensure to gradual strengthening of such educational endeavours outside of the educational settings.

On the other hand, the CPs appeared to have a less positive experience from the challenge outcomes. As the student team only involved them in their learning process towards the last CBL phases, the outcomes were not yet validated and hence were of lower quality. Making good use of the skills and knowledge of the CPs early on could have allowed them to tap into their already existing knowledge and avoiding covering ground that has already been covered by them in advance. The infusion of CBL practices in the curriculum of the studies could possibly offer superior and more tangible results.

Furthermore, the project was granted extra time allowing its participants to extend even longer to ensure quality. This prolonged period, however, might not have been that beneficial for the project after all, since the CPs were already developing further in their knowledge, while the students were making small steps on the same matter. The results did not need to be life-changing, of course but they were adding up to the CPs already existing databases and adding up towards something bigger. A valuable advice on this matter could be the utilisation of pre-defined milestones which the students need to achieve to reach next levels of development in their projects.

Implications and Conclusions

Implications and Benefits for Students

There were many benefits that student participants in the UoTF challenge gained related to citizenship education skills which have been highlighted throughout this case study. In summary, CBL encourages students to take an active role in their own learning, rather than passively receiving information. In addition to all the skills highlighted in this case study, it can also be added that students developed their **real-world**, **problem-solving**

skills. To do this, students need to struggle with and become comfortable with the open-ended nature of the challenges. In this regard, it can be argued that the greatest level of growth and personal development was demonstrated by students participating in CBL for the first time.

Implications and Benefits for Practitioners

One of the benefits for CBL practitioners in mentoring and overseeing self-directed student learning is that they can leverage student outputs and experiences to enhance teaching effectiveness. Designing courses with the right balance of structure and freedom is essential to encouraging student growth and development. However, CBL is resource intensive and providing material and technical resources to students may help them better achieve their learning aims. One area where resources could be invested is team building as there will always be trade-offs between the flexibility afforded by online technological platforms and the quality of interactions between participants, arguing that interpersonal dynamics would have been better had teamwork taken place in person. Moreover, the design developed by the students (which touches on student and administrator perceptions) could be replicated and extended—to also consider teacher perceptions—by the ECIU to gauge what the added value of CBL really is for universities and the communities that they serve.

Implications for Future Implementation of UoTF

The concept of creating the UoTF is very broad and open. This has both advantages and disadvantages as discussed throughout this case study. A learning from this for future iterations could be to narrow the scope of the challenge to focus on one aspect of the UoTF. Again, achieving a balance between promoting self-directed learning and creative freedom with sufficient structure and direction to produce usable outputs is difficult. While all the learners envisioned a radical transformation of future education, they had different visions for achieving it. Some emphasised cross-cultural and trans-disciplinary collaboration; others argued for a redesign that makes education more affordable and efficient. Still others envisioned education that was more oriented towards the professional ambitions of students to help them cultivate needed skills for future work.

A second learning is the need to invest in greater multicultural education as an approach to teaching and learning that recognises and values the diversity of students' cultural backgrounds and experiences. This is an approach that seeks to promote understanding and respect for different cultures and perspectives. When these two approaches are combined, they can create a powerful learning experience that prepares students to be global citizens who can think critically, communicate effectively, and collaborate across cultures and perspectives. More competent citizens who consider others in their democratic behaviour and attitudes are critical for well-functioning democracies. To the extent that CBL at the ECIU helps students cultivate skills and keep capabilities that promote citizenship behaviour and European values, these challenges also make important contributions to shaping the citizens of tomorrow.

Case Study Thirteen—The CBL Continuum a Tool for CBL Implementation

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Implementing CBL, as illustrated through the cases in this book, can be exciting and rewarding. However, it can also be overwhelming as designing education, particularly when incorporating CBL elements, is a wicked problem in itself. There is no one-size-fits-all approach to applying CBL, and it requires a well-planned and thoughtful execution to maintain the balance of ongoing education.

To assist teachers and educational designers in transitioning to fully realised CBL courses, we—a team with expertise in educational science, educational research, and CBL teaching from the University of Twente—have proposed a conceptual model, the CBL Implementation Continuum (Imanbayeva et al., 2023). The model connects CBL elements to the Curricular Spider Web of Van den Akker (2003), reflecting curricular alignment, consistency, and coherence. The Spider Web compares a curricular design to an intricate and interconnected web. The learning rationale is the key link in the web, and the threads extending from it are the other significant components of a curriculum, such as learning aims and objectives, content knowledge, learning activities, teacher role, materials and resources, grouping, location, time, and assessment (Van den Akker, 2003). This model illustrates how each aspect of a curricular design is interrelated and impacts the overall educational experience.

For each curriculum component, we introduce varying levels of CBL intensity—Mild, Moderate, and Intense—providing a flexible framework to cater to diverse educational needs and preferences. The Mild level describes how CBL essentials can be initially integrated into the existing educational structures. Building on this, the Moderate CBL introduces additional CBL elements, providing a more comprehensive CBL experience. The Intense level describes a full-scale implementation of CBL, where all the elements of CBL are integrated into the curricular design. We will now explore how each spider web component unfolds across the continuum. You can find a visual overview of the model on the University of Twente website at this link: https://challengeup.utwente.nl/.

Learning Rationale

The learning rationale explains why students learn in a curriculum. In CBL, students learn to positively impact society and interact with the real world (Apple Inc., 2011; Conde et al., 2020; Cruger, 2017; Nichols et al., 2016). At the Mild CBL level, students tackle wicked societal problems passively, focusing on engaging with the problem, investigating it deeply, and advising relevant stakeholders. The Moderate level deepens students' engagement by linking the big idea to something personally relevant to the students and requiring a more active real-world impact. At the Intense level, students' actions have direct, measurable effects on the challenge and stakeholders they worked with.

Learning Objectives

Learning objectives in CBL guide students towards identifying and filling their knowledge and skill gaps for personal development (Apple Inc., 2011; Nichols et al., 2016). In Mild CBL, learning objectives are still teacher-defined, but already incorporate CBL elements by facilitating students' reflections on their knowledge and skill gaps and fostering a more mindful learning experience. At the Moderate CBL level, learning objectives expand to encompass higher-level objectives along with 21st-century skills development and require students to define some personal learning objectives, offering students more personalised learning options and promoting ownership. In Intense CBL, students independently set their learning objectives, tailoring the learning path to their ambitions and interests. Teacher-defined learning objectives are abandoned at this level. Instead, teachers facilitate students in defining their own learning objectives.

Content Knowledge

CBL content knowledge includes transversal skills and interdisciplinary academic knowledge crucial to students in designing solutions for their defined challenges (Apple Inc., 2011; Dieck-Assad et al., 2021; Nichols et al., 2016). At the Mild level, students create a knowledge repository that merges interdisciplinary academic knowledge with 21st-century skills mainly defined by the course. However, they are also encouraged to explore other topics relevant to their challenge. When progressing to Moderate CBL, the focus equally balances content pre-defined in the course and content related to the challenge. At the Intense level, the content knowledge shifts completely to prioritising challenge-specific knowledge, incorporating multiple disciplines. Pre-defined content is limited at this level.

Learning Activities

CBL learning activities engage students with wicked societal problems, guiding them through defining, investigating, and addressing actionable real-world challenges (Apple Inc., 2011; Dieck-Assad et al., 2021; Gallagher & Savage, 2020; Leijon et al., 2021; Malmqvist et al., 2015; Nichols et al., 2016; Yang et al., 2018). In Mild CBL, the learning activities are strictly scheduled and focus on understanding concepts, collaboratively identifying actionable challenges, working with stakeholders, and encouraging reflection on solution designs and their potential impacts. The Moderate level increases student autonomy, promoting independent stakeholder engagement and requiring students to implement their solution designs. The reflection becomes more profound at the Moderate level as students are required to reflect cyclically. At the Intense level, learning activities become even more personalised. Students are encouraged to connect deeply with the big idea and form groups based on interests. The solution must not only be implemented but its impact should also be actively evaluated, with a cycle of documentation for broad dissemination of results. Students decide which learning activities are needed to achieve this.

Teacher Role

As CBL is a student-centred framework, the teacher role shifts from the ultimate knowledge facilitator to a coach and an advisor (Chanin et al., 2018; Dieck-Assad et al., 2021; Nichols et al., 2016). At the Mild level, teachers guide the learning process as supervisors and provide expertise as professional advisors. Moving to Moderate CBL, they transition to coaches, emphasising active facilitation and encouraging students to lead their learning journey. At Intense CBL, teachers collaborate closely with students as co-learners, co-researchers, and co-designers, creating a dynamic environment for mutual knowledge exchange.

Materials and Resources

Students are expected to leverage a variety of (guiding) resources and advanced technology to create innovative solutions and boost digital literacy (Apple Inc., 2011; Gallagher & Savage, 2020; Gibson et al., 2018; Nichols et al., 2016; Pepin & Kock, 2021; Tang & Chow, 2020). In Mild CBL, students mainly use resources provided by the teacher and are encouraged, but not mandated, to explore additional materials. At the Moderate level, students are given more autonomy in choosing the resources, while using technology becomes mandatory, and teachers are expected to provide access. In Intense CBL, students should have access to cutting-edge technology to develop advanced digital skills and prepare for the digital world. Students determine which materials to use based on their defined challenge.

Grouping

CBL grouping focuses on assembling students from varied backgrounds to encourage a broad interdisciplinary perspective on a challenge (Dieck-Assad et al., 2021; Gallagher & Savage, 2020; Nichols et al., 2016). In Mild CBL, diverse groups are formed that bring together students from various academic, social, and cultural backgrounds. The teacher plays an important role in forming these groups by, for example, providing guidelines and establishing rules. At the Moderate level, students are specifically required to form multidisciplinary groups encompassing students from different disciplines. At the Intense level, a CBL group includes coaches (teachers) and stakeholders, in addition to students from different disciplines, where everyone is a learner, and the students are in the lead. Group composition at this level depends on the challenge, and there are no pre-defined rules for group formation.

Location and Time

A CBL experience 'extends the classroom environment and necessitates access to the real world' (Nichols et al., 2016, p. 19), encouraging learning flexibility and student autonomy (Nichols et al., 2016). Thus, Mild CBL location and time require students to learn in real-world settings, which could include visiting sites, interviewing stakeholders, and attending lectures by experts. However, the course structure still involves a set of planned, mostly compulsory activities such as rosters. As the course progresses to Moderate CBL, there is a shift towards more flexibility in scheduling and location. Some lessons become voluntary, and more room is given to self-directed learning activities. Teachers support this by providing physical spaces for transitioning between individual and group activities and through virtual platforms for continuous collaboration and resource sharing. The Intense CBL level fully embraces flexibility, giving students the autonomy to choose when and where to engage in learning. It is supported by unfettered access to collaborative learning spaces and stimulates real-world learning.

Assessment

CBL assessment prioritises the learning process and reflections over the product or content mastery. Solutions to challenges are evaluated, focusing on the design's integration of knowledge and feasibility (Gallagher & Savage, 2020; Nichols et al., 2016; Yang et al., 2018). Assessments involve students, teachers, and stakeholders as co-assessors (Cruger, 2017; Nichols et al., 2016). In the Mild CBL level, both the innovation of the product and the reflective aspects of the process are evaluated based on criteria for knowledge integration and feasibility. There is still a significant focus on assessing content at this level. Moving to Moderate CBL, the focus shifts more towards creativity and the process, with students critically reflecting on the outcomes and playing a role in assessment decisions. Content and process are more or less of equal importance. At the Intense level, emphasis is on personal progress and decision making, with students fully participating in co-assessment, promoting a collaborative evaluation of their learning journey.

Using the Continuum

The intensity levels of CBL provide teachers with the flexibility and direction needed to design a CBL course. Rather than implementing CBL all at once, transitioning to CBL step-by-step is valuable to ensure a well-planned and systematic approach, keeping the functional components of the curricula intact and reducing work pressure. Another important reason is the consideration of whether students are ready for CBL. Have they had prior academic experiences that have prepared them for Intense CBL? Are they comfortable with group work and able to handle the complexities of a multidisciplinary CBL group? Have they had any experience working with external stakeholders? Do they possess the skills to convince experienced professionals to follow their lead? Adopting the CBL mindset requires students to be committed to exploring, innovating, and actively participating in the world around them. Answering these questions can help teachers decide on the appropriate CBL intensity level.

