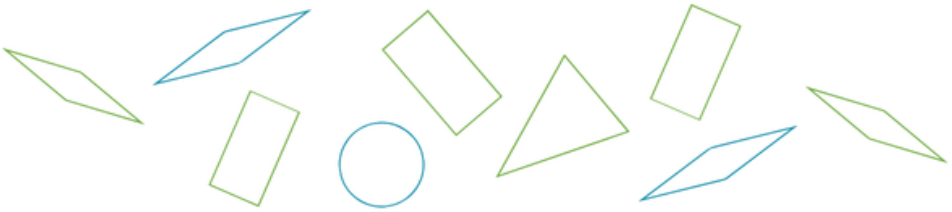

A Challenge-Based Learning approach to the Impacts and Sustainability of Digital Education

Erasmus+ KA2 C-FLEX Result 4

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Section 1: Creating a Challenge-Based Learning summer school

Summary

A guidebook with step-by-step instructions for creating a Challenge-Based Learning course, like a Summer School. It is based on a pilot activity conducted during the Project.

Introduction

This guidebook is a step-by-step manual for creating a Challenge-Based Learning (CBL - to learn more see Result 3) intensive course, such as a summer school, on the topic of the sustainability of digital education technologies and their infrastructure. Inside, you'll find everything you need to replicate, adapt, or even fully customize the program we developed in our project.

At its heart, C-FLEX emphasizes creating a diverse, multi-disciplinary, learner-centred environment where participants tackle real-world challenges collaboratively, combining hands-on learning with critical thinking and innovation. Guided by these principles, the program incorporates tools, methodologies, and practices that are as versatile as the teams using them.

This guide reflects our experience coordinating two summer schools designed around these principles by developing a structured yet open-ended approach to designing educational experiences.

From ideas, attentions, and designing tips to essential materials, each chapter walks you through to tailor the experience to your unique goals and strengths of your team. You can take each material as-is or give it a personal twist to better match your learning goals and staff competences (their knowledge, skills, and dispositions).

Each chapter provides not only the practical materials and templates we used but also tips, lessons learned, and considerations to help you customize the program to your needs. Whether you're looking for a detailed recipe to replicate the experience or take inspiration to design a similar experience, this guide will equip you to create impactful learning opportunities tailored to your goals and resources.

Chapter 1: Design principles

1.1 Guiding Idea:

In C-FLEX, we organised two summer schools: one in 2023 and one in 2024. The heart of the 2023 pilot was to let students discover, explore, and understand the often-invisible infrastructure that underpins the transition to digital education — an infrastructure shaped by strategic decisions that ripple through society, especially in terms of sustainability, with far-reaching impacts.

Following the success of the first pilot, we did a second C-FLEX Summer School in Eindhoven in 2024. The 2024 edition was built on the same basic principles of the 2023. What made the two experiences different is that, while the 2023 pilot was a two-weeks programme and saw the participation of external stakeholders in the C-FLEX network as challenge providers, the 2024 pilot tried to directly apply the lessons learned in C-FLEX to the educational space directly, seeing the involvement of an external teacher as a challenge provider. As most of the project's effort went in the development of the 2023 pilot, when we generally refer to "the summer school", we refer to the 2023 pilot. In both summer schools, the focus was on exploring the **sustainability of digital education technologies and infrastructure**, encouraging students to analyze it through the four key project dimensions (see also Result 1):

- **Technological:** What makes digital tools functional and maintainable over time?
- **Social, ethical, and legal:** How do we ensure fairness, accountability, and respect for individual rights in digital education?
- **Environmental:** What are the environmental costs and benefits?
- **Pedagogical:** How do our teaching choices impact the learning experience?

Because of this, the summer school designed all its activities to encourage students to explore topics through these four lenses. Even the traditional teaching methods were aligned with at least one of these dimensions and should be clear which lens(es) is being used. This helps students to focus their exploration, understand the different perspectives, and build competences for analyzing diverse subjects through each of these critical areas.

1.2 Learning objectives/Philosophy:

The C-FLEX Summer School is built on the principle that each **experience is authentic**, shaped by real relationships, in a context-rich environment, designed to foster exploration, where learning occurs through dynamic interactions and shared experiences. To create this context, we promote a collaborative environment, without strict hierarchies or divisions between students and staff. This doesn't imply that teachers should act as friends but rather that they should join students on an open journey, and everyone is engaged. In such a context, no one can predict where the CBL experience will exactly lead, but everyone should be committed to the collective exploration and discovery along the way.

This journey involves a shift away from traditional top-down teaching: it promotes a culture of **mutual learning**, where each participant, including educators, learns and gains insights through the exchange of ideas. Every perspective holds value, and each voice is respected, resulting in a collaborative atmosphere in which all participants feel safe to explore, question, and participate.

***Practical suggestion**:*

Establish a safe environment with clear dialogue guidelines. Set up ground rules that encourage respectful communication. Focus on empathy and constructive feedback to make participants feel comfortable sharing ideas without fear of being judged. Make it clear that discussions should be about ideas, not people. This way, different voices can coexist in a place where respect and freedom encourage useful and inclusive conversations. This groundwork creates an atmosphere where participants feel encouraged to engage deeply.

Creating a **safe, inclusive environment** is a top priority throughout the program, regardless of whether the activities are physically demanding or socially challenging. However, they are carefully cultivated: when needed, staff reinforce the guidelines to maintain balance and to prevent the environment from becoming chaotic or overly focused on achieving unanimity. In this way, the freedom to express does not become a source of friction or deter participants when differences arise. Instead, it promotes healthy, constructive exchanges and a genuine sense of belonging.

