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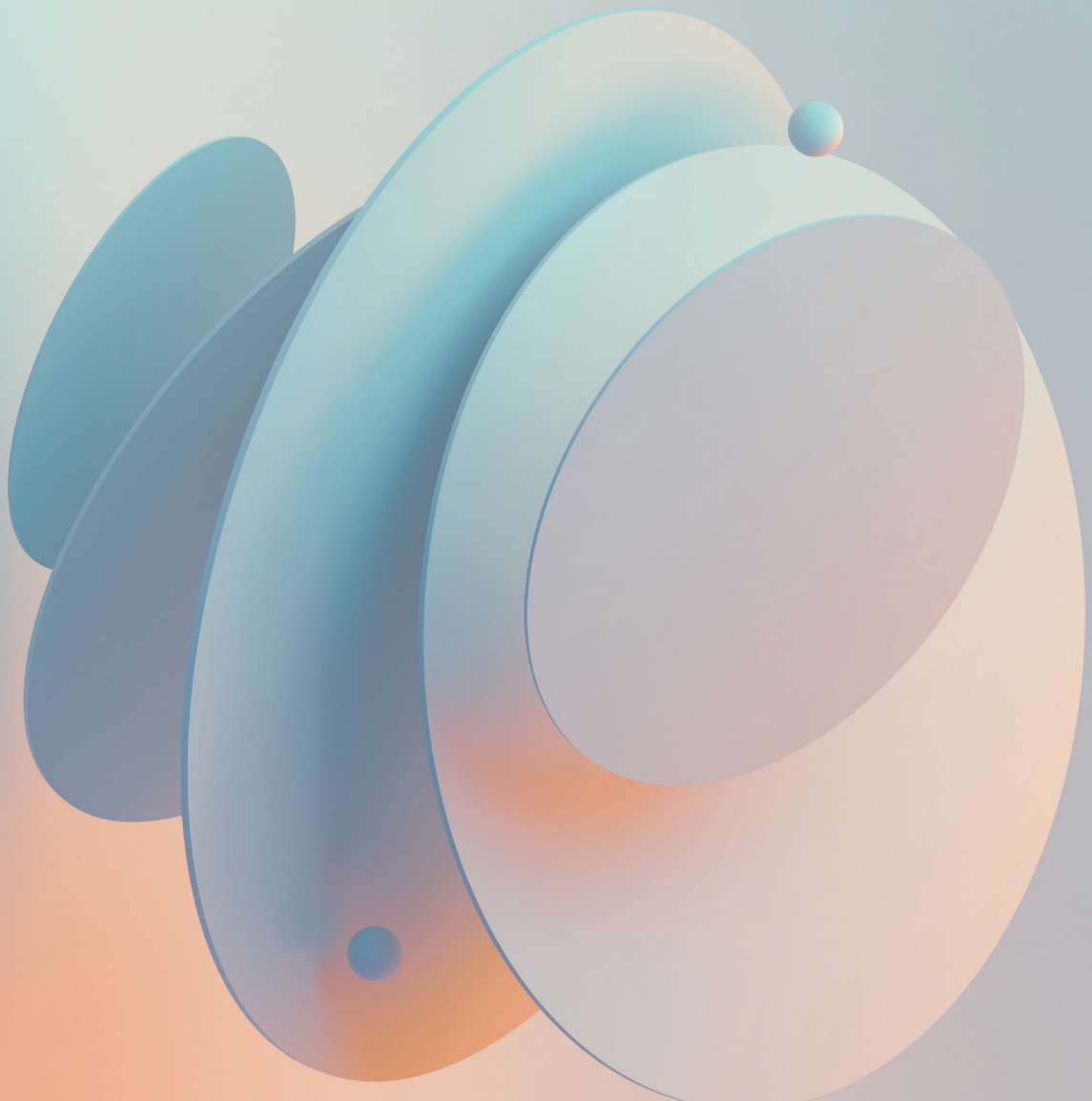
IMPLEMENTING CHALLENGE-BASED LEARNING FOR UNIVERSITY TEACHERS

PART A - THE CBL LANDSCAPE



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PREFACE

Challenge-Based Learning handbook on implementing CBL for university teachers - Part A

Challenge-Based Learning (CBL) has been gaining momentum in higher education since the publication of the 'Apple Classrooms of Tomorrow – today' in 2008. It is now adopted as an innovative learning methodology by all 14 partners of the ECIU University, the European Consortium of Innovative Universities[1]. When thinking, sharing, and discussing its role to innovate education, at the University of Twente we see different perspectives, ideas, beliefs, opinions and experiences. With this handbook, we hope to help you find your way in this maze. At the same time, we want to add some new perspectives that can contribute to the discussion about educational innovations with CBL.

This handbook was created for people that need or want to discover the main elements of CBL and their implementation. It can be also used by those with more advanced knowledge and experience with CBL. We have tried to focus on the practical aspects of the main features of CBL, as our experience is that teachers can get lost when they need to implement CBL in their classroom. When a teacher is doubting the implementation, this obviously results in confusion for, and sometimes rejection of, CBL by the students. Meanwhile, we also give some theoretical background, as we think it offers a better understanding of what CBL entails. The theory is especially useful when people have already started implementing CBL.

As of today, multiple perspectives and applications of CBL exist, which is common for every educational concept. As confusing as it might seem at first, this richness of definitions allows us to build a more complete landscape of what CBL is. In fact, the more we dive into the understanding of CBL, the more we believe that it is not about a series of techniques or elements that must be applied. Rather, in our opinion, CBL is a mindset, a specific view on higher education where the learner sits in the driver's seat. Even though putting the student in the centre is not unique to CBL, the way it is applied throughout the entire CBL process is unique. We are not suggesting that there is one single correct way to implement CBL. On the contrary, when a teacher wants to apply it, the most suitable way within the given context should be found. In this handbook, we will offer guidelines and examples of applications, but they should be considered as illustrations that can be applied in multiple creative ways and these examples are given to help you understand the implementation of the CBL framework. In this handbook, we want to stimulate you to think about the instructional decisions that you can make in your specific context.

Therefore, this handbook wants to offer you an overview of the main elements, to build a knowledge base to start navigating the beautiful and complex world of CBL. From here, you can then explore more resources on CBL, for example, found on https://www.utwente.nl/en/cbl/. Hopefully, after reading this handbook, you will be able to look at the resources critically, picking those elements that best fit your context and support your goals as a teacher.

Finally, as you will discover, teamwork is a core element of CBL for both students and teachers. CBL invites all those who are involved to discuss, share and co-create solutions. We hope that you can also adopt this mindset when reading this handbook. We encourage you to get involved with the community of your organisation, your colleagues and students to share your findings about CBL, and together build solutions for the challenges of today's education. If you do this, it will certainly result in a better and more satisfying learning experience.

About this handbook

With the aim of providing you with a helpful tool, we have used both theoretical and practical knowledge to write this handbook. Both sources were used to answer the question "What information do teachers need to implement a CBL approach in their courses?"[2]. We asked this question to both teachers that were already experienced with CBL and to those that were taking their first steps into the CBL world. Starting from the information we received from them, we interrogated both scientific and non-scientific literature to give a sound theoretical basis to the handbook. On top of that, we integrated the practical knowledge of different teachers and educational consultants that make use of a CBL approach. The document was then peer-reviewed, and the necessary changes were made.

How we suggest using this handbook:

- Skim read the handbook initially to understand the main CBL elements. Also, you can decide to read only the parts that interest you the most. We do not think it needs to be

[1] See: https://www.eciu.org/for-learners/about#cycle

[2] Even though most of the content presented is backed with scientific literature, this handbook is not a scientific work.

read from cover to cover (unless you want to!).

- Use the handbook as a guiding resource. Like every other skill, learning how to implement CBL takes time, errors, and reflection on what was done.
- Dare to experiment and deviate slightly from this handbook, ask for the opinion of teachers and students. We have tried to tackle the main issues and challenges related to the implementation of CBL. We will prompt you to reflect on the aspects that have to do with the design of a course. However, there is not one answer for everything: in such cases, we advise you to ask the opinion of other teachers or experiment to find an answer yourself (or both!).

How this handbook is structured

The handbook is divided in two parts (the second part is still in development). Part A is about the CBL landscape to get different perspectives on the framework. It is designed to give you an overview on the essential CBL elements to get started. In most of the paragraphs, you will find sidenotes in yellow boxes. These sidenotes give you information about different implementations of a specific aspect, extra resources or tips on best practices. Finally, Part A ends with the question whether CBL is the desired solution for your context. In Part B (in development) the implementation of CBL will be discussed in more detail regarding making concrete educational design decisions where the CBL framework is a reference.