One may now wonder how to use the continuum to choose the appropriate intensity level for course design. The key is ensuring that the CBL design aligns with the broader learning objectives of the course. Asking why CBL is being incorporated into the course design can determine the appropriate intensity levels for each component and the course holistically. For example, if the goal is to teach students how to have an impact, the CBL Learning Rationale should be at the Intense level. This will help students truly connect to their big idea and the challenge, work towards immediate societal impact, and actively interact with the real world. As such, it is important to frequently reflect on how CBL benefits a course and fosters students' growth. It is crucial to remain open to changes in course design when necessary and when the time is right.

Incorporating CBL into higher education is a gradual process that aims to build on existing educational practices and may transform the educational landscape. This process requires careful planning, efficient execution, and continuous revisions. To support a seamless and effective transition, we have developed Challenge Up, an online tool co-funded by the 4TU.Centre for Engineering Education (University of Twente). Challenge Up is designed to help teachers apply the CBL Implementation Continuum and provides a comprehensive database of best practices for gradually transitioning to higher levels of CBL intensity. The tool enables users to specify their current and desired CBL levels for each curricular component, giving them the freedom to decide which intensity levels are most appropriate for their specific case. Based on the input, the tool generates personalised, evidence-informed advice on how to bridge the gap and attain the desired intensity level. The tool also encourages users to provide feedback, which will be used to improve the content continually. Challenge Up is accessible through the University of Twente's Centre of Expertise in Learning and Teaching website.

Appendix of Case Study Eleven

See Table 7.5.

Table 7.5 FAQs and responses

FAQs
1. Does the challenge need to be a wicked or complex challenge in final year? It needs to be an open-ended real-life challenge that currently does not have a solution. Final year challenges will usually be more complex than tightly defined challenges students might engage with in first year
2. What are the key criteria for defining a 'challenge'? Academics should work closely with students during the *Engage* phase to help them define the challenge. If time and support are not dedicated to the *Engage* phase, students may find it difficult to solve the challenge. Essential questions are used to help students define the challenge. This is similar to helping research students define their research question. The essential questions help students refine the challenge to make it manageable and realistic within the time frame and appropriate to the assessment weighting and ECTS credit allocation. Examples of essential questions include 'what subtopics or areas could you investigate in this challenge? Which topics are you most interested/competent in? Will other modules help you solve that challenge? Can you realistically try to solve this challenge in the timeframe you have?' etc.
3. What is the difference between PBL and CBL? A working definition for CBL at DCU has been developed by the CBL Working Group and approved by Education Committee. On page 2, there is a list of differentiators between CBL and PBL which may help to guide decisions about which term is most appropriate in any context. This list was adapted from the distinctions described in Membrillo-Hernández et al. (2019). The working definition can be viewed at the following URL: https://bit.ly/CBLdefn2

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Table 7.5 FAQs and responses

FAQs
4. What level of input should the academic have in helping students define the challenge?
For first year, students should have some guided direction with their challenge so that it aligns with the learning outcomes of the module(s) and programme to ensure students do not feel overwhelmed. This could include: (i) providing a list of potential topics/challenges from which students can choose, (ii) providing regular academic/industry mentorship to students as they work through the challenge, and (iii) offering students a small number of different pathways in how the challenge could be addressed. Frequent opportunities for formative feedback are also important for all CBL students, but most especially first year students as they are learning about the process. However, it is important to remember that CBL does require student agency and self-direction
5. Can many/all students take the same challenge?
Yes, because even if groups do define the same challenge statement (which would be most unusual), their approach to solving it will be different
6. What is the optimum ECTS credit size of a challenge?
There is no optimum ECTS credit size. CBL needs to be designed into each stage of the learning journey (as part of a programme assessment strategy) and may be one large challenge module (5–10 ECTS credits), or a shared challenge across two or more modules. The congruence of credit allocation across the different cohorts engaging in a challenge needs to be considered. If it is a multidisciplinary challenge, in the interest of fairness to students, it should be the same number of credits across the board
7. Can something the lecturer is already doing be 'rebranded' as CBL if it fits the criteria?
Yes, many good challenge ideas come from the lecturer's area of interest or research, particularly if it is through an SDG that the lecturer is experienced in. However, for CBL experiences, it would be important to ensure that the full CBL Engage-Investigate-Act framework is adhered to
8. Who would the stakeholders be and how do we define, manage, & assess the relationship?
Stakeholders can be any partner(s) that supports learners in solving the challenge, e.g., industry, society, community, NGOs, researchers, peers, etc. Managing the relationship can be challenging, but also very rewarding. The stakeholders are often involved in formative assessment throughout the challenge phases (e.g., Engage, Investigate, and Act), but the academic usually does the summative assessment (with input from the stakeholder if appropriate)
9. How can industry engagement be developed in Year one?
Students are motivated to work on real-world authentic type challenges. Industry and external stakeholders can suggest challenges and provide feedback at one or two points throughout the process. They could also offer once-off master classes. Student exposure to industry or external stakeholders in year one needs to be managed carefully to ensure both the students benefit from the experience, and realistic expectations are managed for stakeholders' involvement, remembering we wish to make greater use of external stakeholders in final year, so we don't want them to peak too soon!

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FAQs
10. Can both a CBL module and Project be accommodated in final year? One objective of a final year project usually includes giving students the opportunity to plan, develop, and carry out a single significant piece of work that typically spans a whole semester or year. Consideration would have to be given by the programme chair/team as to the appropriateness of splitting the final year workload into both CBL and a Final Year project, as this would likely compromise the duration and/or depth of the project
11. What does multidisciplinary mean? Using a lens beyond the discipline(s) being studied by each student. The idea is that the team will be multidisciplinary, or they will explore the challenge through a multidisciplinary lens. It is mainly about different disciplines coming together and sharing their perspectives in pursuit of a better solution while the approach, tradition, and strength of each discipline is maintained. The major benefit of multidisciplinarity is that it enables students from different disciplines to work as a team and in the process explore different perspectives
12. How can a 'multicultural perspective' be achieved? If the challenge team is not multicultural, it will require them to investigate the proposed solutions through the lens of different cultures and contexts. For example, investigating solutions proposed across different cultures for similar challenges
13. Does reflection need to be tangible? Yes, reflection should be tangible and have real impact on learners' learning. It requires some solid action or takeaway for the learner, something that will enhance their future studies or career. Learners can reflect on the process, the end solution, or both. A range of reflective practice toolkits and resources are available from the TEU
14. What does 'evaluation of solution' mean? Evaluation of the solution requires teams to take feedback from peers and external stakeholders, to reflect on that feedback and document how the proposed solution might have impact or has room for improvement for the next iteration
15. How prepared will the final year students be? If the CBL Learning Pathway is applied, the students will be supported and scaffolded in their CBL learning journey from year one to final year. This will involve more simple and well-defined challenges in early years, advancing to more wicked, complex, real-world challenges in final year
16. How is a challenge different from a First-Year lab experience (which arguably supports Transversal Skills quite well?) A lab experience is hands-on practical experience, which typically has a defined standard operating procedure (SOP) and is structured throughout. CBL is less hands-on, learners have more autonomy within a guided framework to explore potential solution(s)
17. How do you assess students in CBL? Can you assess them individually? Like all assessment strategies, CBL assessment should be carefully designed to ensure it is scaffolded with many opportunities for reflection and feedback throughout. In final year, CBL is usually assessed on an individual basis. There may be occasions when it is a group assessment, but an individual component could be included, e.g., a reflection element, or interactive oral assessment. See Assessment descriptor above

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FAQs
18. What level of weighting should be given to a challenge? There is no one-size-fits-all answer. The decision about assessment weighting (and indeed ECTS credit allocation) should be made at programme level and be part of a coherent programme assessment strategy. There may be some logic to having a smaller weighted challenge in first year when students are learning the skills required to solve a challenge, and then weightier challenges in final year when students have learned the underpinning skills and processes required to solve challenge. Similarly, the ratio of direct instruction (i.e., teaching of content) to challenge time is likely to change over the years. For example, in first year, the teaching time may be more content-focused whereas in later years, there may be a weightier challenge and a smaller amount of time dedicated to content teaching
19. Will teamwork (and other Transversal Skills) come with guidance, and will performance be assessed? If so, how? A key affordance of CBL is the opportunity for students to both develop and apply a variety of transversal skills. To date, DCU expert panels have developed definitions and constituent competence statements for each transversal skill. These constituent competence statements lend themselves to the development of appropriate assessment rubrics, which may vary based upon the discipline within which the CBL is taking place. Assessment of a transversal skill is also informed by whether that skill is 'socially applied.' That is, transversal skills such as 'teamwork and collaboration,' as well as 'leadership,' by definition, require engagement with others and therefore their assessment may be different to skills which an individual may demonstrate independently, such as 'critical thinking.'
20. Can the challenge be incorporated into the INTRA experience? It is not currently possible to ensure that a sufficiently supportive CBL framework would be in place for INTRA students. However, there is certainly potential to develop a challenge as part of an INTRA alternative for students. In some disciplines, students are not always successful in securing INTRA placements and so for these students, a relevant challenge could be offered. A 30-credit ECIU Explorer challenge may be one example
21. We are very unlikely to get to the point of solution implementation. Does this mean it does not qualify as CBL? In many cases, CBL solutions or recommendations may not reach full implementation within a stakeholder context. It may not be feasible in all circumstances, especially with short timeframes. It is emphasised, however, that regardless of implementation in practice, the solutions/recommendations must be sufficiently detailed and viable, and presented in a way that peers and other stakeholders can provide feedback

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PART III

CBL Implications and Reflections

CHAPTER 8

CBL Future Implications for Teachers, Practitioners, Students, and Stakeholders

Introduction

In part two, we provided a number of CBL case studies from multiple contexts written by teachers and practitioners. These case studies were categorised within the three levels of the ecological framework including micro, meso, and macro. In this chapter, building on these case studies and the review of CBL research presented in Chapter 2, we draw practical implications for all stakeholders who are involved in the process of implementation of CBL. In our request to contributors, we asked them to present implications and benefits for practitioners, teachers, students, and stakeholders and we can now draw on the details of these CBL implementations in different disciplines and in different ways. This analysis will reveal contextualised practices and understandings that shape an emerging set of implications for those who would like to implement CBL.

Implications for Students

Our case studies also helped us draw implications for students who need to adapt to new ways of learning within the CBL framework as an alternative to learning within the boundary of the classroom through the lecture model.

K. Dikilitaş et al., *A Practical Guide to Understanding and Implementing Challenge-Based Learning*,
https://doi.org/10.1007/978-3-031-67011-4_8

Adopt and Practice Self-Directed Learning

One of the key implications for students in a CBL project is that they need to learn how to be and become a self-directed learner. Since CBL provides space for flexible, active, collaborative learning without much presence of the teacher (Franco et al., 2023; Padua, 2020), they need to monitor and self-assess their own learning continuously. We argue that students assume full ownership of their learning processes by gaining insights into unique and independent learning where necessary. This is clearly highlighted in case study one. We also offer the implication that students should analyse, design, develop, and execute real-life problems through CBL. Case study two places particular emphasis on students as 'self-directed learners' in CBL. Many case studies discuss the role of the students in CBL as active knowledge constructors with sensitive scaffolding from the teachers or the practitioners. Similarly, case study three suggests that CBL should facilitate active student learning through self-directed activities and self-reflections on the process of learning while addressing and solving real-world problems.

Acquisition of New Knowledge and Skills

CBL argues that the knowledge students need to acquire should be discovered through teamwork in close collaboration with multiple stakeholders (Keenahan & McCrum, 2021; Mesutoglu et al., 2022). This is because the knowledge we expect students to learn is often contextualised in the real world and students have limited access to those contexts. With CBL, students are taught that learning is an active process that can and should be grounded in a particular context (Gallagher & Savage, 2020; Ojasalo & Kaartti, 2021). Without that context, knowledge may not be properly acquired, and skills may not be developed. When constructing knowledge, students need to be guided through the context in which they need to build it. When students identify and address challenges, they initiate the process of acquiring new knowledge and developing a diverse set of skills, which will be of practical use in the real world (López-Fernández et al., 2020; Nichols et al., 2016).

The case studies report a wide range of skills that students develop throughout CBL engagement which include managing leadership, learning through teamwork, engaging in continuous critical thinking, and conducting constructive communication. For example, case studies two and four report how students improve their communication skills both within groups in a classroom setting and also in public settings with external stakeholders as showcased in case study six. Similarly, case study seven shows how students develop transversal competencies like entrepreneurial spirit and innovation. Case study eight exemplifies how students enhance their professional skills including teamwork, project management, and intercultural competencies, which constitute key skills for participating in international projects. In addition, case study two emphasises that critical thinking and 'self-reflection' are the most demanded soft skills required by the job market.