An additional pillar of the program is a commitment to **flexibility** and **comfort with ambiguity**. The summer school schedule is designed as a loose framework, and students are not provided with detailed schedules in advance. Instead, they receive a summary that emphasizes the adaptable nature of the program. This approach encourages everyone to let go of rigid expectations, accepting the program's flow without feeling pressured by a tightly controlled timeline. Everyone is invited to participate in the activities but is free to do so or not based on their comfort level. At the

same time, they are strongly encouraged to **voice any concerns or doubts**, and the **agenda should adapt flexibly** to the group's evolving needs.

It is fundamental that students are on board with this vision from the outset. As we will discuss later, we particularly recommend that, during a presentation moment defined on the first day of activity, the staff should introduce the main concepts and clear guidelines to help establish a foundation of respect and collaboration, reminding participants that their voices are valued and consensus-building is essential.

***Practical suggestion**:*

Incorporate reflective practices. Hold regular reflection sessions, allowing participants to process and reflect on their experiences. Activities like journaling, group reflections, or peer feedback can help build self-awareness and support shared growth. Reflection sessions can turn each experience into a meaningful takeaway, strengthening the program's learning objectives.

When it comes to **technology**, the C-FLEX teaching method is intentionally **minimalistic**. Rather than relying on digital devices, the program encourages a return to basic tools such as paper, pencils, colors, and physical diaries for note-taking. This approach emphasizes the idea that profound learning can happen with simple tools and techniques, without the need for technology. This approach also immerses students in the types of real-world challenges found in remote or **resource-constrained educational settings**, where access to the internet or computers is limited or unavailable.

***Practical suggestion**:*

Encourage active listening. Foster a culture where participants are not only sharing ideas but also deeply listening to each other. Activities like structured listening exercises can cultivate genuine engagement, turning discussions into opportunities for meaningful exchanges. When group activities are performed, we always recommend to break them down in two phases: in the first phases, participants work on the activity individually; in the second phase, they aggregate individual perspectives at a group level.

Finally, **social activities** play a vital role in the program, connecting participants beyond the academic setting and building a true sense of community. These moments reveal each individual's distinct personality, experiences, and strengths, allowing everyone to become active participants in the group dynamic. This approach applies to both students and staff, bridging any gaps and allowing teachers and participants to connect on a human level. The chance to interact socially enables participants to understand and appreciate each other's real abilities and interests, moving beyond mere roles or idealized expectations. Social activities, though straightforward, hold profound potential in joining participants and strengthening the authenticity of their learning journey together.