Part A overview:

- In Chapter 1 we explore CBL from a theoretical perspective. We give a limited pedagogical basis, as well as information about the central role (and definition) of the Challenge. Finally, the roles of the teacher and the students are introduced.
- In Chapter 2 we give an overview of how the CBL framework unfolds during a course. The three CBL phases are explained, along with the steps that characterise them. To increase the understanding of the process, practical examples follow along with a theoretical explanation of the phases.
- In Chapter 3 we explore those elements that can help you decide whether CBL is suitable for your teaching goals. CBL might not be suitable for every context. Therefore, before adopting it, it is better to consider if CBL is what you are looking for to reach your teaching goals.

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HOW CHALLENGES AND LEARNING DEFINE CBL

Ideas about learning within a CBL learning environment did not appear out of thin air. You can even say 'there is nothing new under the sun'. As with every innovation, CBL is about creatively combining existing and known educational concepts from different perspectives to create a new educational approach.

The University of Twente defined Challenge-Based Learning as:

> A process whereby learners are actively engaged in situations that are real, relevant and related to their environment, driven by challenging, open-ended problems that have multiple solutions, built on the foundation of experiential learning, the learning process is more important than the outcome (solutions) (Vreman-de Olde et al., 2021).

As can be seen in the above definition, in the CBL approach, students are actively involved in their learning, driven by real-life challenges that give context, a sense of urgency and direction to the learning process. These ideas are far from being new in education. Indeed, CBL comprises elements that you might already be familiar with. It is important, however, to understand how these elements are interpreted and applied in this context. This is why, in the current chapter, the learning perspective, relevant learning elements, and the Challenge perspective are explored. Understanding these three elements is essential to grasping the core of CBL. Where challenges and learning meet, they strengthen each other and CBL takes shape. Their integration makes CBL more than the sum of its parts.

1.1. The Learning Perspective

In the literature reviews on Challenge-Based Learning in higher education (Gallagher & Savage, 2020; Leijon et al., 2021) several learning perspectives can be found that form the origin of CBL. These perspectives help understanding the foundation and the rationale behind CBL:

- Active learning,
- Experiential learning,
- Inquiry-based learning, and
- Collaborative learning.

1.1.1. Active learning

Learning is not only about actively participating in the learning and teaching process, but also about the students taking responsibility for it. Active learning results in a mental process of creating rich meaning and deep processing through analysing, synthesising, and evaluating new knowledge and skills (Gogus, 2012). In the CBL approach, students are actively involved in their learning. They formulate questions and investigate widely in cooperation with different stakeholders and disciplines (Nichols & Cator, 2008).

1.1.2. Experiential learning

The concept of real-life experiences being at the centre of learning is present in various learning theories of scholars like Kolb, Vygotski and Dewey. Through a process of action - reflection and concrete experience - abstract conceptualisation learning is structured to facilitate the construction of knowledge (Kolb & Kolb, 2012).
Working in a real-life, authentic setting creates opportunities for relevant learning experiences. In CBL, these learning opportunities can also be characterised by a close interaction with a variety of stakeholders and happen both within and outside the academic setting. Working on real-world cases is a means for students to be exposed to complexity, instead of working on synthesised or simplified cases. Finally, in each phase of the CBL approach, time and guidance are given for action, reflection, concrete experiences, and abstract conceptualisation.

1.1.3. Inquiry-based learning

In inquiry-based learning, new knowledge is explored through systematic questioning (Caliskan, 2012). The learning process is also about acquiring the ability to ask the right questions and finding answers in a structured, scholarly way. As you will see in Chapter 2, this systematic questioning is applied in CBL from the very beginning of the learning process. The CBL approach requires the student to 'not jump to conclusions (and solutions)', but first explore the field of a Big Idea. This exploration happens through formulating Essential Questions, and then investigating in more depth through Guiding Questions[3].

1.1.4. Collaborative learning

In collaborative learning, students' abilities and contribution are

[3] The CBL specific terms like Big Idea, Essential Questions and Guiding Questions are addressed in more detail in Chapter 2.

actively solicited by making them work in small groups (Udvari-Solner, 2012). Working in teams is an authentic part of real-life work, where the final result goes beyond the contributions of each individual member. Working in groups is part of many teaching and learning methods such as Project-Based Learning and Problem-Based Learning, because social interactions play an important role in the learning process of students.

In CBL, collaborative learning happens by working in multidisciplinary and interdisciplinary teams, where the learning is brought to a higher level. Teachers, students, and stakeholders work together and can even be co-designers of the learning process as well as the solution. In other words, these subjects take an active role in participating and building the Challenge (Nichols et al., 2016). For example, characteristics of engineering and entrepreneurship (van den Beemt et al., 2020) can be combined, with emphasis on the environmental, social and economically domains (Malmqvist et al., 2015; Kohn Rådberg et al., 2020).

1.2. Learning Elements

Along with the learning perspectives described above, in CBL, there are essential elements to create an effective learning environment. Some important ones are described below:

- Motivation,
- Reflection,
- Scaffolding, and
- Other learning concepts.

1.2.1. Motivation

It is well known that motivation is an important concept in learning. Intrinsic and extrinsic forces have a balanced influence on actual student behaviour (Willems & Lewalter, 2012), which can be made visible via the Self-Determination Theory framework of Deci and Ryan. Feelings of competence, relatedness and autonomy are mentioned as the universal needs for growth and integration, constructive social development and personal well-being (Ryan & Deci, 2000).

In the CBL approach, motivation is facilitated by different aspects, such as allowing students to co-design their individual learning process, working on real-world issues, and collaboration. Moreover, motivation is increased by the fact that students collaborate with extra-academic actors (Morales-Menendez et al., 2019).

1.2.2. Reflection

Students being conscious of their own learning takes place through a process of reflection, self-reflection, and critical reflection and thus is a crucial aspect of learning. The process of reflection can be focussed on different learning aspects, such as the learning goals, methods, interactions or topics and subjects in relation to one's thoughts, desires and feeling (Gläser-Zikuda, 2012).

In the CBL approach, reflection is a fundamental part of every phase and step. Reflection enhances students' learning by creating a deeper understanding of the content, experience, and relationships with other people (Observatory of Educational Innovation, 2015).

1.2.3. Scaffolding

Scaffolding is a process that support learners in achieving better results than when they work without assistance (Zydney, 2012). This is done by providing a structure that is gradually removed throughout the learning process. This is why it is important to keep assessing learners' proficiency in a task (Zydney, 2012). Reiser & Tabak (2014) state that scaffolding is a characteristic element of contextualised approaches, where learners work on real-life or complex tasks. For this type of task, guidance is essential to allow the learner to acquire the necessary skills and knowledge to perform the task. Common scaffolding tasks are recruiting and maintaining the learner's attention toward a goal, simplifying the task, modelling and demonstrating, ongoing diagnosis and assessment, and fading support and eventual transfer.

Scaffolding is essential to provide a successful CBL experience (Nichols et al., 2016). Providing adequate support is necessary to avoid students feeling lost, especially during the first weeks of a course (Doulougeri et al., 2022), but also to develop a sense of agency in the students and autonomy towards their learning (Doulougeri et al., 2022; Nichols et al., 2016).

1.2.4. Other related learning concepts

As well as the above stated general learning concepts, high impact learning and teaching strategies have proven to be effective in teaching and learning in education in general[4], and we think they can also be applied to CBL. For example:

- Building on prior knowledge and experience,
- Constructive alignment, and
- Expectation management of students, coaches and stakeholders.

1.3. The Challenge Perspective

Learning in CBL environment is driven by Challenges. What is a Challenge and what distinguishes it from a problem or a project?

A Challenge is a real-world problem (Gallagher & Savage, 2020) on which students will work and try to find an implementable solution (Membrillo-Hernández et al., 2021). Challenges differ from (project- and problem-based) problems in the sense that they are not pre-defined statements or tasks that are given to the students. On the contrary, Challenges are usually chosen and defined by the students (Membrillo-Hernández et al., 2021; Pepin & Kock, 2021). Because Challenges are a way to tackle wider societal open-ended problems on a local scale, they require the integration of different perspectives to be solved (Membrillo-

[4] Read more in: Kirschner & Hendrick (2020), Biggs & Tang (2011) and De Bruyckere (2018)

Table 1 *Differences between PBL, PjBL and CBL*

Characteristics	Problem-Based Learning (PBL)	Project-Based Learning (PjBL)
Learning	Students' learning is supported by teachers (Gallagher & Savage, 2020)	Students' learning is supported by teachers (Gallagher & Savage, 2020).
Problem/case	Students receive a specific pre-defined problem (Gallagher & Savage, 2020) for which a solution is required (Membrillo-Hernández et al., 2021).	Students receive a specific pre-defined problematic situation (Gallagher & Savage, 2020; Membrillo-Hernández et al., 2021) for which a real solution is not needed (Larmer, 2015).
	The case is often fictional (Observatory of Educational Innovation, 2015) and the solution is already known by the teacher.	The case is often fictional (Membrillo-Hernández et al., 2021) and the solution might be known by the teacher.
Focus/Objective	The objective is the solution to the problem (Membrillo-Hernández et al., 2021).	Focuses more on the final product (Gallagher & Savage, 2020).