Furthermore, CBL promotes a hands-on approach. For example, case study nine suggests that students need to develop critical thinking and problem-solving skills through activities that require them to analyse situations, brainstorm ideas, and engage deeply with the subject matter. They should also develop the ability to communicate and transfer knowledge across disciplines as they address complex challenges (Christensen et al., 2021). Moreover, in case study twelve, students were encouraged to think about the concept of citizenship education and the skills required to build 'the university of the future.' We can suggest allowing students to deal with big issues and find necessary space for collective critical thinking and develop problem-solving skills within the content of learning.

All these skills are directly or indirectly promoted and applied in each of the CBL phases through diverse activities, for example, when students conduct interviews with stakeholders, do statistical analysis, and design visually meaningful presentations. They also support knowledge construction as they become more and more skilful in discovering and generating knowledge in the social context through interaction with multiple stakeholders.

Connecting to Real-World Challenges and Working with Stakeholders

Connecting the theoretical content and knowledge in a course to the practical work of stakeholders using CBL proved to be a transformative experience for students, as highlighted in various case studies in this book. For example, case study two argues that students be given the opportunity to analyse, design, develop, and execute real-life problems. By doing so, they could excel their skills to learn beyond mere presentation of models and tools by their teachers. They should actively seek opportunities to apply new concepts in a real-world context and question the arguments for a deeper understanding of a problem. Similarly, case study eight emphasises that students need to be guided to address real-life challenges from both a practical and academic perspective since it is this combination that can develop their intellectual understandings. This nexus between developing theoretical and practical knowledge simultaneously is further exemplified in case study six, where students actively participate in a hackathon sponsored by the challenge provider and directly interact with professionals in a coworking space. This way, students get to know the real context of an authentic challenge. Case study nine also shows how students connect their learning through hands-on experience with the world beyond the classroom. This connection not only makes the learning more meaningful and engaging but also encourages collaboration among students and various stakeholders involved in addressing and solving the challenge.

Problem-Solving, Prototyping, and Implementing Solutions

CBL is an enabling catalyst for addressing and solving societal challenges through student-led problem-solving, prototyping, and implementing solutions, as shown in many of the case studies. For example, in case study one, participants express how CBL helps them understand the root of a problem and not rush straight to a solution, to think holistically about a challenge. This shows that students need to be given chances to develop intrinsic motivation in learning actively while trying to develop a meaningful solution for a real-world problem. The authenticity of such learning where knowledge developed is immediately contextualised for use in the real world creates such a desire to engage, learn, and develop over time (Nichols et al., 2016). Therefore, we recommend that students make this relevance explicitly and see the role they play in solving the societal and industrial challenges in a specific context. They need to perceive the significance of a problem they have addressed and solved as described in case study one. As students identify challenges, they should engage in prototyping and test different potential challenges. They should exercise ownership of the process of making sure the defined challenge is addressed properly. This gives them credibility and they learn how to create robust work. Case study two exemplifies this process and implies that students need to develop authentic solutions to challenges and establish real-world relevance.

On the other hand, case study five suggests that students should directly make a positive influence on their university environment by mobilising their challenge between the classroom and industry. Case study eleven also implies that students should also develop a flexible thinking ability to locate potential solution outputs developed within the CBL framework in the real-world context. They need to engage in reporting their experiences of how they identified and addressed the challenges. They need to share solutions to challenges within the broader community and see how the solutions generated through CBL can be applicable to the real-world context. Finally, case study eight implies that students need to be facilitated to develop innovative ideas and effective solutions, which is complemented in final written and verbal reporting.

Undertaking Accountability of the Solutions

Giving students time and space to prototype solutions developed to address the challenges is key to guiding them to generate functional and relevant solutions. They need to test their own solutions and collectively report that their solutions are contextually appropriate and address the challenge initially identified within the specific field. Several case studies imply that students need to be given an opportunity to experience a transformative process of learning and exercise control over challenges faced by specific industries. They should not only identify and address challenges but also report how they work to address their specific challenge. During the prototyping process, they might fail to see a positive alignment between the challenges and the solutions. However, this should not be seen as wasted time and effort but on the contrary, a learning opportunity where they develop a deeper understanding of the contextualised issues. The failure here should be seen as a start for another round of challenge identification. For example, in case study eight, students openly acknowledge that learning from mistakes is an intrinsic part of the CBL process, emphasising the generation of new ideas and the courage to start afresh. Notably, one team advises their peers to '*Learn from mistakes and look for constructive feedback and critique. Do not be afraid to fail and experiment with your ideas.*' Expressing a proactive approach towards failure, a student from the same case study says their learning goal was to '*allow a place for failure and allow me and the team to start over from zero if our* *approach wasn't suitable*.' Challenges in CBL often involve obstacles and setbacks as shown in several case studies, which in fact helps students get used to receiving critical feedback and developing resilience.

Collaborating in Intercultural/International/Multidisciplinary Teams

Several of the case studies include direct quotes from students reflecting on their experiences of participating in CBL challenges where they express appreciation for the intercultural and international dimensions of their collaborative experiences. One participant in case study eight for example said: '*I liked the most the intercultural aspect of the challenge*,' and another participant from the same case study notes, '*One of the most important experiences I had for myself was being able to work in a multidisciplinary and international team and understanding how different backgrounds shape different understanding, opinions, perspectives, and ideas*.' According to these reflections, we suggest that students need to be facilitated to engage in multidisciplinary and international teamwork, which might help them develop a comprehensive understanding of diverse perspectives. Based on case studies three, six, and eleven, we can suggest that students should also work in international and intercultural teams and engage in collaboration by mobility schemes. The students then need to learn in hybrid modalities where they can effectively communicate and participate in CBL teamwork through a variety of modalities including online, face-to-face, synchronous, and asynchronous participation.

Case study eleven suggests that in their first year of working with CBL, students need to be included in smaller-scale collaborations, such as sharing specific aspects of challenges with those from other disciplines. However, as they progress to the final year, they could contribute to the project from start to finish, which might help them develop basic skills they need to work and learn with the CBL pedagogy. Furthermore, we suggest that students need to be guided to engage in individual and teamwork incrementally. For example, in the first year, participating in teamwork could be highly scaffolded, since their collaborative abilities may not have been developed yet, as illustrated in case study eleven.

Preparing for a Career

CBL offers a great opportunity for students to prepare themselves for a career in the specific industry they are aiming for. Students should see CBL as a gateway to the specific industry while they are still students. Having knowledge about the industry context and developing awareness and understanding of potential industry-specific challenges are the key processes for students to consider.

While doing that, teachers and practitioners have a responsibility to use CBL as a process of entering the professional world. However, this responsibility must also be shared and driven by the students' own motivation, interests, and willingness to engage enthusiastically. Stakeholders should also see this as an opportunity to prepare students for a career in their sectors and facilitate students' adaptation to the workplaces (see Section 'Implications for Stakeholders'). For example, based on case study six, students should keep in touch after the CBL-initiated connections and interactions within the emerging network. They need to expand their networking opportunities, develop their CVs, and seek further opportunities for securing more internships in related areas. This aligns with the broader perspective presented in case study nine, where students use CBL as a tool for addressing the complexities of real-life challenges, reframe it for future projects and professional tasks. Students should re-establish connections and build relationships with industry experts and professionals in meaningful ways by contributing to their development rather than expecting to be recruited without tangible projects and experiences. Similarly, according to case study four, students should see CBL as a career preparation phase, and increase their readiness to undertake professional roles.

Implications for CBL Practitioners and Teachers

Raising CBL Awareness Through Continuous Reflection

One of the major implications for practitioners and teachers is to ensure they appropriately 'set the scene' for the use of CBL in any educational context and to prepare students for identifying and creating alternative solutions to potential challenges. For example, case study eight clearly implies that teachers and practitioners are also reflective practitioners who understand their new role in CBL practices. Such an exploration process is key to a new approach that is being adopted and implemented since it might bring initial confusion and doubt. Therefore, a continuous reflective practice on potential challenges can raise awareness and lead to greater learning opportunities for teachers and practitioners. The case studies in part two have also shown that teachers' and practitioners' reflections also increase motivation and enhance students' learning experiences, supporting the findings in our analysis of existing CBL research in Chapter 2. For example, case study one highlights the importance for practitioners to take stock throughout a challenge and closely observe the students' learning process within the context of CBL. Similarly, case study two emphasises the transformative nature of CBL as a reflective learning process which helps teachers regulate the processes of challenge identification, challenge development, and knowledge acquisition as a team-based and/or self-directed learning. So, we argue that while teachers and practitioners need to engage in continuous self-reflection for awareness raising, they could also engage their students in reflecting on their own learning process to better monitor and improve own learning. The reflection process can be highly supportive of learning during the CBL integrated course since the way CBL engages students in learning can pose challenges for many due to the non-traditional ways of learning where students have a number of active learning responsibilities with the team. Therefore, reflection might raise their own awareness of potential difficulties.

Facilitate the Identification of Authentic, 'Real-World' and Open-Ended Challenges

Challenges in CBL are by nature open-ended and need to be solved uniquely by a group of students. Dealing with the identification of challenges in the real-world context, students are encouraged to engage creatively in localised and contextualised problem-solving and critical thinking (Lara-Prieto & Flores-Garza, 2022; Ruiz & Wever, 2024). This creates a dynamic and exploratory learning environment for them and for their teachers. Therefore, practitioners and teachers in CBL alike need to take responsibility for helping students identify and work on authentic, open-ended challenges which need to be measurable and actionable (see Chapter 2). Students should be guided to identify authentic challenges which are grounded in the context of the workplace, creating relevance between students and real-world problems, while learning in their own university courses. They need to be fully guided to negotiate the challenges they identify with stakeholders to increase the degree of authenticity and usefulness (see Chapter 2). Ensuring authenticity will also positively impact the learning process as they deal with real-world challenges. For example, as highlighted in case study eleven, challenges are designed to address real-world problems that are authentic and intricately linked to significant issues in social, technological, environmental, and economic domains. This aligns with global themes of the UN Sustainable Development Goals, on which ECIU challenges are built. We suggest that the authenticity of the challenges is underscored by their high relevance to the work environment that CBL students are preparing for.

Consider Appropriate Format for Course Design

CBL courses are designed to assign different roles to students enabling them to undertake more active roles in the course. They are guided to link the course content to the real world to make it more relevant to their future roles in the society. Such a pedagogical shift requires redesign of the course (see Chapter 9 for first-hand testimony of this from CBL practitioners). However, there are many factors to be taken into consideration such as roles distribution, tasks and activities, the duration of the course, tasks to be assigned, the assessment, and evaluation practices (see Chapter 3). Course design is dependent on the educational context, i.e., whether CBL is implemented as an intra-curricular or extra-curricular course, as this affects several factors such as the level of multidisciplinary of the teams, the duration of the challenge, and the nature of assessment and evaluation (see Chapter 3).

We should also consider course design since the boundary of the classroom is extended to include other learning spaces such as a classroom, design lab, or workplace of external stakeholders not only within local but also international contexts. The learning spaces might also include and designed as a hybrid format, where online platforms and other digital tools are used to facilitate smooth communication and collaboration as demonstrated in case study seven and case study twelve.

Teachers and practitioners should also adapt their course design to provide relevant materials and technical resources for students while they identify and address challenges. These materials and technical resources include collaborative online platforms such as Miro, Mural, or Padlet (as detailed in case study twelve). A CBL course design is also based on how teachers and practitioners organise team building as noted in case study eleven. Since in CBL learning occurs in groups, the interactional dynamics in team formation can substantially impact the process as the teams should work in harmony. Therefore, teachers and practitioners should clearly communicate the course objectives, learning activities, and assessment practices with CBL students as the success of the course is based on these design-related aspects. It is important to therefore strike a balance in the flexibility and freedom offered in a CBL course design which might promote student engagement and motivation. Teachers and practitioners integrate in the course design unique collaborative processes with their students and create a student-led learning process as exemplified in case study one.