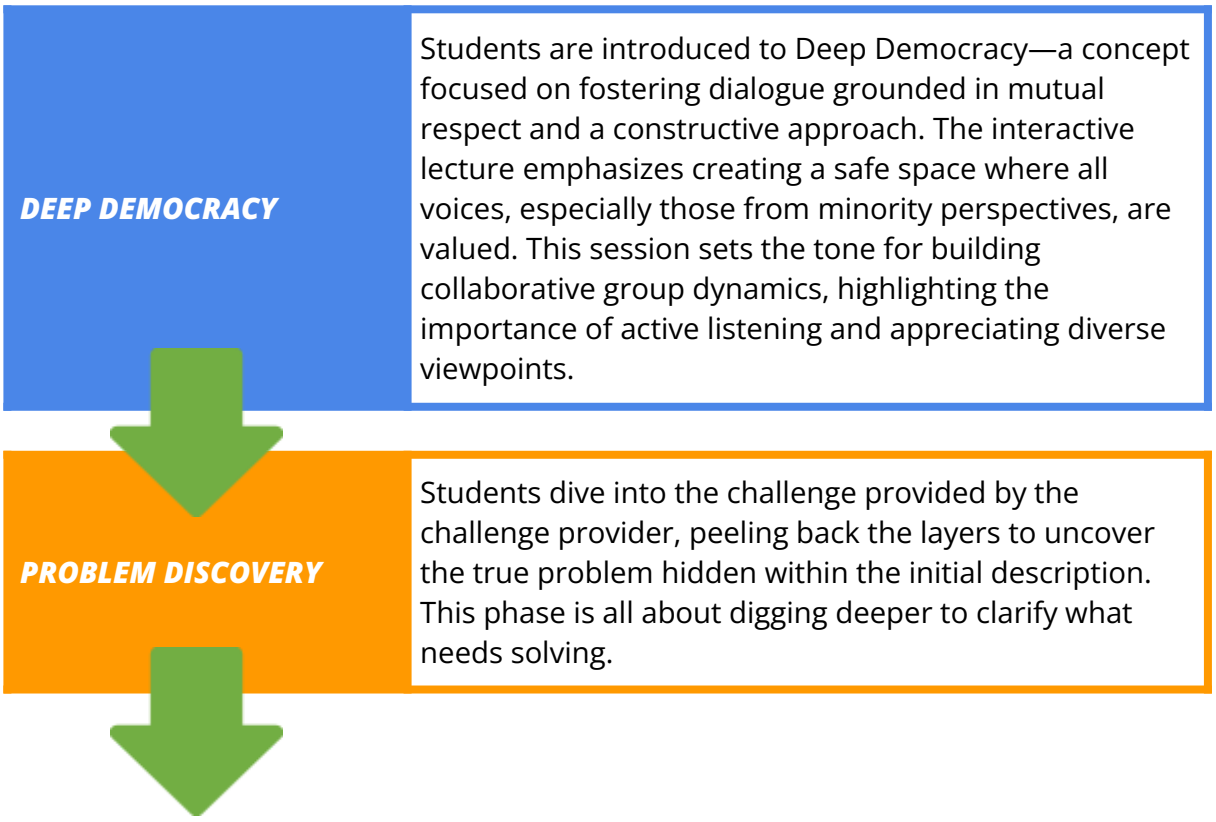
1.3 Framework

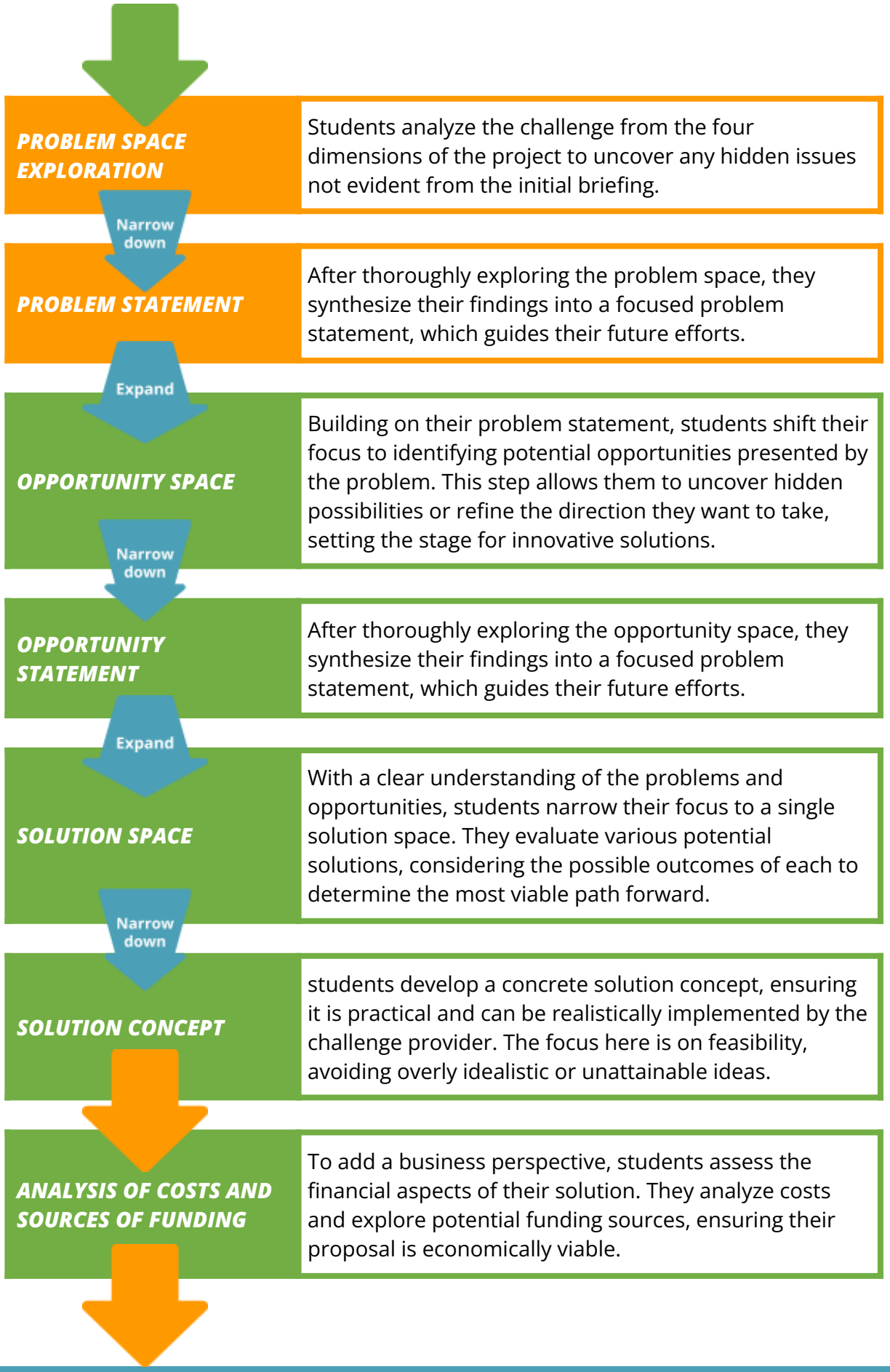
The C-FLEX framework, which is based on CBL, is organized into two main phases:

1. **Problem space identification and exploration**, in which students immerse themselves in understanding the problem from multiple perspectives, resulting in a shared understanding of the subject. This phase culminates in the creation of a problem statement and an opportunity statement, which together provide a structured outline of the challenges and opportunities ahead.

2. **Solution space definition and exploration** redirects students' attention to brainstorming and refining potential solutions, engaging in hands-on, iterative activities, and developing and evaluating solutions creatively while maintaining a critical mindset. As they refine their ideas, they also begin constructing narratives to effectively communicate their proposed solutions.

Throughout both phases, students must repeatedly broaden and then narrow their ideas, which mirrors real-world problem solving. This iterative approach is key to developing a comprehensive view of the problem and identifying viable solutions. The following figure illustrates the full C-FLEX process.




PROBLEM SPACE EXPLORATION
Students analyze the challenge from the four dimensions of the project to uncover any hidden issues not evident from the initial briefing.
Narrow down
PROBLEM STATEMENT
After thoroughly exploring the problem space, they synthesize their findings into a focused problem statement, which guides their future efforts.
Expand
OPPORTUNITY SPACE
Building on their problem statement, students shift their focus to identifying potential opportunities presented by the problem. This step allows them to uncover hidden possibilities or refine the direction they want to take, setting the stage for innovative solutions.
Narrow down
OPPORTUNITY STATEMENT
After thoroughly exploring the opportunity space, they synthesize their findings into a focused problem statement, which guides their future efforts.
Expand
SOLUTION SPACE
With a clear understanding of the problems and opportunities, students narrow their focus to a single solution space. They evaluate various potential solutions, considering the possible outcomes of each to determine the most viable path forward.
Narrow down
SOLUTION CONCEPT
students develop a concrete solution concept, ensuring it is practical and can be realistically implemented by the challenge provider. The focus here is on feasibility, avoiding overly idealistic or unattainable ideas.
ANALYSIS OF COSTS AND SOURCES OF FUNDING
To add a business perspective, students assess the financial aspects of their solution. They analyze costs and explore potential funding sources, ensuring their proposal is economically viable.