Note. Table adapted from Membrillo-Hernández et al. (2019)

Hernández et al., 2021). This also implies that there is not one single (and correct) solution to the Challenges, which also distinguishes them from problems in other educational approaches. Moreover, the solution can only be evaluated when implemented in a real context, and the focus of the evaluation is not the final result, but the development of students' competences (Membrillo-Hernández et al., 2021).

It is paramount that a Challenge is real-life and authentic, linking global issues with local realities. The Challenge is part of the dynamic, complex and changing future work field of the students. Simultaneously, Challenges cross the boundaries of academic disciplines, institutes, organisations and industries. In this sense, Challenges are different from (project- and problem-based) problems because the multiple perspectives encompass multiple 'problem-owners' and different stakeholders.

Different practices

Two main perspectives on the choice and implementation of a Challenge are possible. On the one hand, the Challenge is chosen by the teacher for the student; on the other hand, the students determine their own Challenge during the process (Gallagher & Savage, 2020). In practice the difference is less strict, and different types of implementations are possible.

Teachers are often confused about the differences between Problem-Based Learning (PBL), Project-Based Learning (PjBL), and CBL. The confusion is caused by the fact that these three learning approaches share some commonalities (Gallagher & Savage, 2020), and that CBL draws from both PBL and PjBL (Malmqvist et al., 2015; Membrillo-Hernández et al., 2021; Nichols et al., 2016). Using the structure of Membrillo-Hernández et al. (2019) as a starting point, Table 1[5] shows the main differences and commonalities between PBL, PjBL and CBL[6]. The list presented is not intended to be comprehensive, but to give a general idea of what the specific features of CBL are.

1.4. Integrating Learning and Challenges in CBL

The integration of learning and challenges in CBL takes place through multiple dimensions. The following dimensions can be seen as the core of this integration, but the list is not intended to be exhaustive:

- Structure and sequencing,
- Role of the teacher,
- Role of the student,
- Document/share/reflect,
- Multi-, inter-, and transdisciplinary educational practices,
- Real-life learning, and
- Stakeholder involvement.

[5] The original content of the table by Membrillo-Hernández et al. (2019) was not reported here. You can find the table on the website of the Teaching Enhancement Unit of Dublin City University: https://www.dcu.ie/teu/challenge-based-learning

[6] It must be noted that the concepts of PBL and PjBL are based on the same learning principles (de Graaff & Kolmos, 2007), therefore, it is sometimes hard to tell them apart. Moreover, there are many different models and applications of these approaches (Kolmos, 2009).

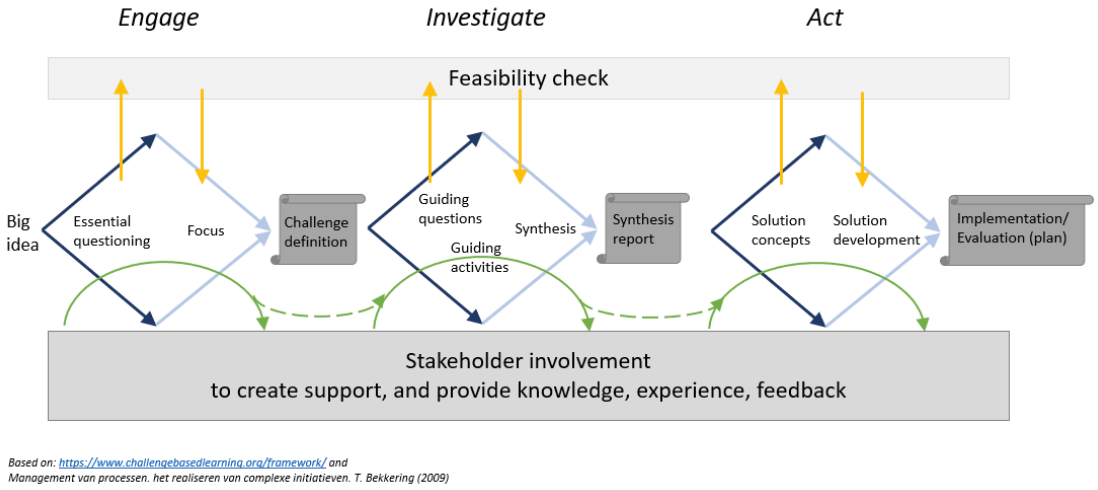

Figure 1 *Managing the process of CBL through a process management approach*

1.4.1. Structuring and sequencing your course design

The structure of phases and steps in which activities take place in CBL (also see Chapter 2) can be portrayed as a continuous process of zooming out and zooming in. The phases of engage, investigate and act force the students not to jump immediately into solutions and conclusions, but dive into the domain via iterative sequences of exploration and selection. This process is shown in Figure 1.

When zooming out (dark blue arrows), students explore a topic together (e.g., the Big Idea, or the Guiding questions), and are open to the possibilities of discovery. Students are then in a process of curiosity and creativity. This also means that they can be a bit out of their comfort zone, for example, taking new and unexpected roles or knowledge into consideration.

When zooming in (light blue arrows) students narrow down the results of their exploration. They do this by making choices, focusing on specific aspects, and prioritising what they want to continue with. Intended learning outcomes of the course and personal learning goals can support this decision-making process.

A boundary condition in the process is checking feasibility. That is, feasibility sets the boundaries to creativity when zooming out, and it helps to make the decisions when zooming in. In addition, progression in the process of zooming in and zooming out is supported by stakeholder involvement.

Along with the above-mentioned processes, stakeholders' involvement influences the zooming in and zooming out processes. That is, their involvement brings additional knowledge, experience, feedback and inspiration. Therefore, it is possible for stakeholders to be involved in different phases for different purposes (see section 1.4.5 for further information).

The process of zooming in and zooming out, guided by feasibility checks and enriched by stakeholders' involvement, needs to be delicately balanced. Processes that are too restrictive or too vague will influence the subsequent outcomes. For example, too much support, or stakeholders that are too solution-driven, can make the 'playing area' too tight and limit the creativity of students. On the contrary, if the playing area is too wide, it will result in a slow progression. Finally, the process of zooming out and zooming in results in some type of consolidation (e.g., Challenge definition, Synthesis report, Implementation/Evaluation plan). This can be in different forms such as written text, video, schemes and/or images. Each consolidation is not set in stone and always open for new insights.

1.4.2. Role of teacher/coach

The role of the teacher in CBL is twofold[7]. Firstly, the teacher will design an effective and efficient learning environment for the students based on a vision of learning within the CBL principles. Secondly, the teacher will implement teaching strategies and guide the learning process of the students in a CBL setting.

Within CBL, the teacher needs to integrate the roles of (disciplinary content) expert and coach. These two roles must become the mindset adopted by the teacher, which will allow them to design and create an effective and efficient learning environment for the students. This environment must be based on a vision of learning within the CBL principles (see Chapter 2). On one hand, the role of expert is needed to give the bases of the content, to provide students with the necessary elements to start moving in the field. On the other hand, the role of coach is necessary to give the students the freedom to choose their direction of learning while being guided and supported. The role of coach is crucial for CBL to activate the student's learning process. This is also a clear

[7] In practice, the teacher has many other different roles withing a CBL course, such as course-designer, co-learner, evaluator, etc. These roles will be addressed in Chapter 4 (in development).

Figure 2 *The expert-coach continuum*

difference with PBL, where the outcome is often known and the teacher steers students towards that answer. In CBL, the optimal solution/knowledge is unknown (as many solutions might fit the Challenge). Therefore, steering towards a solution is not feasible, and the teacher can only coach the students.

During the actual teaching activities, it is difficult to tell these two roles apart. They can be visualised as a continuum, where the two perspectives overlap. Teachers are then asked to move along this continuum, adapting their style according to the situation (Figure 2). Moreover, a CBL teacher does not have to be the (only) expert expected to provide all the answers. In fact, while working on a Challenge, students could be taught by other professors, experts, researchers and stakeholders from industry and the community (Kamp, 2016), as well as referring to literature studies.

According to the Observatory of Educational Innovation (2015), the teacher should focus the coaching role on:

- Asking leading and open-ended questions that help the students develop their critical thinking (Socratic method), instead of providing answers,
- Helping students reflect and monitor the process,
- Challenging students' thinking to activate deep learning,
- Motivating the students, making them believe in themselves and making them feel comfortable in their group (Grandmother method), and
- Providing a network and acting as a linking pin between students, external experts and stakeholders.

As shown in Figure 3, the integrated expert/coach role is also important to provide boundaries. These boundaries are essential to prevent overshooting. In each phase, students are asked to explore the topic (zooming out) and make decisions implementing creative thinking and decision-making (zooming in). The teacher must scaffold and guide these processes to avoid students getting lost. Zooming out allows students to come up with out-of-the box ideas, but this creative process need to be balanced with the time available. That is, time constraints also need to be considered when exploring the topic. Moreover, students have to zoom out, but this process has to be scaffolded to avoid losing focus on the task at hand.