Create Diverse, Multidisciplinary Teams

As detailed in Chapter 2, the formation of multidisciplinary teams in CBL is a process essential for the inclusion of diverse perspectives and skills. However, team formation dynamics can differ based on whether the challenge is intra- or extra-curricular. While intra-curricular challenges inherently pose a greater difficulty in establishing multidisciplinary teams (for example, as students are all on the same bachelor's or master's programme), the unique nature of each team working on a distinct challenge still promotes multidisciplinary collaboration. Case study two, for example, shows that student groups exhibit diversity not only in their educational backgrounds but also within professional experiences, prior knowledge of the challenge topic, and of sustainability. Teachers and practitioners can even use pre-challenge tools for team formation such as survey to identify previous teamwork experience and soft skills as evidenced in case study four where students were given greater autonomy by being asked to self-organise into three teams, each 'striving for the highest level of multidisciplinarity.'

Many of the case studies in this book also highlight the international composition of teams and ensure greater equity, inclusivity, and diversity. In both case studies six and twelve where the focus is on engaging with one specific challenge, there is a strong emphasis on the concept of 'mobility.' This means that students travel to be physically present in diverse and international teams after having worked with them in an online only format in the earlier stages of a challenge. Similarly, in case study ten, which presents the unique situation of CBL implementation among professionals rather than students, the multidisciplinary team was still facilitated by ensuring participants worked cross-departmentally with people they did not collaborate with on a day-to-day basis. We argue that such interdisciplinary collaboration practices are empowering since students and other stakeholders develop new skills, experience new learning processes, and be exposed to multiple views and ways of doing things. More importantly, challenges are identified and addressed from multiple points of view where creative and original solutions are more likely to be created. The next section will also illustrate the benefits of working in diverse, multidisciplinary teams with direct reflections from CBL participants.

Initiate and Promote Active Learning and Collaboration

Active learning encourages teachers to engage in students to take charge of their own learning with strategic scaffolding, offer collaborative tasks, reflective tasks, and problem-solving supported by team-based learning (Roehl et al., 2013). CBL includes all of these in various pedagogical designs. These aspects regarding active learning were implicitly and explicitly noted in the case studies. For example, case study nine uses the term 'amplified active engagement' which 'promotes deep learning' and both case studies seven and nine mention active learning as a criterion on which student learning is assessed. In addition, case study one established the award of the highest grade, A, to 'excellent capacity for critical reflection of issues under consideration.' For CBL students to be able to engage in reflection is key as they need to self-regulate their own learning within the teamwork.

Active learning in CBL includes activities where teachers and practitioners guide learners through each phase, from identifying and exploring their challenge to finding potential, implementable solutions. This empowers them as decision makers through active and collaborative problem-solving. CBL courses, as outlined in case study two, encourage students to conduct self-directed research, collaborate with teammates and stakeholders. Case study two also introduces thematic workshops as active learning practices while case study eight presents project management tools to support students' active learning in international collaboration with CBL groups. We suggest that CBL teachers and practitioners need to understand the practical principles of active learning and how it could be adapted to CBL-based instructional processes. Active learning occurs when students are deeply engaged in tasks and assess the results of them. For example, case study eight adopts a positive approach to students' failure, particularly in the project's initial stages. They suggest that mistakes taken into consideration through collaborative reflection can be a source of learning for students. This could significantly enrich their overall learning experience within the CBL framework. How students can engage in and address their failures is explored in the next section exploring the benefits for students.

Monitor and Support Students by Taking on Different Roles

Within the context of CBL challenges, unlike the traditional lecturing models, teachers and practitioners need to shift their roles from lecturing and imparting information to facilitating and mediating students' discovery-based learning, providing space for experiential learning. They also need to understand the role of scaffolding the process of student engagement and learning, which is key to implementing a successful CBL practice. This is because students conduct the CBL process especially independently as teamwork, which might require teachers and practitioners to know when and how to provide feedback and support. CBL encourages students to take on different roles throughout the challenge in their teamwork. These can include taking on a leadership role, being a facilitator or mediator. They can also undertake the responsibility of completing different skills-based tasks. Teachers and practitioners mirror this process by also taking on different roles to ensure the success of the educational approach.

For example, case study two introduces three distinct roles including the organiser (shaping challenges and contextualising the learning process); the teacher (orientated towards specific academic knowledge acquisition); and the coach (supporting skills such as critical thinking and raising self-awareness). These roles can all be facilitated by one person, a teacher, or split among several people. Case study one sets a great example of how multiple roles can be undertaken by different people. For example, a teacher focuses only on content delivery and organisation, while CBL experts both organise and provide coaching with some CBL assistants who support the process of coaching. The role of a coach appears in several of the case studies, so we suggest that teachers and practitioners need to develop the identity of a coach who motivates and supports students' developing theoretical and practical knowledge.

Moreover, based on case study five, we can also suggest that coaches should take a proactive stance in suggesting new solutions to propel students' ideas further, fostering their skills for creativity and empowering them to initiate innovation within the CBL framework. Case study eight presents a unique context where students from different universities work not only individually for their master's theses but also collaboratively on the jointly identified CBL challenge. The CBL coach in case study eight supports students throughout the CBL phases through regular coach-team weekly meetings during the *Engage* phase and biweekly meetings in the *Investigate* and *Act* phases. This ongoing support structure ensures consistent coaching in a collaborative mode where students are strategically scaffolded during their teamwork.

Similarly, case study four presents a different role for teachers and practitioners, which is CBL guides. The role includes meeting weekly with students, monitoring their progress, providing feedback, and conducting informal assessments. Finally, as many of the case studies argue, teachers and practitioners must also be willing to step beyond their comfort zones and no longer be the sole providers of knowledge. Instead, they must facilitate a two-way learning process with their students and therefore take on the role of a student themselves. That is why we use the term 'teamcher' in some challenges, implying the teachers as learners' perspectives. With this stake in the success of a challenge, practitioners and teachers alike can then increase student outputs and enrich their own learning experiences as argued by case study twelve.

Use Network and Prepare Students for Their Future Careers

One of the central aspects of CBL is that it connects the classroom to the 'real world' which extends beyond the immediate learning environment (Nichols et al., 2016). Therefore, the key objective for teachers and practitioners is to help prepare students with the skills and competencies they need for their future careers. They can do so by giving them relevant practical tasks and authentic scenarios that support their learning meaningfully and give them a purpose of learning. For example, students can be asked to conduct research or pitch their final challenge solutions in a presentation to an audience. As many of the case studies illustrate, students can be guided to be part of a professional network where they not only learn but also develop an identity as future staff in the given field.

Students establish connections while they are engaged in identifying and addressing challenges with both their peers and stakeholders. This helps them to develop their professional network and enhance their career opportunities as discussed in case study five. As case study seven highlights, CBL experiences provide a platform for long-term collaborations between students, stakeholders, and researchers, which can be a key strategy for amplifying the impact of CBL. The constructive role of networking and long-term collaboration in future career preparedness maximises the impact of CBL outputs for students. We therefore suggest that teachers and practitioners need to build an actively progressing network where CBL students can find opportunities for their career and possibilities to build relevance between what they learn and what the specific field of work expects them to learn.

Implications for Stakeholders

CBL projects have implications for both internal stakeholders such as university decision makers and curriculum designers and external stakeholders such as local businesses or other organisations acting as challenge providers. Many of these implications have been covered indirectly through the discussion of those for teachers, practitioners, and students in the previous two sections. However, there are still implications to be shared for stakeholders who should develop a deeper awareness of how CBL could offer a facilitation for future recruitment processes. It is commonly discussed that students graduate from higher education without sufficient experiences of the content of work and awareness of the challenges, this limits their employability and the companies in the sector suffer from the process of accommodating them in the relevant positions. CBL, reads well though, strengthens the connection between higher education institutes and the industry as shown in case study two. As exemplified in case study two, the networking potential embedded in CBL courses emerges as a powerful force, which establishes the strong links among the knowledge triangle between CBL practitioners, students, and the broader sectoral system including regional innovation systems. Stakeholders should take the opportunity of working with CBL projects to address the potential disconnection and lack of relevance among the graduates who might not be completing their degree with relevant skills and contextualised knowledge. It is a general duty that industrial stakeholders contribute to the preparation and education of the future human workforce and strengthen their recruitment processes by prioritising entrepreneurial students as detailed in many of the case studies. According to case study six, external stakeholders should be part of CBL communities and meet with teachers, practitioners, and students regularly. In case study seven, societal actors like citizen associations, local cooperatives, city councils, small and medium enterprises, and industry associations are also external stakeholders who need to collaborate between universities on the education of potential future employees.

Stakeholders' engagement in CBL courses should also involve some pedagogical tasks where they could offer feedback and contribute to the assessment practices, as detailed in case studies three and eleven. They should provide their current staff with opportunities to gain skills in mentoring students and presenting their own work in an educational setting where students benefit in various ways. As mentioned, universities themselves are stakeholders, so they can also continue to facilitate CBL projects by functioning as CPs themselves, as exemplified in case study twelve which looks at the future of educational design. Universities should also benefit from the learning of their own staff and students who can provide a number of recommendations as a great example of bottom-up–top-down mutual informing, which could offer implications for broader educational strategies and policies.

Conclusion

This chapter sets out in detail the multi-faceted implications of using CBL for students, teachers, practitioners, and stakeholders both internal and external through an analysis of the case studies provided for this book. We present a fresh set of implications from a diverse range of contexts, connecting and building upon existing CBL literature, and strengthening the evidence for its positive application within contemporary European higher education.

In terms of implications for students, the case studies focus on self-directed learning and the acquisition of critical skills through authentic, real-world challenges that provide excellent preparation for their future careers. By engaging in such challenges, students develop many competencies including leadership, teamworking, critical thinking, and communication and active and reflective learning practices. For teachers and practitioners, the case studies highlight how they must adapt their practice to embrace new roles beyond traditional teaching methods. They take on the role of facilitators, coaches, and reflective practitioners who guide students through their learning journeys. Stakeholders too gain many benefits from interacting with students who provide them with new perspectives and critical insights into solving real problems they face. Students can act as mirrors, reflecting and challenging stakeholders' approaches to problem-solving. Therefore, the students' learning extends beyond their own future gain, and they become a resource for stakeholders, who have access to a talent pool of creative problem solvers. This highlights how CBL creates a mutual learning process and mutual benefits, creating symbiotic relationships that contribute to societal gains.

In summary, the successful implementation of CBL demands a collaborative effort from all involved parties. It requires students to take active ownership of their learning, teachers to adopt flexible and supportive roles, and stakeholders to engage actively in the educational process and for all to provide continuous feedback for effective assessment and evaluation (see Chapter 3). Collectively, these efforts create a dynamic and effective learning environment that prepares students for their future studies and careers, while also benefiting teachers and practitioners in their professional development and benefiting stakeholders and society at large.

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CHAPTER 9

CBL Conversations with Colleagues and Students

1. Interview with Tatiana Aleksandrovna Iakovleva, Professor of Entrepreneurship Studies at the University of Stavanger
2. Interview with Lukasz Derdowski, Assistant Professor of Associate Professor of Service Management at the University of Stavanger
3. Interview with ECIU colleagues on CBL implementation
4. Interview with Dóri Csiszár, student at the University of Twente

Interview with Professor Tatiana Aleksandrovna Iakovleva

Background

Interview with Tatiana Aleksandrovna Iakovleva, Professor at the University of Stavanger School of Business and Law conducted by Masoumeh Shahverdi and Tim Marshall in February 2024 using Microsoft Teams. Professor Iakovleva has implemented CBL in two master's level courses.

In the course Sustainable Business Development and Innovation: the firm perspective, students develop a critical perspective of the firm strategies for the continuous management of the sustainable innovation process in organisations. The course is rewarded with 10 ECTS.

In the course Sustainable Entrepreneurship, students examine the factors that promote entrepreneurial success in new business ventures and

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will gain knowledge on how to start a business. The course is rewarded with 10 ECTS.