BUILDING THE STORYTELLING AND DEMO	students craft a compelling narrative to present their solution. They create an engaging demo and presentation tailored to the challenge provider, ensuring their work is both clear and persuasive.
FINAL DELIVERY	The process concludes with a report covering every stage of the project. This final deliverable is presented to the challenge provider, showcasing the journey from problem discovery to the proposed solution.

1.4 Types of activities

To provide a dynamic and effective learning experience, the program included a **variety of activities** that easily transitioned between teaching and non-teaching levels. This balanced approach proved vital for reducing cognitive load, improving social connection, raising motivation, and encouraging critical thinking on the challenges through different methodologies.

Group Work Activity	These consisted of group activities, analytical sessions, and checkpoints.
Teaching Activity	A combination of 3 main types of teaching activities: 1. **Self-discovery:** Interactive sessions focused on developing soft skills, enabling learners to reflect on their strengths and understand how they can contribute effectively to solving the challenge. 2. **Vertical nuggets:** Lecture/workshop-style content aimed at deepening students' subject-specific knowledge and providing the theoretical foundation needed to tackle complex problems. 3. **Challenge exploration:** Mentoring-based, hands-on sessions where students collaborate to explore and address their challenge, applying what they've learned in a practical and creative context.

Social Activity	Organized Experiences: The program featured a variety of structured social activities designed to foster connection and provide memorable cultural and recreational experiences. Free Time: To balance the structured activities, students were given designated periods of free time, typically in the early evenings or some afternoons, allowing them to unwind, explore independently, or simply relax at their own pace.

The strategic mix and balance of activities are critical to the program's success. By mixing the types of activities—teaching, group work, and social experiences—the program avoids overwhelming students with monotony or an overemphasis on a single approach. This dynamic structure helps to keep the learning process interesting and engaging for all participants, rather than feeling like an intensive work environment.

Maintaining a positive mood is also critical. The program fosters a feeling of passion and well-being among students by stressing encouragement, teamwork, and a friendly atmosphere, so increasing both their motivation and their ability to confront challenges effectively.

Another important feature of the program's design is to encourage student autonomy. Participants may pick whatever activities they wished to participate in; they did not have to attend every session. This approach shows respect for their individuality and maturity, allowing students to take control of their learning journey. By allowing students to choose their own activities, the program fosters real interest and engagement, enhancing their feeling of agency and responsibility in shaping their experience.

1.5 Delivery

A successful summer school program is built not only on its structure and activities, but also on the effective delivery of its core outcomes. These deliverables enable students to show what they have learned while allowing them to align their work with their team. Below are the key deliverables students are expected to complete by the end of the program:

Solution Pitch + Demo

The main purpose of this deliverable is for students to clearly communicate the problem they identified and the innovative solution they developed. This task emphasizes not only the technical and creative aspects of their solution but also the importance of clear, effective communication.

- **The Pitch:** Students pitch their idea in front of a jury of external judges. This is an opportunity to showcase their problem-solving process and the value of their proposed solution.
- **The Demo:** In addition to the pitch, teams must present a demo or proof-of-concept to demonstrate the feasibility of their solution, helping to visualize how it would work in practice.

***Constructive Feedback**:*

The comments offered by the judges are crucial to the students' growth. It is important to understand that this is not a moment for harsh criticism, but rather for constructive input. Jury members should focus on providing feedback that helps students improve their work, recognizing the effort and creativity behind it. By offering feedback in a supportive manner, the jury fosters an environment of growth and respect, which is a cornerstone of the summer school experience. Critique should be framed in ways that promote understanding and debate, making students feel respected and valued throughout the process.

Case study reflection

The Case Study Reflection allows students to build on their initial presentation and provides an opportunity for more in-depth analysis after summer school ends. This deliverable serves as a retrospective exercise where students revisit and refine the key concepts and strategies they explored during the program, synthesizing their learning and taking ownership of the experience, ensuring they leave with a deeper understanding of both their work and the broader implications of their solutions.

- **Content:** In this reflection, students are expected to review their entire journey, revisiting the problems they tackled, the solutions they proposed, and the methods they used. The reflection should capture the progression of their work, from initial ideas to final deliverables, and provide a comprehensive summary in a single document.
- **Future Directions:** Students must also speculate on the future directions of their work, exploring how their solution could evolve or be applied in different contexts. This part of the deliverable encourages forward-thinking and helps students see the long-term potential of their ideas.
- **Personal Review:** As part of the reflection, students should write a personal review of their experience during the summer school. This offers an opportunity for introspection, allowing students to evaluate their growth, the challenges they faced, and the lessons they learned.

These deliverables are designed to ensure that students are not only able to showcase their work at the end of the summer school but also have the chance to reflect and improve upon it after the program ends.

Chapter 2: Implementation

In this chapter, we detail the process of designing and delivering the C-FLEX summer school, offering a comprehensive overview of the key decisions, strategies, and methodologies that guided the development of the program. We walk you through the step-by-step approach used to create an engaging, impactful, and well-structured learning experience for participants. Whether you aim to replicate, adapt, or innovate on this model, the following sections will equip you with the insights and practical guidance needed to implement a successful summer school tailored to your specific objectives and context.