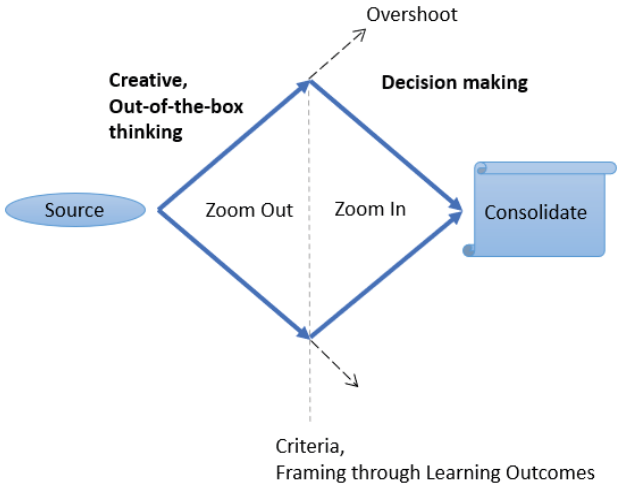

Figure 3 *Overshoot in the process of Challenge-Based Learning*

Different practices

In some cases, student assistants or other teachers act as coaches for teams in CBL courses. That is, each team of students have a coach who assists and guides them during the learning process. However, even in these cases, the teacher must adopt a coaching role, as it is the right mindset for implementing CBL.

Designing a CBL learning experience is solving an open-ended educational problem in itself. As a teacher you are, in the ideal situation, part of:

- a multidisciplinary design team,
- developing creative solutions,
- ideally working based on educational theory and experience,
- working structurally and flexibly (that is, being flexible to adjust the structure according to circumstances and students), and
- making evidence-informed and justified design decisions.

1.4.3. The role of the student

The role and expectation of the students and student teams is a student-driven learning (SDL) approach. In SDL, students actively take initiative in shaping their own learning path (The Twente Education Model, n.d.).

Self-regulation is an important ability for the students to manage this freedom and guide their own learning process. This multidimensional concept of learning engagement

(Wolters & Taylor, 2012) includes the ability to create individual and team plans, actively employ effective learning strategies, make emotional and social connections to the team and topic, and motivate themselves. As many students are new to CBL, expectations management plays a central role. What the teacher expects from them, and more specifically what their role is will be discussed in part B (in development).

1.4.4. Multi-, inter- and trans-disciplinary approaches

As CBL aims to address open-ended complex global challenges, the potential is maximised when a multidisciplinary, collaborative approach is adopted. Complex challenges cannot be understood and solved using a single perspective (de Greef et al., 2017), because each discipline analyses the world in a specific way and has its own models, frameworks, and paradigms. Therefore, three ways to use different perspectives to work on a challenge are multidisciplinarity, interdisciplinarity, and transdisciplinarity (Visscher et al., 2022). Even if these terms are often use interchangeably, they are different concepts (de Greef et al., 2017).

Usually, these concepts are defined according to the way knowledge is integrated (Visscher et al., 2022). De Greef et al. (2017) clearly explain the differentiation between these three concepts according to this conceptualization.

Multidisciplinarity is the use of different disciplinary perspectives to understand a problem. However, these multiple viewpoints are not integrated, and they are only used to gain a better understanding of the problem at hand (de Greef et al., 2017). Interdisciplinarity works in the same way as multidisciplinary, with the difference being that the multiple perspectives are integrated. In this sense, the interaction of the different disciplines' methodology and language is consciously applied.

Finally, transdisciplinarity involves the integration and interaction of academic and non-academic knowledge. The latter can come from subjects such as companies, citizens, among others.

However, Visscher et al. (2022) show that multidisciplinarity, interdisciplinarity, and transdisciplinarity can be differentiate also according to the different educational practices used in these approaches (i.e., learning objectives, design of the challenge, problem solving, and stakeholder involvement). More specifically, multidisciplinary courses have a more pre-structured configuration, while transdisciplinary courses have the highest level of open-endedness. Transdisciplinary projects are a middle way between the two approaches. The best approach to use depends on the characteristics of the teacher and course' goals (Visscher et al., 2022). Finally, even though the challenges tackled with CBL would require the integration of different types of knowledge, in practice, this is not always feasible. That is, CBL with a single discipline is also possible (Gallagher & Savage, 2020; Nichols et al., 2016).

1.4.5. Stakeholder involvement

Within the CBL framework, stakeholders are people (or organisations) that have something at stake related to the Challenge. This means that their role can go much further than that of a 'simple' challenge provider. Indeed, throughout the process, various (types of) stakeholders can be involved (Table 2), with different roles and different levels of incorporation into different phases of the process. Some of these roles are:

- **Primary stakeholder**[8]**:** This can be one or multiple concrete stakeholders (companies, associations, NGOs, local administrations) with a socio-technical question or theme,
- **User/customer/society:** people that are directly influenced or affected by possible solutions,
- **Expert:** Someone that has expert knowledge on one or more relevant topics,
- **Interested party:** people that are interested but are not (yet) directly affected by the theme,
- **Involved:** people that are interested and are also willing to put in the effort to make change possible,
- **Blank:** People that are not related to the theme and don't have an opinion, and
- **Executive power:** people that have access to resources and/or can decide on resources to make change possible.

Due to the various types of people involved, stakeholder involvement can take different forms, according to their association with the Challenge, as well as the moment of their inclusion in the learning process. CBL stakeholders' roles are based on interests and intentions that could be different from problem-owners and clients in project-based and problem-based learning.

The level of involvement of stakeholders has a large impact on the implementation of CBL, as the teacher can choose to involve them from the beginning or leave the students free to choose their stakeholders in later phases of the learning process[9]. Variations of these two strategies are also possible.

1.5. Next Step

Now we have a clear understanding of the different aspects of learning and challenges in CBL, it raises the question if it is possible to include more structure. In the next chapter we investigate the different elements of CBL and address the three CBL phases, Engage-Investigate-Act, in more detail.

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[8] In same cases primary stakeholders are known as "Challenge providers", but we do not want to promote the notion of Challenger provider because Challenges are not provided, but rather formulated by the student (teams).

[9] Stakeholder management is addressed in more details in Chapter 6 (in development).

Table 2 *Example stakeholders: Energy Transition Challenge*

Example stakeholders	
Challenge provider	Construction company that needs to put power cables in the ground.
User/customer	Inhabitants living in a street that needs to be excavated. This will lead to a lot of disturbance. But solar panels on houses need thicker cables for all the green power.
Expert	Researcher in civil engineering managing and planning underground constructions, coordinators from municipalities, foundations for settings standards and researchers in sustainability design.
Interested party	People working on the energy transition, NGO's and government, construction companies.
Involved	Different departments of municipalities, companies.
No specific opinion	For example, students.
Executive power	Policy makers, subsidy providers, companies, CEO's, etc.

DIVING INTO THE PROCESS OF CBL

In this chapter, we introduce the learning and challenge perspectives that make up Challenge-Based Learning (CBL). First, the main structural elements are introduced covering what the CBL framework entails, the three phases and their nine steps. Each phase and the associated steps are explained in more detail and to increase understanding, concrete examples are provided. The examples given were developed in a way that includes, for what was possible, perspectives from different disciplines[10]. Second, by using prompting questions, we try to activate creativity and stimulate thinking about the implementation of the CBL elements described. Finally, in the last section of this chapter, some explanation is given about the ongoing process of sharing, documenting and reflecting.

Figure 4 *ECIU Challenge-based Learning Framework* (Source: https://www.eciu.org/for-learners/about#cycle)

2.1. Three Phases in the CBL Framework

Figure 5 presents the ECIU educational framework for CBL with three interconnected phases: Engage, Investigate, and Act. Each phase includes three steps that prepare learners to move to the next stage. All nine steps of the process are accompanied by an ongoing process of documenting, reflecting, and sharing.

2.2. Phase 1: Engage

2.2.1. Overview of Phase 1

The Engage phase brings students from a Big Idea to a concrete and actionable Challenge through a process of Essential Questioning. As the name suggests, the aim is to engage students in a Challenge that they can experience as personal and involving. In the Engage phase an emotional connection is created, both with the topic and the other participants in the Challenge.

The process of zooming in and zooming out is done in three steps: sharing a Big Idea, phrasing Essential Questions and creating a Challenge.

2.2.2. What about the Big Ideas?

The first step in the CBL process is initiated with a pre-defined Big Idea, which is a wicked[11] problem (Imanbayeva, 2022) that is relevant for both a larger community and the students. Big Ideas should be broad enough to be explored from multiple perspectives (Observatory of Educational Innovation, 2015).

[10] The examples given have the main goal of showing how the different elements of the CBL process look like in practice. The inclusion of multiple perspectives has itself a twofold intention. On the one hand, we hope it will allow you to find something that is closer to your field/discipline. On the other hand, as CBL is often multidisciplinary, the example illustrates a potential multidisciplinary case where students from different disciplines collaborate.

[11] In her research, Imanbayeva (2022) defines wicked problems as "inherently and socially complex, ever-evolving critical societal issues (De Stefani & Han, 2022) that cannot be ultimately solved, because the problem definition changes as the solutions create new ways of understanding the problem (Rittel & Webber, 1973)" (pp. 10-11).