Interview

Masoumeh Shahverdi: *How do you experience challenge-based learning when you implement it in your courses, what is your overall experience?*

Tatiana Aleksandrovna Iakovleva: *I was very enthusiastic because it seems to align very well how I teach, with a practical approach. The fact that students have to work on real problems, that is something that we naturally do in both entrepreneurship and innovation classes and in both cases, they either work on their own ideas or together with the companies. But it's a very applied course and I thought that OK, CBL seems to fit very well, so it should be easy but and then we discovered some challenges as well. The most challenging thing is to combine to integrate CBL into an existing course because you want to have your own path and how you think students should progress and CBL always has phases and when you start planning the course, it's normally like a semester before and you think you know what is going to happen. And so, you insert these dates for CBL and then of course the dynamics could be different, you know? So sometimes the students have already started working on the problem and we are not yet there with CBL, or the opposite they've got some insights from CBL, and they haven't yet found the company to work with. So, this alignment is I think is the most crucial part to find a combination that not too intensive, not too ignorant of CBL.*

Masoumeh Shahverdi: *What do you think is the biggest challenge for students?*

Tatiana Aleksandrovna Iakovleva: *In general, they were very stressed when we asked them to find the companies, but it equally applies to the course as it does to CBL because in the course they must do this, and we normally have a couple of cases already provided. They always write this reflection and what we can read from them is that this is fun, and sometimes they have a good or bad team dynamic. I would actually prefer them to work in smaller teams, maximum three, and that is because when you have four then someone who is just like a 'passenger' there and then they start complaining and also the way I grade them they are they deliver this written assignment and they get a group grade, so that is also something that I don't know how to solve yet.*

Masoumeh Shahverdi: *What do you think is the best strategy to help the students to find a challenge provider?*

Tatiana Aleksandrovna Iakovleva*: We notify them early from the first lecture and repeat this every time we meet and ask did you find a company. So, I think that they will come up with their own companies. So, their environment is one strategy and also pushing them, Each time I run the course you never know what the company will require them to do, and sometimes they get more like marketing tasks and some haven't had a real opportunity in innovation management then they have an opportunity to make an innovation audit of a company. Then you can see if you have all components of what it takes the organization to be innovative and you can review their internal organization like where are strengths and weaknesses. Companies that approach students themselves, you know they always expect them not to look at what they already have and would rather go into new markets or understand customers better. I don't think it has direct connection to CBL anyway, so yeah. I always say that, OK, there will be maybe two or three cases that we can provide you and you can apply to work with them in kind of a competition. Sometimes there are too many teams for one challenge provider. Only one will get it and then the others have to find a company for themselves.*

Masoumeh Shahverdi: *What are the main benefits for students?*

Tatiana Aleksandrovna Iakovleva*: Well, I think the benefit that is they have a very clear picture with CBL. What the process consists of, and I think they really appreciate that and that they know what to do which is to identify the challenge, collect information and make a solution. And of course, it's fun with the workshops, they like to be creative. What is boring in university is getting the theoretical knowledge and not knowing how to apply it in practice. But when you have hands on activities, that's what they like and where they can be creative and think of new ways to engage with the activity. So, I think this is very good approach to let them be innovative, let them have fun and learn alongside that.*

Masoumeh Shahverdi: *Do you think that the CBL process helps them with the learning outcome of the course?*

Tatiana Aleksandrovna Iakovleva*: Yeah, absolutely, because you are learning by doing. You can just read or listen many times and think you know but when you do it then it's different and it's always different when you do something right, then it's some obstacles you have to overcome So it's a very, very different path of learning.*

Masoumeh Shahverdi: *What is the impact of CBL on some skills and competences like teamworking, collaboration, leadership, critical thinking?*

Tatiana Aleksandrovna Iakovleva: *I think the teamworking is of course important. They learn how to collaborate, and also critical thinking is definitely one, because they have to pivot many times with their solution and that is very good. I don't think there is a lot about leadership skills. Collaboration and collective working to find a good solution, engaging with each other and with a company, especially when they have a good dynamic with the company, because of course sometimes you get you get cases where a company is not really responding, or they stop altogether. They make one or two interviews with the students and then they stop answering because people may be too busy, and they don't know how to move forward. So, then it's not that exciting for the students but for the successful cases, they really start collaborating with a company and that's where they really get excited.*

Masoumeh Shahverdi: *So, if you wanted to just pick up one of the most valuable skills or competences that students can gain when CBL implemented in a course, what do you think you can share?*

Tatiana Aleksandrovna Iakovleva: *Group working is important, but that they can maybe also learn through other subjects. I think critical thinking here is really the thing because they face a reality that is not what they expect. And then they have to pivot. They have to change. They have to collect new information and then make new decisions.*

Masoumeh Shahverdi *If, for example, a teacher or practitioner wants to implement CBL, what are the limitations or challenges?*

Tatiana Aleksandrovna Iakovleva: *I think that maybe CBL is not suitable for all courses. It should be a particular course where you maybe need this collaboration and you (Masoumeh) did very well on my courses, but it might not be the case if you teach classical physics or something, right? So, it is not applicable in all courses to work with real world companies. Some courses are theoretical, so I think CBL is a good approach but suitable for some and not suitable for others. You need to think about what and how they teach, what they expect from CBL, how they would like to deliver and then to see if this method fits. There is maybe only one way to find out which is to try it yourself and take the time to understand that it might not work from the first time and that you might need to try several times.*

Tim Marshall: *How would you approach balancing assessment on the theoretical part of your course with the CBL components?*

Tatiana Aleksandrovna Iakovleva: *We found that the best way is to ask students to make a reflection on CBL in the written assignment. Initially*

I thought this was not very good for us because the learning outcomes of the course would be that they would need to understand, for example, entrepreneurship, process components or innovation management process and not to demonstrate that they understand CBL, because CBL is just one of the tools that could be used. It could also be blue ocean strategy; it could be SWOT analysis. It could be business model, canvas, whatever it. They are also tools, right? So, you can practice them to a different extent after trying different things. I think that reflecting on CBL in the end allows them to express what they think is positive or challenging with this approach.

Assessment is always a difficult part because some students might be very good in the workshops and very active, but they might not be so reflective in a written report. We tried before with a combination of a delivery of written assignments and an oral exam and honestly, it didn't give much to me because it was still like a group presentation. Now we are eliminating this oral exam or, but they always have a pitch to the companies or pitch to panel. So, it's just kind of one of several mandatory activities that they must do, and this is important for CBL as well because then they provide feedback to the company right and then they can present their solution.

Tim Marshall: *Liking to assessment, how do you provide feedback to the students on their engagement with the CBL process? Do you do it better each stage or do you provide more feedback at the end?*

Tatiana Aleksandrovna Iakovleva: *No, the assessment is a written delivery of the report and then the criteria of what components should this report include. So basically, the collaboration and communication skills, I mean it's not really evaluated, so maybe it should be and mixed into grading and well, I mean they do so much teamwork and collaboration. All this should matter in assessment, but I haven't got a good way of doing this yet. When they had CBL reports and presentations then they try to use it in the final assignment and a lot of students submitted fishbone diagrams and things like that in the final report. So, I think that one of the challenges there is that since they can be a little bit confused about what this report should be, is it part of the final assessment or not and how important it is., They feel they are important because they experience CBL very intensively, right? So, this is another thing that we need to think how to not to overwhelm them with but to ensure that they also understand that this is just a part of the learning process.*

Tim Marshall: *At the end of the process, how do you evaluate the success of CBL with the students? Do you have a survey? Do you get feedback from them on how they've engaged with it?*

Tatian Aleksandrovna Iakovleva: *We have student representatives and it's two students normally a boy and a girl. I have an early dialogue with them, and I have a late dialogue with them, so I always ask how things were generally with the course, what should be improved, how they feel about CBL and things like that. I mean, last year they were very positive about CBL and there was some confusion regarding the CBL report. In general, they were very satisfied with the CBL part of the course, and so that that's the way I get feedback. I don't have a specific survey and then of course a student evaluation of the course which every teacher gets. I agree that the soft skills also need to be evaluated as they invest so much time in activities and group working so maybe there should be a better way of doing it.*

Questions for the Reader:

1. As Tatiana mentioned, there are often cases where students feel frustrated, uncertain, and overwhelmed by the collaborative teamwork and continuous mode of interaction in CBL. How would you cope with this in your own CBL practices?
2. Based on Tatiana's experiences of sharing the learning objectives embedded in CBL practices, how do you reformulate your own learning objectives and communicate them with your students?
3. In what ways do you think CBL might contribute to development of your students' learning skills? What skills do you think they can develop as part of CBL?
4. Motivated by Tatiana's story of CBL practices, how do you think students' evaluative feedback could help you address the challenges in your course design? And how do you think you could adjust and redesign your own CBL practices? *For further information on strategies for effective assessment, feedback, and evaluation* see Chapter 3.

Interview with Associate Professor Lukasz Andrzej Derdowski

Background

Interview with Lukasz Derdowski, Associate Professor of Service Management at the University of Stavanger by Masoumeh Shahverdi and Tim Marshall conducted in February 2024.

Lukasz implemented CBL in his bachelor's level course Corporate Social Responsibility (CSR) in service organisations—a leadership perspective in Autumn 2022. The primary objective of the CSR course is to create knowledge and stimulate awareness about the CSR phenomenon, as a basis for making decisions about, and incorporating CSR in the very fabric of a contemporary business. The course is offered by the Faculty of Social Sciences at the Norwegian School of Hotel Management and is rewarded by 10 ECTS.

Interview

Masoumeh Shahverdi: *What is the biggest challenge for you for the implementation of CBL?*

Lukasz Derdowski: *First of all, the administrative challenge. To incorporate new pedagogical approaches into a course, you often must include them in the course description as well. For example, design thinking, challenge-based learning or futures literacy lab sometimes requires updating the course description and it takes time to update those course descriptions, sometimes even a year. That was one of the challenges, but U got over it by not directly calling it challenge-based learning. It was just a method for group work to simplify it. Another challenge was that I personally did not have any prior experience with CBL so, I wasn't sure if that approach would work with an elective course with international students who have different cultural and educational backgrounds. For me, that was a kind of uncertainty; I wasn't sure if the implementation would work in that context. When it comes to the hands-on implementation during the course, I think I wouldn't be able to do it without your help. I think the implementation of CBL requires collaboration with teaching assistants, pedagogical experts, and teachers delivering the course. It's not a one-person job because there's a lot of novelty in introducing all the phases, tools, and delivering feedback to the students on their presentations.*

Masoumeh Shahverdi: *What are the main challenges for students?*

Lukasz Derdowski: S*o, students are very reluctant to engage with things that they don't really understand. If you overwhelm them with pedagogical terms and terminologies, trying to tell them, 'Okay, we will be using this challenge-based learning pedagogical tool,' then students feel uncertain. For them, we need to simplify things a little bit, translating it from academic language to student-friendly language. On top of that, the fact that they actually have to show up for the sessions is a challenge as well. We know* *that the attendance rate is quite low, especially in classes of 50/60 students. Normally, if you have 15/20 showing up for the class, that's already a lot. So, for challenge-based learning to work, I think you have to somehow force or convince the students that they have to show up because then they can actually reap the benefits of it. Otherwise, it wouldn't work if they just show up for one or two sessions. For those students, it's then taken out of context, so they wouldn't understand it.*

Masoumeh Shahverdi: *Do you think that students have some problems engaging with the course itself through this framework?*

Lukasz Derdowski: *I think the most critical point, if the whole framework is properly introduced to the students, is if it's delivered in a way that they understand it, find it exciting, interesting, and entertaining. I think what is most challenging for them would be the engagement of external stakeholders, the challenge providers, right? To fully engage with the whole process, that could be a thing as well.*

Masoumeh Shahverdi: What do you think, according to your experience, is the best strategy to engage challenge providers?