2.1 Selection of the Students

The student selection process for the summer school program is a critical component in ensuring the diversity, quality, and overall success of the experience.

To begin, define the program's objective recruitment numbers early on. This clarifies the number of students that can be accepted and how scholarships should be distributed. The budget must be assessed to determine the amount of scholarships offered and the financial constraints on participant selection. Once these requirements are established, the selection process can proceed, with the goal of increasing participant diversity. Diversity should be viewed broadly, including aspects such as gender, academic background, geographical origin, and prior studies. Balancing these elements ensures that the group is varied and that the program incorporates a variety of perspectives and experiences.

The first step in the selection process is to pre-filter applications to verify they meet the minimum eligibility requirements. This step comprises data cleanup to standardize application forms and ensure that all responses are consistent. Any applications that are incomplete or do not satisfy the required requirements, such as students from non-consortium universities in our case, should be rejected at this point.

Once the first cleanup is complete, the selection process moves on to phase one, in which students are automatically shortlisted based on specified criteria. This includes automatically picking students from universities who have suggested fewer participation than the available scholarship seats. During this round, colleges that propose fewer candidates than their assigned spots are prioritized for filling those positions. Additional shortlisting can be done by taking into account students who are ready to pay their own participation fees or those from underrepresented backgrounds, such as specific colleges or countries in the consortium.

Round two includes a more in-depth examination based on other criteria such as academic background, CV quality, and motivation. Candidates from specific universities, particularly those with minority student populations, are evaluated to highlight those whose profiles exhibit strong qualifications while also reflecting the program's diversity aims. These could include students from less common study backgrounds, alternative gender expressions, or those that provide distinct viewpoints to the group dynamic. Furthermore, proposals with poor written content or insufficient motivation should be rejected at this stage. When reviewing applicants' written materials, make sure they put a lot of effort into it because this can indicate their commitment to the program.

The third stage of selection is usually a general evaluation of the top applicants. This round determines the final shortlisted students based on the overall strength of their profiles. Special care should be taken to ensure that the final cohort reflects a diverse range of academic fields, backgrounds, and motivations. If overqualified or their backgrounds don't match the program's goals, candidates may be disqualified at this level.jectives. This is the point at which certain profiles that offer value to the group, such as individuals with extremely intriguing histories or complementing abilities, can be added to the reserve list.

2.2 Pre-Course

To provide an overview of the topics addressed during the summer school, an online pre-course was conducted beforehand. This pre-course provided a foundational introduction, preparing participants for the in-depth workshops that followed. Further information regarding the pre-course's content and structure can be found in Result 2.

2.3 Places

The choice of a suitable venue for a summer school is as crucial as the learning program itself, since it will determine the participants' experience and the program's overall success.

Our two-week program was held in **two different locations**, each with its own set of goals for the week. The **first week** was dedicated to **team building** and establishing a **shared understanding** of the program's topics. This week necessitated an introspective and immersed environment in which participants could confront the challenges in a supportive and stimulating setting. A semi-remote location rich in nature, San Lorenzo in Banale (TN), proved ideal for this goal, as it provided chances for outdoor activities and even park-based learning. The **incorporation of nature** into the learning process not only gave opportunities for relaxation, but also facilitated deeper introspection and creativity. We recommend that you investigate similar locations for such phases, focusing on sites such as nature reserves, countryside lodges, or educational farms that can allow both scheduled learning and informal team interactions.

The **second week**, on the other hand, was more urban-focused, with an emphasis on **problem solving and critical evaluation**. This phase necessitated venues designed for **intense communication and ideation**. Trento's urban environment was chosen so that resources such as co-working spaces and innovation laboratories could be accessible. A biking trip, which participants could freely perform at different lengths or not perform at all, served as a refreshing interlude, but also emphasized the importance of connecting the journey with the learning experience. To keep participants engaged and to establish a sense of story continuity, try to combine similar journeys or transitions.

When creating a summer school, it is critical to evaluate the learning objectives and choose settings that support those goals. Unconventional venues, such as public gardens, outdoor amphitheaters, or local innovation hubs, might provide a welcome break from regular academic settings. These venues encourage creativity and collaboration by inspiring participants with their individuality and adaptability. Urban environments can provide access to modern amenities and numerous resources, whilst natural settings can provide peace and quiet. Furthermore, combining public and private venues, such as libraries, community centers, or maker spaces, promotes inclusivity and links to the local community. We encourage you to **think outside the box** and use different settings to boost your learning experience.

2.4 Intensive Course

The following pages, we provide a precise guide to planning and conducting a summer school program. This guide is structured to help you navigate the design process at two levels: the macro design, which outlines the overarching framework and goals for the week, and the micro design, which details individual activities and their implementation.

Week 1

Goals: Gain a deep understanding of your team's challenge, know each other, build a common background on the school's topic.
How it feels: Somewhat reflective, immersed in nature, with lots of outdoors activities.

Calendar

	Early Morning (9-11am)	Late Morning (11-13am)	Early Afternoon (14-16pm)	Late Afternoon (16-18pm)
Day 1	Arrivals			
Day 2	Welcome	Social Activity: Orienteering	Self-discovery: How to work with CBL	Self-discovery: Identifying roles
Day 3	Vertical nugget: Deep Democracy		Social Activity: Trip	
Day 4	Vertical nugget: FLOSS vs Proprietary Software	Challenge exploration: Group Work	Challenge exploration: Problem Statement	
Day 5	Challenge exploration: Worst possible outcome	Challenge exploration: Group Work	First Checkpoint: Problem Space Setting / Challenge Idea	
Day 6	Social Activity		Vertical nugget: Economic dimension of sustainability	Challenge exploration: Group Work

Day 7	Vertical nugget: Challenges for sustainable energy system	Free Time	Challenge exploration: Opportunity Statements
Day 8		Social Activity: Bike trip	

Description of the activities

ORIENTEERING

🕑 **2 hours**

Students explore and discover the area where the summer school takes place, using maps to navigate and uncover key places.