In this way, students can find real personal meaning when looking for problems within their scope (Nichols et al., 2016). Additionally, the Big Idea has to be related to the content of the course (Nichols et al., 2016), and it should trigger and motivate students to collaborate to gain deep multidisciplinary content knowledge (Apple, 2010). Remember that Big Ideas (and subsequent Challenges) must not be fictional but from the real-world (Observatory of Educational Innovation, 2015).

Resources

The United Nations' Sustainable Development Goals can give inspiration when choosing a Big Idea. Any other topic that is relevant to society can also be chosen.

Think about the following prompting questions:

- A course can have a single Big Idea introduced by the teacher or multiple Big Ideas chosen by each group of students. What is the best option for your setting?
- How would you present the Big Idea to the students?
- How and where can you find inspiration for Big Ideas?
- If you are choosing, and involving, specific stakeholders, can you consider making them present the Big Idea instead of a specific problem?
- What is your understanding of the difference between a Big Idea and a problem?

2.2.3. Phrasing Essential Questions

Essential Questions are open-ended questions that can be elaborated by looking from different perspectives and disciplines. The formulation of the Essential Questioning process can take place individually or in teams. It should reflect students' interests and needs and can be used to understand the complexity of the Big Idea, contextualise and personalise it. Prior knowledge and personal experience are strong catalysts in this Essential Questioning process. Answering these Essential Questions will also stimulate and prepare students to learn about the fundamentals of the introduced topic. Once they have explored the topic through different Essential Questions, (a team of) students should focus on one or a few of these questions that are relevant to them. These questions serve as the link between their personal lives and the Big Idea, so it provides a framework for the Challenge definition (Apple, 2010). These chosen Essential Question(s) can only be answered through research, which will serve as a foundation for the Challenge (Observatory of Educational Innovation, 2015).

Think about the following prompting questions:

- Are students already able to make Essential Questions? How can they learn to phrase such questions? How would you support this?
- How would you prompt the students to ask Essential Questions?
- Should students try to formulate Essential Questions on

Practical Example - Big Idea and Essential questions

Examples of Big Ideas:

- Climate Change,
- Community,
- Relationships,
- Creativity,
- Health,
- Sustainability,
- and Democracy (Nichols et al., 2016).

Big Idea: Climate Change
Possible Essential Questions:

- What is climate change according to me and other disciplinary perspectives?
- Who has a stake in the problem?
- Whose life is affected by climate change?
- What are the factors contributing to climate change?
- How can I recognise climate change in my surroundings?
- How does climate change affect our community/my life?
- How do people perceive climate change?
- What are national/European/international policies to limit climate change?
- What are the effects of climate change on the environment?
  - How do different consumption habits impact climate change?
  - How do different food consumption habits impact climate change?
  - How do fashion production and consumption impact climate change?
  - How do different energy consumption habits impact climate change?
  - How do different transportation habits impact climate change?

Final Essential Question[12]**:**
How do different transportation habits impact climate change?

[12] Usually, each (group of) students has a different Essential Question to work on. Therefore, students feel more connected to the question they choose. However, according to your context and learning goals, you can also decide to have a single Essential Question for all the (groups of) students

Resources

An Essential Question (McTighe & Wiggins, 2013):

- is open-ended, meaning that there will not be one single correct answer,
- is intellectually engaging (thought-provoking), can easily spark a discussion or debate,
- calls for Higher-order thinking and cannot be answered by only recalling knowledge,
- will lead to important transferable ideas within and across disciplines
- raises additional questions,
- requires justification, not just an answer,
- recurs over time, answers can be different at any given moment.

Essential Questions are usually formulated by the students, but they might need some guidance to do it, as it is a new (and difficult) process. To support this process a useful tool that students can use is a concept maps tool, such as https://miro.com

their own or should you give them some examples?
- Which final questions will be chosen is a decision-making process. For example, it can be based on students' interest(s), time availability, course content. How can you support students in choosing the final Essential Question(s)?
- How do you make sure that students are exploring the Big Idea to its full extent? How could you prevent students from tunnel-vision?

2.2.4. Formulating the Challenge

In the third and last step of the Engage phase, students translate the Essential Question(s) into a Challenge, which is a call to action to develop local actions to the Big Idea (Observatory of Educational Innovation, 2015). Challenges must be personally meaningful for the students, immediate, actionable, and feasible to solve within the timeframe of the course (Apple, 2010). Moreover, Challenges must describe what students want to achieve without indicating a precise solution (this is vital as it would bias their investigative process).

The Engage phase ends when the (group of) students come up with a convincing and actionable Challenge statement. When the Big Idea is explored, Essential Questions are identified, and a Challenge is formulated and accepted by the student (team), then the Investigate phase starts.

Think about the following prompting questions:

- How can you support students in choosing and formulating the Challenge(s)?
- How can you support students in choosing a Challenge appropriate to the timeframe of the course?
- How much time are you giving the students to define the Challenge?

Clarification

Sometimes stakeholders are involved from the beginning, and they present their connection with the Big Idea. In this case, it is important that the Challenge should be identified by the students and not already provided by the stakeholder. Remember that the Challenge is not the same as a problem. Involving the stakeholder is not about a client–consultant relation or the role of a problem-owner.

2.3. Phase 2: Investigate

2.3.1. Overview of Phase 2

The second CBL phase is the Investigate phase, which consists of three steps: first, all student teams identify Guiding Questions, then they define and engage in Guiding Activities and Resources, and, finally, complete the analysis. All answers to the Guiding Questions need to be analysed, structured, evaluated and prioritised for the next phase. The goal of the Investigate phase

Practical Example - Challenges

Big Idea: Climate Change
Final Essential Question: How do different transportation habits impact climate change?
Possible Challenges:

- **Challenge 1:** Reducing the contribution of transportation habits in my region to climate change.
- **Challenge 2:** Promoting sustainable transportation habits at my university.
- **Challenge 3:** Increasing awareness of the effects of transportation habits on climate change.

During the process (e.g., transition between the Engage phase and the Investigate phase) the Challenge might need refining as the (group of) students start to look closer at their Challenge. Taking Challenge 1 as an example, students and teachers might want to define specific aspects of it. For instance:

- What do we mean by contribution?
- What type of transportation do we want to focus on?
- What do we mean by habits?

Redefined Challenge 1: Reducing the greenhouse gas emissions produced by the regional bus company.

is that students examine the topics in-depth and achieve deep learning by exploring (academic) resources, and collaborating with peers, stakeholders, experts, and educators. The second phase involves looking at the Challenge deeply and from multiple perspectives, rather than from a narrow perspective of pre-existing beliefs and ideas (Nichols & Cator, 2008). The investigate phase is where students learn most of the concepts and theories related to the course and Challenge.

2.3.2. Identifying the Guiding Questions

The first step of the Investigate phase is the formulation of Guiding Questions. When working in multidisciplinary groups, the Guiding Questions formulated should reflect each member's disciplinary perspective (Nichols et al., 2016). Moreover, the sets of questions need to point towards the advanced knowledge students will require to develop a Solution to the Challenge. Even though questions will continue to emerge throughout the CBL process, the development of an extensive list of Guiding Questions in this phase is essential. The Guiding Questions will guide students' learning and keep them from getting lost when looking for information (Loohuis & Bosch-Chapel, 2021). Teachers should allow students the freedom to write their own Guiding Questions, while paying attention that they do not deviate too far from the Challenge and the final learning outcomes of the course.

Think about the following prompting questions:

- How capable are your students of formulating Guiding Questions? How can you scaffold this process? (e.g., show students examples related to the Challenge or other topics, make them come up with their own questions and coach them to improve them, etc.)
- How do you ensure that (teams of) students are still interacting with each other during this step?
- How do you prevent students jumping to conclusions too fast (e.g., they might do too little analysis or identify Guiding Questions that are too narrowly focussed)?
- How can you support students to make decisions within the given time frame limits? How do you guide them to delve in one direction without steering them too much? They must plan their own learning process. How can you facilitate these learning processes?

Best practice

Student can categorise their questions, in order to improve their learning process and subsequent phases (Nichols et al., 2016). Categories emerge from like-questions, and they also help to prioritise questions for each category (i.e., Nice to know, Good to know, Must-know).

2.3.3. Building knowledge through the Guiding Activities and Resources

In the second step, (teams of) students identify and engage in Guiding Activities and make use of Guiding Resources to build new knowledge and answer the Guiding Questions. That is, the Guiding Activities include any methods, resources, and tools that help each student acquire the knowledge needed to answer the formulated Guiding Questions. These answers are needed to come closer to an innovative, insightful, creative, and realistic solution (Apple, 2010; Nichols et al., 2016). To organise the process of Guiding Activities a time plan helps in planning who does what and when as given in the example.