Lukasz Derdowski: *I would engage students to find their own challenge providers at first. Very often, they would lean towards either the family network or maybe their own part-time jobs. That would be the first choice for them. But at the same time, I think that either the course leader or the lecturer, or someone involved in delivering the challenge-based learning framework, should also assist the students in initiating contact with the company. There needs to be some sort of support; students need to feel that they are not on their own and can get advice on how to talk to businesses. They don't really know how to do that, so if they had a template or some sort of short workshop or seminar on how to approach businesses, how to talk to them. They need some assistance in that process as well. And if they choose companies that they are interested in, find them attractive, and have some assistance in that process of communicating with the businesses, I think that would be the most beneficial? I remember we had a case where the students were not clear in their communication with the stakeholder and that illustrates the need for clear, transparent, open communication supervised by either an academic assistant or someone from the communication department.*

Masoumeh Shahverdi: *Do you have, in advance, some companies to introduce to students? For those teams that couldn't find companies, do you suggest having such a list?*

Lukasz Derdowski: *We had some companies from the local network of hotels and restaurants that we've already worked with. For example, the campus hotel is always very engaged with whatever is happening at our institute, and we have some sort of agreement that they have to invite students for collaborations to provide research-based practices for the hotel. So, if we have those challenge providers from the local network who already expressed interest in collaboration, that helps a lot because they are used to interacting in that way with students, teachers, and researchers.*

Masoumeh Shahverdi: *Now I would like to ask about what kind of benefits CBL had for you and for your students. What is its impact on the outcome of the course that you wanted to achieve or the objectives of the course?*

Lukasz Derdowski: *The benefit is that students are pushed a little bit outside of their comfort zone. I mean, they need to define the problem, get in touch with the companies. At the personal student level, they gain a lot of experience and knowledge from hands-on projects framed around the subject. But at the same time, it's tailored towards their own interests, creating interesting dynamics in the classroom that allows students to fully engage with the programs. For me, as a teacher, I think it helps as well because it avoids traditional lectures where there is a monologue, the teacher delivering knowledge to students. Some courses may still work with that approach, but for subjects like sustainability or digitalization or wicked problems like climate change, these topics require personal engagement from the students. To achieve that, you need to introduce novel pedagogical practices. Even though I may have clear objectives in the course descriptor, CBL helps in delivering on those objectives and brings much more value than just meeting those objectives. It is an opportunity for students to grow, learn, build networks, and collaborate not only with group members but also external stakeholders like challenge providers. It forces them to think critically, communicate, and develop universal transferable skills beyond the course itself.*

Masoumeh Shahverdi: *Which specific skills or competences like critical thinking, leadership, motivation, collaboration, communication, teamwork, leadership, what competencies and skills do you think CBL can affect?*

Lukasz Derdowski: *It depends a little bit on the maturity of the students for example if you talk to the first-year bachelor's students, although I have only the experience from third year bachelor's students, who are used to the academic system and structures. But if you think about the first-year students, they will learn how to collaborate and communicate with each* *other within the group. They will learn how to resolve conflicts. And these are the basic skills of group work group dynamics, right? If we think now about the master's students, I will assume that these students would develop more complex skills and competencies and holistic understanding of research problems, right? Often, we teach the methods, and we try to present the problem, a simple problem that they can approach, but if they engage with challenge-based learning and similar pedagogies then they understand that very often the reality is more complex than that. It's not only one research question that you have to work with. Suddenly you discover that the challenge provider has seven research questions, and even that is not the whole story. So, they learn that the challenge provider again may have a its own vision and understanding of the problem. They learn that it's not only the challenge provider, but also maybe other external additional stakeholders that need to be involved. This is a kind of systems thinking, that's for sure, but that is the skill that you can only develop at a certain stage. I wouldn't expect that from early bachelor's students unless they already have some degrees early from earlier studies or something like that. So, at the bachelor's level it is mainly to equip them with some sort of experience in how to work in teams and communicate and how to maybe delegate the tasks, how to take the leadership roles in the group, how to write in academic way. So, sort of writing skills and how to write emails, maybe to the challenge providers so that it's understandable and clear. These are some sort of the basic skills right that we would expect them to learn in that process. But from the master's students I would expect more right? Although I don't have the personal experience with that.*

Masoumeh Shahverdi: *If you want to just mention one of the competences or skills as a most valuable one, what did you can mention?*

Lukasz Derdowski: *I would go back to the systems thinking. Not sure if the bachelor's students that we worked with actually achieved that skill, but I think it's extremely important and very often a not really well-delivered skill in practice throughout the courses. We are very afraid of exposing students to too complex problems, right? If we start delivering wicked challenges to them and telling them, 'Okay, here's the business perspective. But here's the consumer perspective. And here is also the municipality perspective.' We are a little bit kind of protective and afraid that the students will disengage because of the complexity of the challenge. But challenge-based learning is forcing them to think in those terms. It forces them to think about the challenge provider, it forces them to think about their own dynamics within the group, to identify maybe some primary or secondary stakeholders already* *affected, and by the practices that they are hoping to develop. So, I think this is one of the most exciting elements being practiced through challenge-based learning. The fact that they need to basically have the holistic picture on the problem they're working with is of the greatest value, at least to me, as an educator, right.*

Masoumeh Shahverdi: *What advice would you offer to other colleagues wanting to implement CBL?*

Lukasz Derdowski: *There is some sort of paradoxes related to the timing of different phases of CBL, right? What we did in our course was that the students had around two to three weeks between phases. And they had the time to process, to gather the information, to think about what is relevant in each phase of CBL. At the time of the implementation, I felt like, 'Okay, 2-3 weeks is just, it's enough.' And then when the feedback came from the students, they actually claimed that it was not enough for the processing of different phases, but from the experience, we also know that the students tend to work last minute. So honestly, I didn't know how to structure it because there were some students that said they need more time, but at the same time, we know that they work last minute. So, what is the most optimal interval between the phases? I don't know, that may depend probably also on the context, on the complexity of the challenge, the company involvement, many aspects, but I think it's worth investigating for the future and the length of the intervals between the phases just to see what is the most optimal in which context for what sort of groups, what sort of problems and so on. So that the students gain the most right out of it. It's not really that you have to deliver, but at the same time, they need to have time to reflect and avoid last-minute deliveries.*

Masoumeh Shahverdi: *Do you want to implement CBL again?*

Lukasz Derdowski: *I'm very open to all kinds of action-based learning methods. And if so, then again, I come back to my very first comments from this interview, if they have some sort of support in the form of either the teaching assistant or pedagogical staff or, you name it. And if they find it to be kind of relevant for their own course, then why not challenge-based learning?*

Tim Marshall: *How do you assess the CBL components in your course so the reports and the exams and how do you balance that against the traditional assessment?*

The mandatory part of the course was that they had to deliver a short presentation to be allowed to take the final exam right. So that's the mandatory component and what we did was that the students presented at the end *of each CBL stage and delivered a 5 to 10 minutes presentation. What I really valued was the feedback that you (Tim and Masoumeh) delivered to the students. So that was an informal assessment in the way, and that helped students to grow, to move forward with practice, with the next phases. So, we did not wait until the delivery of the final report, but they got feedback on the way and that was of great value I think to the students. To gain these learning possibilities from the experts who understand the dynamics of CBL. Then what we did, in the final exam, students were given a space for self-reflection and that was individual as well as the group self-reflection on the CBL practice. So, they could think about what worked, what did not work and reflect on the learning process itself, not only about the outcome. They also evaluated the process of learning themselves and I think that was of a great value for them.*

Tim Marshall: *How much weighting did you put on the assessment of content knowledge and how much did you weight the CBL part?*

Lukasz Derdowski: *For the overall grade, I think it was 40% theory, 40% CBL, and 20% self-reflection Since my course is kind of based on a concept that is not well known and understood by the students, we needed to grade the theory at the level of understanding of theories, the understanding of models, frameworks, existing tools for evaluating corporate social responsibility in that context. So therefore 40% for that, then the CBL itself, which is a hands-on practice of applying corporate social responsibility. A topic in the context of either sustainability or the green transition. The CBL part was 40% because that is more kind of a practical dimension that shows and illustrates the students can use their theories in practice and then learn from that experience as well. And then the 20% for the self-reflection to see whether they actually learn from those experiences and reflect on them critically to see that that helps them to grow. It is a subjective approach that I took, which could be adapted in different courses.*

I graded the exams, but you as CBL experts assessed as pedagogical experts. You could assess the performance of the students as well, the development of their capabilities. The students provided their own evaluations, and we could also have the evaluation of the challenge provider, Overall assessment came from different sources, self-assessment, external stakeholder assessment, and so on. A combination of assessment throughout the process with the final assessment of the output to kind of balance and capture what is actually going on and which could also be informative to us, to teachers, to the educators. Because if we see that the students are struggling at some stages, we could help them to facilitate those challenges in one way or another.

Tim Marshall: *How do you evaluate the success of the CBL components of your course?*

Lukasz Derdowski: *I think because we received the course evaluation right afterward, and even though there were no specific questions on the scale from 1 to 7, how did you evaluate CBL or anything like that that we didn't have in that particular survey. But we had open-ended questions as well, where the students could reflect on the course itself and talk about issues that they found interesting or challenging in the course. Many students talked about CBL as something that initially was confusing. But after the completion of the course and the completion of the CBL project, they found value in it, and I personally see it as well because I've been delivering the same courses for six or seven years. I see that the dynamics is completely different in the classroom if I deliver traditional lectures with some sort of discussions and small group works here and there. Of course, I engage students to some extent, but if we expose them to CBL, that is a completely different story. It's just a completely different level of engagement and an interaction and the dynamics in the class. It's just something that is not comparable to the traditional teaching methods, right? And so, students' evaluations, although some of them were critical, after the delivery, most of them were positive. As an educator, I see a value in it, a great value in these kinds of action-based learning methods because it helps them to learn and support them in this kind of educational path that they go through. I would love to try and test the CBL methodology among master's students and see how they respond to these kinds of opportunities.*

CBL also gives students the opportunity to see that people may differently understand what the challenge is and how it should be framed. So, they are exposed not only to their own kind of cognitive frames, but they also see that others approached a very similar topic but from a completely different angle. And that is a learning lesson as well for them because it's just that it's not about me and my project, and then I deliver the report at the end of the semester it's also about how others are approaching similar things without really being afraid of plagiarism. It's just a very healthy debate and exposure to different understandings of challenges and how they could be approached through different angles. So that is also the value for the students to see that it's not only one answer that is correct; there are many answers, there are many approaches. There are many ways to do the thing, right, and that is also bringing value to the whole kind of education, I think.

Masoumeh Shahverdi: *Anything else you wish to add?*

Lukasz Derdowski: *So, if I had more time for CBL, I would definitely arrange the sessions in a way where students can practice those tools at each stage so that it's not only that we talk about tools such as the fishbone technique and then say go and practice. But I would actually arrange the sessions where we all meet together, and then we try to play a little bit with the six thinking hats in the classroom to learn from those experiences so that when they come back to their own groups, they already know how to do that, how to employ the given technique right for a given stage, for instance, and that will give them a little bit more confidence in applying those tools and knowing how to use them. So, I would have one or two sessions for different tools at different training opportunities on how to use those tools together to get feedback and to talk about them in a little bit more hands-on setup, right. That would be one of the main changes that I would introduce so that the interval between the stages would be a little bit longer so that they can, at the beginning of each stage, practice the tools that we present: the systems thinking, the six thinking hats, or the fishbone technique so that they have the confidence in applying this later on in their projects. Maybe also with assessments that to bring a more data so that we as educators learn as well, and then they have the opportunity to reflect and provide feedback to us as in a very kind of digital dynamic and interactive way so that we can maybe address their concerns at each stage.*

Questions for the Reader:

1. As Lukasz highlighted, CBL practitioners could encounter administrative challenges when incorporating CBL in their courses. Can you also reflect on the potential challenges in your own context? What kind of institutional support mechanism do you have?
2. Lukasz also mentioned some challenges in motivating students to actively engage in CBL. When considering your own CBL implementation design can you list these challenges, he has raised and then compare them with the ones you experience?
3. Compared to Lukasz's CBL evaluation strategies, how would you evaluate your CBL process? What would you ask your students and how? If you have already done so, reflect on the feedback as Lukasz did.

Interview with ECIU Colleagues on CBL Implementation

Background

Following the January 2024 workshop 'Smart education for innovative teaching in CBL' organised by ECIU University trainers from University of Stavanger, Kaunas University of Technology, and Lodz University of Technology, Tim Marshall and Masoumeh Shahverdi conducted a follow-up interview with five CBL practitioners. The interview questions were recorded via a Microsoft Office Form. Professor Ilaria Petrot, Department of Civil, Environmental and Mechanical Engineering, University of Trento. The respondents are:

- Clare Gormley, Senior Academic Developer, Dublin City University
- Prajakta Girme, Academic Development Officer, Dublin City University
- Dr Thomas Groen: Associate Professor Department of Natural Resources at University of Twente
- Dr Svenja Damberg Associate Professor, Faculty of Behavioural, Management and Social Sciences (BMS), University of Twente

How many times have you implemented CBL and on which course(s)?

Ilaria Petrot*: More than 20 times, In my Bachelor and Master courses, as Thesis and as ECIU Challenges at the University of Trento*

Clare Gormley*: Once to date on a staff professional development initiative (Hackathon) but have supported several staff members implementing CBL.*

Prajakta Girme*: I have supported CBL implementation as part of academic development team. Co-created CBL professional development plan for DCU*

Thomas Groen: *I used (some form of) CBL in a standard curriculum of one of our master's since 2018. Also, we use some form of CBL in our bachelor minor that prepares students for this master, and which is running since 2023.*

Svenja Damberg: *I first started implementing CBL in 2019 at one of the ECIU partner universities, both on a bachelor and master level.*

What are the biggest challenges for you (and other practitioners) for implementing CBL and what are its limitations?