🎯 OBJECTIVES

Build teamwork and collaboration between students and teachers while learning navigation basics.

🔑 COMPETENCES

Understanding the map of the location, working together as a team to navigate.

📣 PEOPLE

An orienteering expert to teach how to read maps, plan the activity, and ensure everyone's safety.

The activity should feel exciting and adventurous, encouraging curiosity. It can be structured as a timed competition for those who like a challenge or as a relaxed treasure hunt to focus on discovery.

🐾 STEPS

1. Brief students on how to use the map and explain the activity rules.
2. Form teams to make it more collaborative (or competitive).
3. Stagger the starting times to manage pacing and allow timing for races.
4. Let the students navigate through the checkpoints, where there could be clues or challenges to solve.
5. End with a group reflection on teamwork and experiences during the activity.

📚 MATERIAL

Map of the place

Trips

A trip to an interesting place in the area to learn something new, enjoy the surroundings, and build group connections.

🎯 Objectives

Experience local culture, history, or nature while strengthening group relationships.

🔑 Competences

Observation skills, curiosity about the location, and group communication.

📣 People

Teachers to coordinate and guide, plus a local expert or guide who knows the place well.

The trip should feel engaging and relaxed. Allow students to ask questions, explore, and share observations. It's important to have backup plans for delays or changes (like bad weather).

🐾 Steps

1. Explain where the group is going and why it's interesting.
2. Travel together and ensure everyone knows the schedule.
3. Explore the destination with a guide or through planned activities.

📚 Material

Transportation, entry tickets (if needed), and any activity handouts or guidebooks.

How to work with CBL

🕓 2 hours

An interactive session to understand how the phases of Challenge-Based Learning (CBL) work.

🎯 Objectives

Help students grasp the structure and purpose of CBL.
Align expectations for upcoming activities.
Highlight the importance of problem exploration as the most critical step.

🔑 Competences

Understanding the phases of CBL, focusing on problem exploration.

📣 People

Teachers and motivators who clearly understand the CBL framework and are confident in explaining its phases, especially the focus on problem exploration.

This session is critical for setting the tone and aligning expectations. The centrality of problem exploration should be emphasized since it requires the most time and effort. Teachers must communicate this clearly to avoid misunderstandings and potential fatigue among students.

🐾 Steps

1. Introduce CBL and outline its main phases: Engage, Investigate, and Act.
2. Provide examples of real-world challenges to illustrate each phase.
3. Focus on problem exploration—explain why it's the most time-intensive and challenging step.
4. Conduct a quick group activity to practice identifying a problem.
5. Facilitate a discussion to reflect on the process and ensure understanding.

📚 Material

Slides explaining the phases of CBL, examples of challenges, and brainstorming sheets for practice.

Identifying roles

🕓 2 hours

Students figure out their strengths, preferences, and roles within a team to ensure smooth collaboration during the summer school activities.

🎯 Objectives

Help students recognize their strengths and how they contribute to a team.
Foster better collaboration and clarity in group work.

🔑 Competences

Self-awareness, effective communication, and teamwork.

📣 People

Teachers or facilitators who can guide students in reflecting on their skills and preferences.

The activity should be introspective but fun. Students should feel supported and valued, ensuring no one feels pressured or left out. If confusion arises, teachers should offer prompts or examples to help clarify roles.

🐾 Steps

1. Start with an icebreaker to make everyone comfortable.
2. Ask students to reflect on their skills, strengths, and preferred roles (e.g., leader, creative thinker, problem-solver).

📚 Material

Brainstorming material like Post-it.

Deep Democracy

🕓 **4 hours**

A frontal lesson where students and teachers engage in hypothetical scenarios to explore the principles democracy, and how these concepts apply in the world and within a team.

🎯 Objectives

Introduce the concept of Deep Democracy.
Highlight the importance of inclusivity and understanding unconscious biases in decision-making.
Explore how democracy works in larger systems and small teams.

🔑 Competences

Critical thinking, reasoning, and understanding group dynamics and inclusivity.

📣 People

Teachers who can clearly explain the concepts of conscious and unconscious democracy and lead engaging discussions about practical applications.

The session should feel thought-provoking and reflective. Teachers should use relatable examples and ensure the discussion feels open, respectful, and engaging. It's important to manage differing opinions to maintain a constructive atmosphere.

🐾 Steps

1. Begin with an explanation of democracy, focusing on its conscious and unconscious aspects.
2. Present real-world or hypothetical scenarios where democratic principles are tested (e.g., team decisions, societal dilemmas).
3. Engage students in reasoning through these scenarios, encouraging them to think critically and share their perspectives.
4. Connect the concepts to teamwork, discussing how unconscious biases can affect group decisions.
5. Wrap up with reflections on how students can apply these ideas both in the team and the larger world.

📚 Material

Slides or handouts explaining the principles of Deep Democracy, scenario prompts, and material to leave to students

FLOSS vs Proprietary Software

🕓 2 hours

Students explore the differences between open-source and proprietary concepts, focusing on their impact on the world.

🎯 Objectives

Understand the concepts of open-source and proprietary systems.

Encourage critical thinking about the advantages and trade-offs of each.

🔑 Competences

Critical thinking, basic understanding of digital tools, and decision-making.

📣 People

A teacher or expert with knowledge of open-source and proprietary platforms.

This activity should feel engaging and relatable, with real-world examples students can connect to. If concepts feel abstract, provide practical demonstrations or case studies.