Think about the following prompting questions:

- How can you support students in finding relevant Guiding Activities and Resources?
- How can you stimulate students to go beyond the knowledge they already have from other courses?
- What relevant Guiding Activities and Resources can you already provide them?
- Students might tend to start thinking about Solutions when engaging with Guiding Activities and Resources. How can you stimulate an open mind, and prevent quick-solution-thinking from happening and make sure that they are still open to every possibility?

2.3.4. Making sense of all the information

The third step in the Investigate phase is to make sense of all the information. When the Guiding Questions have been addressed, and the results of the Guiding Activities and Resources have been documented, students can analyse the collected data and

Practical Example - Guiding Questions

Challenge: Reducing the greenhouse gas emissions produced by the regional bus company.
Guiding Questions:

- Why do people use buses in the region?
- How many people use buses daily in my region?
- What type of buses does the company use?
  - How much greenhouse gas do the buses produce?
- Why do people choose to use buses instead of other means of transportation?
- What actions has the regional bus company already taken to reduce the greenhouse gas emissions of its buses?
- Are any subsidies available to improve the company's bus fleet?
- What is the current bus fleet management of the company?
  - How does the current fleet management contribute to greenhouse gas emissions?

It is important to notice that the guiding questions are formulated in a way that does not lead to any solution yet. In other words, guiding questions should help (group of) students to explore the different aspects of their Challenge so that, in a later phase, they are still open to different solutions.

identify themes (Nichols et al., 2016). The (teams of) student come together to analyse the information gathered in relation to their Challenge. They share their findings with the teacher and possibly stakeholders to receive feedback

The investigation phase concludes with the production of a synthesis handout (e.g., report, presentation, video). The information gathered will set the foundation for the Solution and learners can move to the final phase of their CBL approach, the Act phase.

Practical Example - Guiding Questions and related Guiding Activities, Guiding Resources, and Plan:

Question: Why do people use buses in the region? Why do people choose to use buses instead of other means of transportation?

Guiding Activities	Guiding Resources	Plan (time/when)
Interviews of commuters about their use of local buses	Workshop about conducting interviews	4 hours, week 1
Questionnaire for the regional population about the use of local buses		2 hours, week 2

Question: How many people use buses daily in my region?

Guiding Activities	Guiding Resources	Plan (time/when)
Interviews of the bus company representatives	Collecting data from Google Maps or the company's database	3 hours, week 3

Question: How much greenhouse gas do the buses produce?

Guiding Activities	Guiding Resources	Plan (time/when)
Calculation of greenhouse gas emissions of the company's buses	Textbooks Online journals and periodicals	2 hours, week 3

Question: For what purpose do people use buses in the region? Why do people choose to use buses instead of other means of transportation?

Guiding Activities	Guiding Resources	Plan (time/when)
Interviews to commuters about the use of local buses	Workshop about conducting interviews	4 hours, week 1
Questionnaire for the regional population about the use of local buses		2 hours, week 2

Question: How many people use buses daily in my region?

Guiding Activities	Guiding Resources	Plan (time/when)
Interviews to the bus company	Collecting data from Google Maps or the company's database	3 hours, week 3

Question: How much greenhouse gas do the buses produce?

Guiding Activities	Guiding Resources	Plan (time/when)
Calculation of greenhouse gas emissions of the company's buses	Textbooks Online journals and periodicals Local experts Lectures	2 hours, week 3

Question: What actions has the regional bus company already taken to reduce the greenhouse gas emissions of its buses? What is the current bus fleet management of the company? How does the current fleet management contribute to greenhouse gas emissions?

Guiding Activities	Guiding Resources	Plan (time/when)
Research on technology that can reduce greenhouse gas emissions	Local experts Workshops	2 hours, week 5
Interviews of the bus company representatives		

Continue >

Practical Example - Guiding Questions and related Guiding Activities, Guiding Resources, and Plan:

Question: Are any subsidies available to improve the company's bus fleet?

Guiding Activities	Guiding Resources	Plan (time/when)
Research on regional or national policies on greenhouse gas emission reduction	Scientific or governmental websites	2 hours, ?
Expert interviews	Regional and national policies	4 hours, week 8
Seminars	Lectures	Tbd

Practical Example - Possible results of the analysis

Analysis 1: the regional bus company has a mixed bus fleet. Only a small number of buses use low-polluting engines. Most of the buses are old, therefore, their greenhouse emissions are high. Moreover, the company does not make educated choices when buying new buses and does not appear to be up to date on new available technologies. The biggest proportion of passengers are workers or student commuters. They use the bus instead of other means of transportation because of the cheaper price and the higher coverage of bus-routes. Around 10% of the commuters use buses even for short distances. The majority of people do not think about the impact their transportation habits have on greenhouse gas emissions.

Analysis 2: the management of the fleet is quite outdated. For example, it has been identified that buses sometimes travel half empty, and also that their maintenance is limited. The company does not use any technology (e.g., software) that might help it to improve its management. The majority of management processes are still human-managed, which leads to many mistakes and, in turn, to unnecessarily high greenhouse gas emissions. In addition, the company does not know that some technologies might improve their fleet management and their possible advantages. Finally, a series of national and European subsidies are available for companies that reduce their greenhouse gas emissions. However, the regional bus company does not have personnel with skills (and time) necessary to apply for them.

Phase 3: Act

2.3.5. Overview of Phase 3

The Act phase is the moment where students explore different possible Solutions to the Challenge, choose one to prototype and, when possible, implement it in a real context. The Solution chosen must be evidence-based and introduced to an authentic audience in order to validate the results. An evaluation will also be conducted for the product, and the learning process will be reflected upon. With its tangible component and the focus on societal impact, students should experience a renewed engagement. Finally, when working on the prototype of the Solution, the three steps of the Act phase (i.e., come up with a solution, implement it, and evaluate it) follow a recursive cycle of development, implementation and evaluation that can bring the students back to previous CBL phases or steps.

Clarification

The Act phase is very discipline-specific, and it can be based on different design models. Moreover, during this phase, it is probable that additional questions will arise, bringing the need for additional research. Finally, due to time constraints, students might not be able to implement the Solution and instead finish with a prototype product.

2.3.6. Explore multiple Solutions

With the information retrieved from the analysis, the students can start defining Solutions for their Challenge. This solution finding is done collaboratively (e.g., within the team, with stakeholders, with peers, with experts, etc.) based on findings from the previous Investigation phase. Multiple Solutions can be initially proposed, then students need to select one to develop (Apple, 2010, p. 13). The chosen Solution must be thoughtful, concrete, clearly stated and achievable in its (possible) implementation.

Think about the following prompting questions:

- To guide the thinking of students, you can present a design cycle model. This design model will help the Solution creation process via prototyping, testing, and refining. What type of design cycle model best fits your field/course?
- How far can you go with the implementation in your course? Does the topic/field allow for a real implementation in the timeframe of a course? What are the limitations?
- How can you support/guide students in evaluating whether the solution can be implemented in the timeframe they have?
- When do the students have all the information needed to make an educated choice? How can you guide the students in selecting a single solution?

2.3.7. Implementing the Solution

The Implementation step can entail recursive cycles of prototyping and evaluation, especially if students are not always able to develop and implement a final product. In some cases, the Solution is the actual implementation of a product or action, in others it could be a piece of advice or an answer to a question. In the latter case, implementation is then equivalent to handing over the findings to the stakeholders and receiving feedback on the content as well as usability. Regardless of the format of the Solution, it is important that the students are aware that it will have an impact on the Challenge, and they should present a first step towards a Solution that is of value to the stakeholders.

Think about the following prompting questions:

- What type of Solutions are feasible in your course/field? How can you make sure that students see how they can make an impact in the real world?
- What is the role of the stakeholders in this phase? Are they involved throughout the process (e.g., to give feedback and suggest adjustments) or only when the Solution is finished?

2.3.8. Sharing and learning through Evaluation and Reflection

The final step is to share and learn through Evaluation of learning and Reflection by the students. There are two types of evaluation strategies: formative and summative[13]. We will focus here on summative evaluation, but we encourage you to also think about how you want to implement formative evaluation throughout the CBL process.

Once the chosen Solution is implemented, both the knowledge acquisition process and the Solution itself must be evaluated. Moreover, the Solution should always be shared with the stakeholders, from whom students will receive feedback. Students can reflect on the outcomes, evaluating their successes as well as their failures (Nichols et al., 2016). They can determine the impact of the Solution in relation to the Challenge. This also means that students should think about how to evaluate their Solution beforehand. That is, when they are planning and working on the Solution, they should already consider how they want to Evaluate it. For example, they can ask themselves "How are we going to know if the Solution has had the impact/effect we desire?" and "Is this type of Evaluation feasible in the timeframe available?".

In addition, a Reflection on the personal learning process should be conducted. A major part of deep learning takes place when

Practical Example - Possible Solutions

Analysis 1: the regional bus company has a mixed bus fleet. Only a small number of buses use low-polluting engines. Most of the buses are old, therefore, their greenhouse emissions are high. Moreover, the company does not make educated choices when buying new buses and does not appear to be up to date on new available technologies. The biggest proportion of passengers are workers or student commuters. They use the bus instead of other means of transportation because of the cheaper price and the higher coverage of bus-routes. Around 10% of the commuters use buses even for short distances. The majority of people do not think about the impact their transportation habits have on greenhouse gas emissions.