Ilaria Petrot*: Finding the right challenge for the students 'level and interest, planning the time of the challenge especially is it is a hackathon. CBL main limitation is that students should know sufficiently the domain/ state of the art of the challenge.*

Clare Gormley*: Time to organise and plan; Opportunities to learn from the practices of others; Time for meaningful external stakeholder involvement.*

Prajakta Girme*: Time to organise and plan; Opportunities to learn from the practices of others; Time for meaningful external stakeholder involvement.*

Thomas Groen*: A big challenge is to get real interaction between the students and a challenge owner. Especially because often challenge owners expect something out of the project for their time investment, and this is something that is hard to promise as students should be allowed to make mistakes and learn from it.*

Svenja Damberg*: Among the biggest challenges is the extra workload required to design or redesign a course according to CBL principles. Also, fair assessment can be difficult.*

What are the biggest challenges for students?

Ilaria Petrot*: Finding qualified information in order to develop the prototype or to test it in a relevant domain.*

Clare Gormley*: If they are not comfortable with group work, the fast paced and collaborative nature of CBL may prove difficult for some. The sense of uncertainty will also be a big challenge for those asking for highly structured approaches.*

Prajakta Girme*: The team-work element especially in multicultural and multidisciplinary contexts. The unpredictability can be jarring for some students especially neurodiverse students and students with learning disabilities. Extra and specific support needs to be developed and provided at the appropriate stages.*

Thomas Groen*: To really get out of their comfort zone and open up for an interdisciplinary approach.*

Svenja Damberg*: students report that they typically feel very lost in the beginning of courses or modules that are based on the CBL-methodology. They are not used to being independent and tend to get stressed. However, this is part of the learning experiences and Teamchers might guide them to reduce (negative) stress.*

Do you assign Challenge Providers to students, or do they seek out their own and how often do students meet with them during the challenge?

Ilaria Petrot*: I assign the challenge provider; students meet them at the beginning and at the end during the pitch. If CBL is a thesis students meet them frequently*

Clare Gormley*: In my case, I organise the involvement of the Challenge Providers. In the case of a Hackathon, they are available for the full duration of the Hackathon.*

Prajakta Girme*: Most academics source their own challenge providers or curate the challenge statement out of topics of interest as provided by the student.*

Thomas Groen*: We normally provide this and meting them is often just once or twice. Most interaction is with a university staff member.*

Svenja Damberg*: Currently we as lecturers and professors contact challenge providers and assign them to students.*

What are the benefits of CBL implementation for you? (e.g., the learning process, outcomes)

Ilaria Petrot: *Learning how to solve difficult problems in a relatively short time.*

Clare Gormley*: Helps staff to experience what Challenge-Based Learning is like for students. Helps remind them of the potential issues of group work and working at speed.*

Prajakta Girme*: Engaging staff in innovative pedagogies like CBL makes for an authentic experience for both staff and students.*

Thomas Groen: *It really helps to teach students skills rather than knowledge. And it helps them to also understand the value of their knowledge, because they learn how to apply it to fix real world problems.*

Svenja Damberg: *I see a variety of benefits of CBL as a lecturer at a university. My top three are the following: First, from my perspective, teaching is about impact and CBL offers a useful approach to engage external stakeholders. Second, the utopia of CBL of not only including students but also lifelong learners (e. g., citizens in the local community where the challenge is offered), offers nice opportunities beyond universities. Third, we get to work with both students and teachers in multidisciplinary teams, which offers great learning opportunities content-wise, but also in all other matters.*

How does CBL impact on the students' motivation, engagement, teamworking, collaboration, and communication? What is the most valuable?

Ilaria Petrot*: Positive impact in Team working and engagement. Motivation is more related to the attitude of each student.*

Clare Gormley*: If the student is very interested in the topic and is very invested in finding a potential solution, CBL is highly motivating and engaging. It also allows enables students to learn about a variety of new tools and technologies almost in the background while they work on the challenge itself. When it goes well, it can certainly promote teamwork and collaboration skills and competencies.*

Prajakta Girme*: It's engaging for the students to contribute towards understanding/solving a real-world issue at a global, community and/or the local context. The collaborative and multidisciplinary aspect is also valuable, however the teamwork itself can be a bit challenging according to some general feedback.*

Thomas Groen*: Especially the trigger it gives to intrinsic motivation to learn something is very valuable. But also, the aspects or co-learning and team-working skills is highly relevant.*

Svenja Damberg*: Among the benefits of CBL for students, I clearly see the following three benefits among all courses I have been involved in so far that have implemented CBL. Students need to work in teams and they need to negotiate. At the same time, they need to learn how to make decisions independently and as a team. Moreover, they have a lot of freedom and opportunity develop by framing their own challenge and working on something meaningful to them.*

How do you ensure multidisciplinary in your implementation of CBL? (e.g., in the team formation)

Ilaria Petrot*: As much as I can in relation to the subject*

Clare Gormley*: By ensuring that teams have members from various disciplines.*

Prajakta Girme*: While some academics assign teams taking disciplines/experience into consideration, most of the time though the students pick their own team based on topics of interest. It is harder when the CBL is conducted in one module or a specific discipline.*

Thomas Groen*: We make the teams and mix students with different backgrounds.*

Svenja Damberg: *During team formation in the first week(s) of the course, teams must ensure that they have team members from various disciplines, I. e., study programs.*

How do you assess the CBL components of a course (exams, reports, grades, etc.)?

Ilaria Petrot*: Pitch as team assessment*, *report with indication of each contribution as single assessment*

Clare Gormley*: Assess the process, mainly, using a simple rubric and also by assessing reflections.*

Prajakta Girme: *Academics are encouraged to try different assessment modes and offer a choice in terms of engagement. Sometimes this could be short presentations/reflections followed by a combined group report, recommendations, or an interactive oral. The assessment design depends on the learning outcomes to be assessed and which assessment type might be suitable for a particular discipline within which CBL is implemented.*

Thomas Groen*: We have a group assignment, a midterm assessment of the team plan, an individual test on some of the knowledge they learned during the challenge and at the end an individual oral exam.*

Svenja Damberg: *Depending on the course, we typically use a variety of assessment methods, including team reports, individual assignments, self-reflection reports/elements. Students always receive a grade.*

How do you evaluate the success of using the CBL method on a course?

Ilaria Petrot*: Based on reflection in the class at the end of the CBL and official UNITN questionnaire.*

Clare Gormley*: Ultimately CBL should be in support of the course learning outcomes.*

Prajakta Girme: *Student and academic feedback is crucial to evaluating if the implementation has achieved desired outcomes.*

Thomas Groen*: We don't, because to do so, we would need to run a course parallel to it without CBL, but with the same learning outcomes. That is simply impossible.*

Svenja Damberg*: We use student surveys to evaluate the success, but we also talk to the students and challenge providers regarding the outcomes and to what extent these are sustainable, for example.*

What are the training requirements for CBL teachers at your institution and how do you envision the future implementation of CBL?

Ilaria Petrot*: We are developing specific guidelines within our community of practice in UNITN. We are planning a specific course for teachers in 2024.*

Clare Gormley*: Training is provided by the central learning and teaching unit mainly. Training supports take various forms (including workshops, guides and opportunities to experience CBL). All are optional.*

Prajakta Girme*: The academics are offered expert support in terms of designing their CBL activities, there is also a central CBL guidance document which was created with feedback from the experienced academics from different discipline. There is already a CBL working group and a long term CBL professional development plan in the works.*

Thomas Groen*: We did teach CBL group supervisors (we call them Tutors) some training on how to deal with groups, but the main training is on the job. WE have now a group of experiences tutors, and new staff team up with these experiences teachers to learn from each other.*

Svenja Damberg*: There are guidelines about CBL from a fellow community. The university has implemented a review system of each course, in that students evaluate the course and then teachers are required to write an assessment of how they will implement the feedback the next time they teach the course. However, this is for all courses, not only CBL-related ones. I would love to see more and more colleagues being open to design/redesign courses implementing CBL. I believe that we need to ensure innovation in our teaching, also to remain competitive as a university in the European and international context.*

Anything else you would like to add?

Prajakta Girme: *I think in developing a course it is important to find a right balance between CBL and 'traditional knowledge exchange'. CBL can be a great stimulant also for 'traditional learning' because it shows to students the reasons why to learn something, and also what they already know, and what they still can learn. So alternating CBL like projects and periods where elective courses can be followed can be a good set-up to help students develop their own learning path.*

Svenja Damberg*: It is great to see that our institution now would like to implement CBL even more (such as, out our department and section, we have dedicated internal teaching meetings as well as internal conferences dealing with CBL to learn from each other). It is great to see that this teaching methodology is something that universities are aware of and find relevant for innovation in their teaching approach.*

Questions for the Reader:

1. As the interviewees mentioned, how would you set a balance between providing a structure for learning and creating flexibility during your CBL-based teaching? Claire mentioned such uncertainty as being inherent in CBL. What is your opinion on that?
2. Ilaria said that CBL helped develop a community of practice and a specific course for CBL practitioners. How do you see CBL as an opportunity for professional development opportunities for you in your own context?
3. How do you envision the future of CBL in higher education at your institution? As Prajakta mentioned, they are part of a CBL working group, and a long-term CBL professional development plan is in process. What are the similar initiatives under way in your institutions? If none, are any of the examples the interviewees mentioned applicable to your context and what do you think should be initiated?

Interview with Dóri Csiszár, Student at the University of Twente

Background

'The art of reflection'—In this short interview, a student reflects on her experiences of working with CBL with a focus on intercultural competences. The interview below is from an edited transcript conducted on Microsoft Teams on the 5th of April 2024 by Tim Marshall from the University of Stavanger.

Dóri Csiszár, originally from Hungary, is studying in the Netherlands at the University of Twente where she is in the third year of her bachelor's programme in International Business Administration. She took the ECIU University micro-module on the Intercultural Competences (ICCS) in (Spring 2023) which is awarded with three ECTS. The course was in hybrid format with the Engage and Investigate Phase conducted online with teaching and workshop sessions lasting eight weeks and the Act phase taking place physically in Barcelona for two weeks.

Interview

Tim Marshall: *When did you first experience CBL and in what context?*

Dóri Csiszár: *Actually, with a conversation with a friend, so many of my friends are working on CBL, they are all very invested in the topic. And they introduced me to the concept of CBL, which I was fascinated by because I think it's a very fun approach to learning and studying.*

Tim Marshall: *How did you find the CBL process overall?*

Dóri Csiszár: *As someone who comes from a very theoretical background with very logical structured modules it was quite difficult. In Hungary your schedule is predetermined, right. You have a list of what you must know by the end of the exam. They are taking out critical thinking so CBL from that perspective was very difficult to get into. So, in the beginning of the process, you don't have as much guidance. I would say for most students, I perceived that it was quite difficult and for myself as well to get into the mindset of let's try to get into this topic, right. Let's try to see what I can find. But what interests me the most in this? So, it starts from very broad and then it of course narrows it down towards the problem that you have. Then it gets more and more into something that you can involve your existing knowledge, while still researching something that you don't know. I would say from the student perspective, it was chaotic. I must say that it is very hard in the Engage phase to go from the very broad to the specific, to go into more of the topic of how to do citizen science. In the Investigation phase and in the Act phase then you already have your research questions which is easier for the technical students. Of course there is the teacher to facilitate the conversation, but in the end, the students will have to come up with the issue themselves.*

Tim Marshall: *What did you enjoy the most about the CBL process and what did you find most challenging?*

Dóri Csiszár: *I found the first part, Engage, most challenging and the most difficult part of the process. I remember trying to figure out, OK, where do all of our interests lie? And everyone trying to proceed from their own. But I also enjoyed this part the most because it was challenging. I try to seek out personal challenges because that's the thing that you can learn the most from. Finding a common ground with people in an intercultural and multidisciplinary way is fascinating. Conflict management in teams like this and understanding how different cultures react and behave in certain situations is very engaging.*

Tim Marshall: *Can you tell me a bit more about how your team was formed and team dynamics?*

Dóri Csiszár: *The teachers put us together in a team of around five. So, we started with the topic, let's build a citizen science project. What do we* *want to do? And of course, we had cultural differences. We had the disciplinary differences in our team. We had a PCs student, we had a business student, a law student with all different hobbies etc. Why did they choose to join the programme? So, for us, someone came for the ECTS, someone came for a holiday, and you have to put something that is of value together and align these ideals. I would agree that if you would try CBL individually then the Investigate phase would be more difficult than the Engage phase because you know what you want right?*