🐾 Steps

1. Introduce the key differences between open-source and proprietary systems.
2. Discuss examples like software tools, education resources, or media.
3. Divide students into groups to debate the pros and cons of each approach.
4. Share group conclusions and discuss as a class.
5. Reflect on the relevance of these systems in their lives and learning.

📚 Material

Examples of open-source/proprietary tools, and discussion prompts.

Economic dimension of sustainability

🕓 2 hours

Students dive into the economic factors that impact sustainability, exploring the balance between economic growth and environmental responsibility.

🎯 Objectives

Introduce the concept of sustainable economics. Encourage students to think about trade-offs and decision-making.

🔑 Competences

Systems thinking, critical analysis, and creativity in problem-solving.

📣 People

A teacher or guest speaker with knowledge of sustainability and economics.

This activity should be thought-provoking and discussion-driven. Encourage students to share diverse perspectives while guiding them with real-world examples.

🐾 Steps

1. Start with a simple explanation of the economic dimension of sustainability.
2. Present a case study or example of a business balancing profit and sustainability.
3. Divide students into groups to brainstorm ways to address similar challenges on their work.
4. Share ideas and discuss trade-offs as a class.
5. Reflect on what they learned and how it applies to everyday life.

📚 Material

Case studies, brainstorming post-it, and slides with key concepts.

Challenges for sustainable energy system

🕓 2 hours

A frontal lesson that explores the critical challenges in creating and maintaining sustainable energy systems, addressing technological, social, and economic aspects.

🎯 Objectives

Introduce students to the concept of sustainable energy systems and their importance.
Highlight key challenges, including resource limitations, technology gaps, and social acceptance.

🔑 Competences

Awareness of energy-related environmental and social issues.

📣 People

A knowledgeable teacher or guest expert in sustainable energy systems who can explain the concepts clearly and lead thought-provoking discussions.

This session should be informative and engaging, blending theoretical concepts with real-world examples.

🐾 Steps

1. Begin by introducing the concept of sustainable energy systems, explaining their importance and providing an overview of renewable and non-renewable energy sources.
2. Outline key challenges, including resource limitations, technology gaps, economic factors, social resistance, and environmental trade-offs.
3. Present real-world examples to illustrate these challenges.
4. Engage students in a discussion by asking questions.
5. Conclude with a summary of the challenges and a reflection on the role of innovation and collaboration in addressing them, linking the topic to students' lives and future contributions.

📚 Material

Slides

Challenge exploration

🕓 4 hours

Students work in groups to delve into the challenge, identifying key aspects and contexts. The goal is to fully understand the problem space before moving toward solutions.

🎯 Objectives

Deepen understanding of the challenge by exploring its context and nuances. Encourage critical thinking and group collaboration to uncover different perspectives.

🔑 Competences

Problem analysis, collaboration, and creative thinking.

📣 People

Mentors who can guide groups, ensuring students stay on track and explore the challenge comprehensively.

The session should feel exploratory and open-ended. Encourage curiosity and creativity while guiding groups toward focus and clarity. Avoid letting discussions become too narrow.

🐾 Steps

1. Present the challenge and give students time to discuss initial thoughts.
2. Guide groups to identify key elements of the problem (e.g., stakeholders, potential barriers, or gaps in knowledge).
3. Provide prompts or tools (e.g. 5 why activity, brainstorm on postits) to encourage deeper exploration.
4. Ask groups to summarize their findings and share them with the class and all mentors to receive feedback.

📚 Material

Challenge description, brainstorming templates, and guiding questions.

Problem Statement

🕑 2 hours

Students work collaboratively to write their understanding of the challenge into a clear, concise problem statement.

🎯 Objectives

Build clarity and focus for future solutions.

Set the problem space.

🔑 Competences

Analytical thinking, clarity in communication, and teamwork.

📣 People

Mentors who can coach groups in refining their problem statements and identify when they need more clarity or focus.

This activity should feel structured but collaborative. Mentors should help students avoid overly broad or vague statements and guide them toward concise, actionable framing.

🐾 Steps

1. In groups, recap findings from the Challenge Exploration session.
2. Explain what makes a strong problem statement (e.g., clarity, focus, and relevance).
3. In groups, students draft an initial version of their problem statement.
4. Mentors provide feedback, prompting students to refine and clarify their statements.
5. Each group presents their final problem statement to the class and mentors.

📚 Material

Guides on creating problem statements, examples of strong and weak statements, and drafting templates.

Worst possible outcome

🕑 2 hours

Students brainstorm the worst possible outcomes of their challenge or project, helping them identify potential risks and pitfalls in advance.

🎯 Objectives

Encourage students to think critically about risks and barriers.
Foster creativity by exploring extreme scenarios.

🔑 Competences

Risk assessment, critical thinking, and creativity.

📣 People

Mentors who can coach groups in refining their worst possible outcome and identify when they need more clarity or focus.

Remind students that the goal is to use extreme scenarios to find risks early and solve problems, not just focus on negative outcomes.

🐾 Steps

1. Introduce the concept of the worst possible outcome and its importance.
2. In groups, ask students to brainstorm extreme, catastrophic outcomes related to their challenge.
3. Facilitate discussions to identify common patterns or key risks in these outcomes.
4. Each group presents their worst possible outcome to the class and mentors.

📚 Material

Brainstorming postits, markers, and examples of risks or barriers to spark ideas.

Opportunity Statements

🕓 2 hours

Students transform their problem statements into opportunity statements, reframing challenges as opportunities.

🎯 Objectives

Teach students to reframe challenges positively.
Lay the groundwork for solution brainstorming.

🔑 Competences

Creative problem-solving, positive reframing, and strategic thinking.