Possible solutions:

- Create an advisory report for the bus company about different available technologies that could help it to reduce its greenhouse gas emissions.
- Create an online campaign (e.g., on social media) to inform people about the impact on greenhouse gas emission of different means of transportation based on the distance to be covered.
- Create a series of posters for the regional municipalities about the (direct and indirect) effects on health of different transportation habits

Analysis 2: the management of the fleet is quite outdated. For example, it has been identified that buses sometimes travel half empty, and also that their maintenance is limited. The company does not use any technology (e.g., software) that might help it to improve its management. The majority of management processes are still human-managed, which leads to many mistakes and, in turn, to unnecessarily high greenhouse gas emissions. In addition, the company does not know that some technologies might improve their fleet management and their possible advantages. Finally, a series of national and European subsidies are available for companies that reduce their greenhouse gas emissions. However, the regional bus company does not have personnel with skills (and time) necessary to apply for them.

Possible solutions:

- Create an advisory report for the bus company with possible actions they can take to improve their bus fleet management.
- Help the company implement software to improve the maintenance of their buses.
- Create a workshop for the bus company to teach them how to apply for European subsidies.

[13] If the students are working in multidisciplinary teams, the Implementation of the Solution should involve all of them. In this example, different contributions might include paying attention to the User Interface and User Experience of the software, the creation of a manual to learn how to use the software, etc.

Practical Example - Implementation of the Solution

As we mentioned before, the Implementation can take several forms. Moreover, implementing the Solution in CBL is no different to any other Implementation you might be used to (e.g., prototyping and testing might be necessary before the final Implementation).

Analysis 1:

- **Chosen Solution:** Create an advisory report for the bus company about different available technologies that could help it to reduce its greenhouse gas emissions.

Students will first research the different available technologies that the bus company can adopt to reduce its greenhouse gas emissions. Then, they will select some technologies based on predefined criteria (e.g., price, availability in the country, fit for the company/buses, etc.). After the selection, the students will create a report for the bus company, including information such as the impact that the new technology can have on greenhouse gas emissions, but also on the company's revenue, customer's satisfaction etc.

Analysis 2:

- **Chosen Solution:** Help the company implement software to improve the maintenance of their buses.

Students will customise an open-source software that the regional bus company can use to improve the maintenance of their buses. To do this, they will first need to understand the company's needs and processes. Moreover, they will implement features by collaborating with (and getting feedback from) the company itself. The software will repeatedly be tested before being handed over to the bus company[14].

Practical Example - Evaluation and Reflection

Evaluation:

Possible aspects that can be evaluated are:

- Did anything change?
- Did it change as expected?
- How did the stakeholders react to the Solution?
- Did the Solution have the desired effect?
  - Why yes/no?
- Did the Solution impact stakeholders' lives?
  - If it had an impact: What type of impact did it have? How did it affect their lives?
  - If it did not have an impact: Why not? What happened?
- How did the groupwork go?

Reflection:

Possible aspects that can be reflected upon are:

- What did I expect when working on the Challenge in a team with stakeholders?
- What were the main challenges for me?
- What did I learn that I can use in my future life/career?
- Did I reach the Learning Objectives of the course?
  - What helped/hindered me in (not) reaching them?
- What was my contribution to the team?
- What were my main insights?

one reflects on their own learning process, on the relationships between previous knowledge and new meanings and on the integration of different perspectives (Gordijn et al., 2018). Through personal reflection, students become (more) aware of what they personally gained during the CBL learning experience, for example, new insights, soft skills, a change in their mindset.

Best practice

The Evaluation of the outcome itself can be planned together with the students (this should already be included in the design of the Solution).

Think about the following prompting questions:

- Will you evaluate the Solution together with the students? How will you do that? What is the role of the stakeholders?
- The Evaluation can include qualitative and quantitative methods. How do students choose which evaluation tools they will need? How can you support them in the choice? Consider support you will give according to the time available.

2.4. Document, Share and Reflect

Interwoven with the three phases as well as the nine steps, there is a constant process of documenting, reflecting, and sharing.

[14] See: https://cft.vanderbilt.edu/student-assessment-in-teaching-and-learning/

These processes inform each other and take place at different, but interconnected, levels: individual, group, class and world level (Figure 6).

Within the CBL approach, every student is stimulated to Document the learning experiences that occur (regarding themselves, the topic, the Challenge, etc.) as well as the collected material, throughout all three CBL phases. This process of documenting can be done using a variety of tools, such as video and audio journals, work plans, concept maps, written or oral reports. Moreover, if you have time and resources, such documentations should also include, and facilitate, frequent reflections where learners (individually and collectively) step back and consider (and monitor) their experience and process. If this reflection is done regularly, the depth of the final Reflection will greatly benefit from it, as well as the students making gains in terms of personal and professional development.

At the end of the project, all the documents of every step of the CBL process, together with the Solution and Reflection outcomes, should be shared with a local and a global audience via open-source platforms (Apple, 2010). Communicating their information with 'the world' increases students' motivation and effort as it raises the stakes (Loohuis & Bosch-Chapel, 2021). This means that students are encouraged to share their failures, as well as their successes. In this way future learners' experience and decision-making will be supported (Nichols et al., 2016).

This documenting and sharing process, which should be done collectively in the group, (also) has the goal of assuring that all the team members are on the same page. That is, ideas and processes are synchronised to make them visible to everybody involved. Finally, it also helps to assure that what is done is still feasible and realistic.

Best practice

According to the original CBL Apple guide (Apple, 2010) students should create a learning portfolio with the resources generated during the three CBL phases (videos, documents, etc.). This learning portfolio is meant to be shared online for those universities interested in replicating, or further developing, the same Challenge in their courses..

Think about the following prompting questions:

- What levels of Document, Share, and Reflect (Figure 6) can you/do you want to include in your course? How can you organise and facilitate them?
- How can you organise and facilitate the Documenting process? Will students choose the means to do it (e.g.,

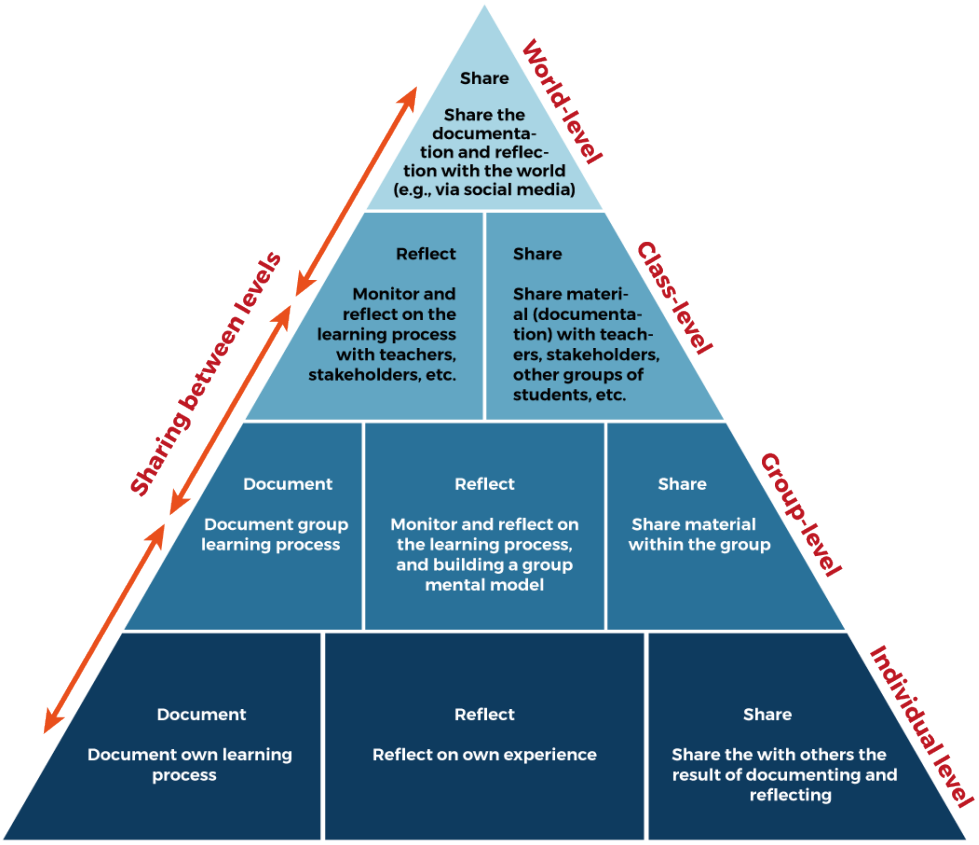

Figure 5 *Levels of the documenting, reflecting, and sharing process and their interconnections*

videos, report, notes, etc.) or will you give guidelines?
- How often will students be required to Reflect (e.g., once a week, once a month, at the end of the course)? What Reflection model best applies to your context? What is the Reflection skill level of your students? How can you facilitate them in their Reflection?
- When will students share their findings with the rest of the class? And with the stakeholders? (e.g., at the end of every phase or only at the end of the Act phase?). Will students be required to share at the World-level?