Tim Marshall: *How did you find working online and then working in person and the and the different challenges?*

Dóri Csiszár: *It was easy in person, as we already knew each other for meeting online. In person you can read body language, you can hear others properly. You can go into details and ask; OK why do you exactly think this without having to stop. Online though, it was difficult to assess people's body language to hear their tones in the voice and it can take away so much from a discussion, but at the same time it hinders the conversation enough that people become not too confrontational. It felt like people were more agreeable to certain things online because you must discuss it as fast as possible, right? You don't want to stay in front of your laptop for two hours, so let's have this discussion in one. But even with the Engage phase being online, I still would choose that part as my favourite. Of course, I would have enjoyed it a lot more if it would have been in person. But the fact that this course existed, it's just so cool.*

Tim Marshall: *What specific skills and competencies do you think you've gained from CBL? How do they relate to your studies and your career plans?*

Dóri Csiszár: *I would say I have two main points. One is really this interculturality aspect and the other is really the critical thinking aspect. To come up with a solution to a problem, you first have to investigate the problem. I think it is a competency that is very important because it not only helps with your critical thinking, but it's like a whole package of quick thinking, on the spot thinking if you have to come up to a problem quickly, it moves you out of your comfort zone. I would say this module was really integrated as an ICCS micro module. Although, it is hard to measure your intercultural competences we had to reflect on in the individual assignments and I found that to be very interesting coaching and reflection. At the start there were actually eight skills that we could choose from and improve. These were: active listening, integrating stakeholders, communicative awareness, embracing cultural complexity, unconscious understanding, exploring ideas, cultural curiosity and expanding relationships. We had to self-assess our level* *for each one and I generally put myself in the average positions for most of them. The one I wanted to really expand was communication awareness through improving empathy and inquiring about people's emotional background in decision making. The other was culture, curiosity, trying to find out by people's values or the way they are because of their background culture and how it influences their behaviours and actually I think this improved, and this has helped me with my bachelor's thesis. More broadly, last year I was part of the student board, and this course has really had an influence on that as well because at my university So how do you make sure to make an environment that is comfortable and welcoming for all nationalities.*

Tim Marshall: *You mentioned assessment and evaluation. How were you assessed in this course? What were the formal mechanisms of assessment?*

Dóri Csiszár: *We had the poster final assessment, and we had many reflections. Essentially, we had to make a big magazine in the end with the whole team. We had small tests for the many reflections. These included questions like how would you describe your role in the team? What degrees do your role describe? To what extent do these differences lead to difficulties for you and your team?*

Tim Marshall: *Overall, then from this experience, what do you see as the main pros and cons of using CBL?*

Dóri Csiszár: *I think CBL could be a powerful tool for or self-reflection for challenging yourself as a person. Where it goes into the difficulty is not the fact that it is CBL, it is difficulty with individuals and their motivations behind learning. So, if my motivation behind learning is just getting the ECTs or the diploma so I can go and work then CBL won't give me anything. We also had to finish many things very in a short amount of time next to your main studies. So, we had to figure out many things about communication and organisation, where do we meet? Do we need about some group? Do we e-mail each other? So, there can be chaos in communication. How do you work as a team? How do you help each other? Then with the self-reflection report you need to be motivated to do this because if someone usually doesn't think about these things, why would they start now. You wouldn't have the incentive to make this something that's really helps you and that's the only flaw really that I saw in the system.*

Tim Marshall: *Would you recommend CBL to other students and what would be your main advice to them for a successful experience?*

Dóri Csiszár: *Yes. It depends on the student. And this is where it goes back to my previous answer on the pros and cons of CBL. It is not good if the student is not motivated and does not want to improve themselves. That does* *not want to grow and has no intentions in this regard. Then I would say no, it is taking a space from someone who would like to grow. If they want to then it is the best opportunity. This is where you can learn how to do it and you get experience.*

Tim Marshall: *Would you like to do more CBL?*

Dóri Csiszár: *It depends on the topic. I like structure. So, for me it would be very chaotic to work with a group where there are some students who are not engaged with it, so that that was my main issue here working with students who don't want to reflect, who don't want to go because they are not there for that then. I would really enjoy it if, let's say the circumstances allowing and the stars are there to align where all students are interested in. It's very rare though, that this happens. So that's, that's where that comes in. The individual reflection I would love to do it more asides from CBL as well. We have to do individual reflections in class as well in my course so that that's something very useful. But again, it requires the mindset.*

Tim Marshall: *What would you say about one skill or one thing you've gained the most from CBL? What would it be?*

Dóri Csiszár: *The art of reflection.*

Questions for the Reader:

1. Dóri mentioned a number of advantages and disadvantages of online versus in-person collaboration during the CBL practice. Can you list them and propose particular strategies to cope with them as CBL practitioners?
2. Dóri talks about the intercultural competences she gained and critical thinking skills she developed. She found CBL as supportive of personal development and transferring the skills and competence beyond the CBL context. As a CBL practitioner, how would you support your students based on Dóri's critical self-reflections?
3. Dóri places particular emphasis on how she did self-reflection in her CBL experience and how relevant and useful she found it. Based on that, how do you think you could use self-reflection as a method for helping your student learning throughout CBL?

Conclusion

In this book, we have introduced and explored how CBL is perceived, implemented, and assessed. We focused on its historical development, practical implementations, and insightful case studies across micro, meso, and macro level frames. We have also provided a range of direct first-hand experiences from CBL practitioners and CBL students' voices in the form of interviews and reflective questions. It was an empowering process for us as the authors and editors to have the opportunity to explore how CBL was narrated as a situated pedagogical practice in diverse contexts. This enabled us to draw a number of implications for CBL stakeholders across Europe and beyond. The implications also underlined how CBL challenged traditional higher education pedagogy partly based on lecturing and led to a new understanding of teaching and learning.

CBL practitioners have experienced a paradigm shift in instructional practices emphasising authentic challenge identification and problem-solving, through collaborative teamworking, active learning, and critical thinking. This is evident in the way CBL is integrated in courses or it becomes the pedagogy of the course itself since it provides an opportunity for students to engage in broader challenges in the actual context it emerges or is experienced. And students can exercise the agency of identifying the challenge in the possible workplaces and learn to address them strategically and contextually. Like CBL practitioners who perform the role of a guide and a facilitator, students undertake the roles of team

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member or leader, critical friends, inquirers, and knowledge generators while engaged in CBL.

Therefore, CBL students not only produce practical knowledge but also acquire new skills for their future professional roles in the industry, while CBL practitioners also learn to manage and support such a learning design that gives students freedom and space for collaboration as well as taking the responsibility of their own learning with their peers when teachers presence is limited outside the classroom. For both practitioners and students, working on authentic challenges and multidisciplinary collaboration creates new ways of engagement in learning. It also minimises students' passive information recipient role and encourages them to discover knowledge in the real context by co-constructing it in the social environment with other stakeholders.

The case studies we edited in the book provide a great deal of evidence as to how practitioners and students transform their roles in various ways and experience new ways of learning and teaching. They also showcase the effectiveness of CBL in activating and sustaining engagement and motivation to learn compared to the traditional ways of learning. Based on the case studies, we argue that, whether it is classroom projects, departmental initiatives, or institutional strategies, CBL has emerged as a dynamic platform for advancing innovation, entrepreneurship, and societal impact.

The implications we drew in Chapter 8, building on the research findings in Chapter 2 and narrating the implications of CBL are numerous and multi-faceted. They have helped us redefine the roles as teachers, practitioners, students, and stakeholders in CBL. As explored throughout Chapter 8, the adoption of CBL necessitated a shift in pedagogical approach, requiring practitioners to actively engage in raising and reflecting on CBL awareness, creating authentic challenges, considering appropriate course design, creating diverse multidisciplinary teams, promoting active learning and collaboration, and providing ongoing support to students.

How CBL Practitioners Can Use and Learn from This Book

CBL practitioners can use this book in many different ways, depending on their level of experience and familiarity with CBL practice. For those completely new to CBL, the chapters in part one should provide a clear guide to the history of CBL, and theoretical framework to foreground new teachers and practitioners into understanding phase by phase the pedagogy. The new research provided by the case studies presented in part two could build upon a literature review of CBL to date and offer a range of CBL learning outcomes identified in diverse new contexts. CBL practitioners could benefit from the detailed guide and practical tips on how to conduct effective feedback and assessment presented in Chapter 3. These can be used throughout a learning implementation and aid effective evaluation of the learning process.

The case studies presented in part two of this book can be used as templates for practitioners that are new to CBL to orientate themselves in a practice that is most similar to their field of interest. The book highlights the many transversal skills that CBL offers and its particular suitability to interdisciplinary and multidisciplinary working. Therefore, it can also be useful for practitioners to read and understand how CBL is implemented in different contexts. It is also a highly internationally situated practice with case studies from a range of countries and institutions and within the case studies, teams composed of students from all around the world.

The book could also provide new perspectives for those who have already experienced CBL to gain deeper insights into how their colleagues have designed, facilitated, and implemented CBL. The lessons that these colleagues learned as practitioners can function as best practice, contributing to an emerging community of practice in CBL. The case studies not only feature a range of practical visual aids and frameworks that can help visualise the planning of different elements of the CBL process internally for practitioners but also as external presentational materials to students.

How Students Can Use and Learn from This Book

By creating authentic challenges, adapting course design to suit diverse student cohorts, and promoting collaboration within multidisciplinary teams, CBL practitioners support students in their process of learning. Students in particular develop their understanding of self-directed learning and collaborative learning in teams aiming to identity and address challenges in hindsight experienced as a positive by-product for stakeholders. So, students' contribution to the working context of stakeholders is unique in that these challenges and respective solutions may not be discovered without student involvement.

For student readers who may be familiar with the concept of CBL but not its practical application, this book could help them understand CBL from a different angle. They can also find out how their active engagement with real-world challenges could help them develop essential skills such as critical thinking, communication, and teamwork, while also gaining practical experience in problem-solving and prototyping solutions. Moreover, throughout the book they could also explore the role of the international and multidisciplinary nature of CBL challenges, which provides them with opportunities for intercultural collaboration and networking, preparing them for entering a globalised professional world.

How Stakeholders Can Use and Learn from This Book

Both internal and external stakeholders, including industry partners, community organisations, universities, and other higher education institutions also stand to gain from this book on the implementation of CBL. They can learn about how they can participate in collaborative learning initiatives to reveal their challenges and address them with university partnership. Stakeholders can access innovative solutions with an outsider perspective to in-house problems, which they might lose sight of. For example, in a course at UiS an external stakeholder reflected that working with students through CBL enabled them to look at problems in a way that they had never thought of before. In another course, another external stakeholder emphasised that a challenge that would have taken them a whole year to identity resolve was instead resolved by a team of students within a couple of months and that their involvement significantly accelerated the pace of their work and improved their efficiency. The stakeholder said '*Our collaboration with CBL students has helped us see that there are certain challenges with civic participation, which can be solved through creative thinking as well as practical and inclusive understandings.*' Finally, another external stakeholder reflected to us: '*We don't have all the answers to problems we need to solve in our work, but by involving students we can test and prototype solutions that we can then practically implement.*'

Therefore, the book can help them learn to work within the CBL framework with the university students as critical partners. This can later help them select and recruit talented students as their employees. The partnership initiated through CBL could also give an opportunity to the students to get to know the stakeholders in the industry and prepare their career path accordingly. They can also find an interactional challenge, which enables them to improve their wok quality as supported with the insights suggested by the students' insights. CBL is more likely to contribute to the development of a dynamic knowledge ecosystem that external partners seek to promote the work they do.

All stakeholders, we hope, find this book useful, relevant, and enjoyable. We believe the content of the book can provide these stakeholders' new insights into their professional learning processes and give them a new lens through which they investigate occupational challenges and their respective solutions.

The book, including case studies from multiple contexts across Europe, holds potential for transforming higher education practices by preparing students for future roles in their profession in an increasingly complex and interconnected world. It also shows how challenges are connected to local educational and community contexts to broader emerging global topics and issues. For example, it serves as a bridge as to how local sustainability initiatives could be replicated and upscaled internationally.

Overall, the book can help practitioners, students, and stakeholders embrace the principles of CBL and leverage opportunities to work together to create meaningful learning experiences and drive positive change not only in higher educations and society but also in personal and professional development.

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