2.5. Next step

Now that you understood how the CBL process unfolds, you might be wondering if this is the right approach for your context. The next chapter will give you some elements to think about.

IS CBL THE WAY TO GO FOR YOU?

3.1. Asking why

You might be asking yourself if a CBL approach is the right one for your educational context. Even though literature claims that CBL can be used for many curricular contents (Observatory of Educational Innovation, 2015), we are aware that there is no one-size-fits-all approach in higher education.

The right teaching approach is the one that is the most appropriate for "student learning, the topic or subject taught, the characteristics of the content, the context and the teacher who implements it" (Observatory of Educational Innovation, 2015, p. 29). In brief, the only person that can know if you should implement CBL is you as a teacher, knowing the topic, the learning goals and the student population. There are no rules that can tell you exactly how to implement CBL successfully, but below you can find some questions that can help you make this decision.
Even if it sounds obvious, the first question that you need to ask yourself is "Why?". That is, why do you want to change your course? Is it because you need or want to? For example, your current course implementation is outdated or is not the best one to reach the intended learning outcomes. Or are you changing it because you must? For example, you need to follow organisational or national guidelines. For students, but also for teachers, motivation is the most important element when approaching something new.

The second question you might want to ask yourself is "What do I want to achieve?". By now, you should have an idea of what the main features of CBL are and what you can achieve with CBL, especially in contrast to other educational approaches.
If you have an answer to these questions, then you can start investigating if a CBL approach can be a good fit for you in more detail. To do that, we advise you to look into three categories:

- personal characteristics as a teacher,
- the context,
- and the subject.

3.2. Teacher Characteristics

The teacher's mindset.

- **Do you want to have everything under control? Do you want your student to only learn in the classroom? Do you want to be the only one making decisions?** CBL is a pedagogical approach where a teacher lets control over the learning of the students go and gives a lot of freedom to the students (e.g., lets them choose their own Intended Learning Outcomes and/or Challenge, define the direction of the learning, learn in class and in the real world, etc.).
- **Do you like the idea of co-learning with your students?** Students might choose a Challenge that could be outside your area of expertise. This would mean that you could find yourself in an unfamiliar environment alongside your students. Then, you might need to join the students' learning journey in their exploration of the Challenge (Membrillo-Hernández et al., 2021; Pepin & Kock, 2021).
- **Are you ready to manage frustrations and uncertainties?** When working on a Challenge, students might feel lost and frustrated, find themselves floating, or even find unwanted results (Observatory of Educational Innovation, 2015). In a CBL educational environment, you are a coach and not there to give answers but to help students learn from their experience, not the results. You would have to allow students to make mistakes and failures, help them to deal with and make the most out of them and manage possible frustrations (Observatory of Educational Innovation, 2015).

The teacher's phase of professional development

- **Are you a novice or an expert teacher?** Experienced teachers might be more prepared to handle CBL since they usually have more developed teaching skills (e.g., they focus more on learning rather than teaching (Kugel, 1993; Robertson, 1999). Nonetheless, we recognise that novice teachers might be more open to the innovative teaching methods common to CBL. Regardless of one's experience, changing your own perspectives and transforming your approach to teaching is challenging. In particular, teachers are put into a "neutral zone" characterised by a feeling of disorientation and an urge for experimentation (Robertson, 1999). In such a zone, teachers need a new reference point that they can integrate into their values and worldview. A good

point of conjunction could be for novice and experienced teachers to combine their forces and work together in shaping a CBL experience for students. As put by Kugel (1993), every teacher's path to development is different, so it is up to you to decide whether (partially) switching to CBL is the right path for you.

3.3. Context Characteristics

What is the innovation climate in your institution? Could you obtain sufficient support to make a transition to CBL? Switching to CBL is a demanding endeavour. In order for this transition to be less exhausting for teachers, adequate organisational support is needed (Observatory of Educational Innovation, 2015). For instance, it is important to consider contextual characteristics such as the culture around innovation and teachers' professional development, the presence of professional learning communities, supportive management, teacher collaboration, availability of resources and time, etc. (Gaikhorst et al., 2019; Sleegers & Leithwood, 2010).

How many students are in your course? Even though there are formally no limits to how many students a CBL course can handle, there are some characteristics that you need to be aware of. If you (plan to) present students with several different Big Ideas and connect them to multiple stakeholders (e.g., companies), then equally distributing them might become difficult if you have many (groups of) students. In addition, supporting students in going through the three phases of CBL requires sufficient support and attention. Will you able to provide this support? Ideally, each learning group would have a coach who can invest time in being part of the group. If you want to have such coaches (e.g., student assistants) how will you be able to involve and support them in your course? Finally, even if it is not a binding condition, it might be worth considering the type of assessment you want to apply. For example, if you are planning to have end-of-the-year group presentations (maybe even with the presence of the stakeholders) having several (groups of) students might make a large group of students unfeasible.

What are your students like? Adapting to CBL is not only demanding of teachers, it can also be challenging for students. For instance, in the first few steps, CBL might cause a lot of confusion and even de-motivate students if they are accustomed to a more passive way of education (Gallagher & Savage, 2020; Membrillo-Hernández et al., 2021) or to the presence of a hierarchy (Gallagher & Savage, 2020). You should be aware that when this confusion is addressed with the proper amount of support (e.g., a clear organisation of a CBL experience, open communication regarding CBL features), students can easily overcome it (Observatory of Educational Innovation, 2015).

How flexible is your course or programme? The structure and content of the programme and courses should be loose enough to allow a CBL approach where students largely define their own learning process. The same goes for assessment. If there are strict requirements for intended learning outcomes for a course in a programme, CBL might not be the optimal choice as teaching method. To go over all nine steps in sufficient depth takes quite some time, probably at least 4 ECs, thus the study load is also a contextual criterion.

3.4. Subject Characteristics

What is the subject that you need to teach? Is your subject more theory or practice oriented? Is there space for flexible learning outcomes? The nature and characteristics of the subject you need to teach are essential when defining your educational approach. In CBL, learning activities are designed to give students full responsibility for their own learning (Observatory of Educational Innovation, 2015). This responsibility means that they have to identify, acquire, and use the knowledge they independently define as relevant to their Challenge (Pepin & Kock, 2021). The definition of the learning paths is up to the students, where you as teacher can coach them in order to achieve the intended learning outcomes. However, if students need to learn something specific, you need to carefully structure the CBL experience in a way that will guide students towards the required topics.

Again, there is no pre-defined set of CBL rules or guidelines on how CBL should be implemented and how to determine if it is the right approach for you. However, we hope that this chapter supports you in reflecting on the goals and methods of your teaching and helps you decide if you want to give CBL a try.

3.5. Final Questions

Finally, if you decided that CBL is what you need (or someone else decided for you) there are two final questions that could help implementing CBL in your course: "When?" and "How?".

Ask yourself: When do you want to implement CBL? This can be immediately, or next academic year. Maybe when you feel ready. The answer to this question will also influence how you want to introduce CBL. More specifically, in a first iteration of your new CBL-based course, you can decide to implement only some CBL elements (especially if you do not have much time available). If you decide to start slowly, you might want to ask yourself which elements you want to start with. There might be elements in your course that are already CBL-like and that would require only small adaptations. You might decide to start from those elements or, on the contrary, from something bigger that requires a more substantial change. This gradual implementation of CBL can offer the possibility of experimenting first, and it might feel less frightening. Moreover, taking the student along this experimental journey is as important as the experimentation itself. Students can help you with feedback on which elements work for them and which do not.

Finally, remember that, for CBL to be effective, it is important that you first understand the rationale behind it. Therefore, implementing some of its elements is not sufficient if you do not back them up with the right mindset.

3.6. Looking Ahead

With Part A of this handbook, we have offered an overview of the CBL landscape. What is CBL about from the learning and Challenge perspective as discussed in Chapter 1. In Chapter 2, the process in the Engage, Investigate and Act phases were explored in more detail. Based on this first overview, reflections can be made about whether CBL is worth researching further for implementation. In Chapter 3 questions are posed to consider when making the step to implement CBL. In Part B of this handbook (in development) we will focus on the different roles in CBL addressing how you prepare to act as teacher, coach, student, or stakeholder in CBL. Assessment and designing a CBL course are topics that will also be discussed in more detail.

As already stated, CBL is defined and applied in many different ways in higher education (and within the same institution). This aspect of CBL should not discourage you. On the contrary, as there is no single optimal educational approach, the different viewpoints on CBL will hopefully prompt you to discover what best fits your context. We hope that this handbook has helped you in (better) understanding CBL, and that it will fuel your creative process in (re)designing your own CBL-based course.

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