📣 People

Mentors skilled in encouraging optimism and helping students focus on actionable opportunities.

This session should feel uplifting and forward-thinking. Teachers should help students stay grounded in their problem statements while thinking creatively about solutions.

🐾 Steps

1. Explain what an opportunity statement is and provide examples.
2. In groups, recap the problem statements from the previous session.
3. Reframe problem statements into opportunity statements.
4. Facilitate group discussions to refine and clarify their statements.
5. Each group presents their worst possible outcome to the class and mentors.

📚 Material

Guides and examples of opportunity statements, brainstorming sheets, and templates for reframing problems.

Checkpoint 1

🕑 2 hours

The initial checkpoint has two goals: first, to ensure that the problem space has been adequately explored, and second, to help students develop a comprehensive understanding of the task at hand and the underlying idea.

🎯 Objectives

Encourage creative problem-solving and idea generation by changing perspectives on the challenge.
Foster effective teamwork and collaboration to align on shared goals and desired outcomes.
Define a clear vision, milestones, and action plan for the group's challenge.

🔑 Competences

Creative thinking, teamwork, goal-setting, and problem-solving.

📣 People

Facilitators who can guide students through the process of brainstorming, organizing ideas, and prioritizing actions.

Encourage students to bold think about their idea when they are alone, and together to make sense of it. It should be a fun activity.

🐾 Steps

Individual Work (Alone)

1. Begin by using the "How Might We" framework. Students should each brainstorm as many questions as possible related to their challenge, thinking creatively and from different perspectives. Encourage them to ask questions like "How might we make our project more engaging?" or "How might we overcome current obstacles?"
2. After brainstorming, students should categorize the questions into common themes and identify the key steps required to address them.
3. For each step, they will write down the goals, activities, and ideas necessary to move forward. They should then place these steps on a timeline, mapping out the sequence of actions.

Team Work (Group)

1. After individual brainstorming, students will come together in their teams. Each student shares their main ideas, and the team collaborates to create a combined timeline using their favorite goals, ideas, and steps.
2. The team should then create a chart with actions on

the Y-axis (effort required) and their potential impact on the X-axis. This will help prioritize which actions to focus on first.
3. At the end, together, they create a poster explaining in detail their idea to present to teachers and mentors.

Material

Whiteboard, markers, and paper for brainstorming and creating the poster.

Reference frameworks:
https://spin.atomicobject.com/2018/12/12/how-might-we-design-thinking/
https://www.smashingmagazine.com/2016/06/a-framework-for-brainstorming-products/

Week 2

Goals: Propose a challenge solution, develop a critical view of the school's topic, reflect on one's learnings.
How it feels: Quite intense! Slightly more "urban" and connected, still lots of outdoors.

Calendar

	Early Morning (9-11am)	Late Morning (11-13am)	Early Afternoon (14-16pm)	Late Afternoon (16-18pm)
Day 9	Vertical nugget: Sustainable EdTech infrastructure (reCluster)		Free Time	
Day 10	Challenge exploration: Value Proposition and defining MVD		Vertical nugget: Unmaking electronics	Challenge exploration: MVD improvement
Day 11	MVD Presentations	Challenge exploration: Viability through 1st steps, costs, funding sources	Second Checkpoint: Emotional check-in	Social Activity: Nautical Center
Day 12	Vertical nugget: Implications of outsourcing of digital education	Challenge exploration: First steps	Challenge exploration: Resources and Steps	
Day 13	Vertical nugget: Justifying value in EdTech	Challenge exploration: Peer critique	Third Checkpoint: Building Narrative	
Day 14	Final Presentations		Free time & Closing Dinner	

Description of the activities

Sustainable EdTech infrastructure (reCluster)

🕓 4 hours

A frontal teaching session where students learn about the University of Trento's project to reuse old computers, creating a server with a lower environmental impact. The session covers both technical and non-technical choices involved in the project.

🎯 Objectives

Understand sustainable technology practices in educational settings.
Learn about the environmental impact of reusing old computers and reducing e-waste.
Explore the technical and non-technical considerations in building sustainable EdTech infrastructure.

🔑 Competences

Understanding of sustainable technology and infrastructure.
Knowledge of resource reuse and circular economy in EdTech.
Problem-solving in designing eco-friendly solutions.

📣 People

A project leader or technical expert who can explain both the technical and non-technical decisions behind the project, making the topic accessible to students with varying technical knowledge.

📚 Material

Slides of the project

Unmaking electronics

🕓 2 hours

This activity, and how you could implement it, can be found in the second section of this book: *Example of activity design: Unmaking electronic*

Implications of outsourcing of digital education

🕓 2 hours

A frontal session exploring the impact of outsourcing on digital education, including the challenges and benefits for educational institutions, students, and educators.

🎯 Objectives

Understand the implications of outsourcing educational services and technology.
Analyze the pros and cons of outsourcing from various perspectives (e.g., cost, quality, accessibility).
Explore the ethical and practical considerations of outsourcing digital education.

🔑 Competences

Critical thinking about the role of outsourcing in education.
Understanding the effects of outsourcing on educational equity and quality.
Analyzing business and educational models in digital learning.

📣 People

An expert or lecturer who can discuss the implications of outsourcing digital education services and provide real-world examples to contextualize the discussion.

Remember to make the lesson interactive by involving the students. Place special emphasis on the challenges of outsourcing.

🐾 Steps

1. Define outsourcing and explain its role in digital education.
2. Present examples of how outsourcing has been used in education.
3. Discuss the advantages (e.g., cost savings, expertise) and disadvantages (e.g., quality control, equity) of outsourcing.
4. Explore the ethical dilemmas outsourcing can present in terms of student access, equity, and the value of education.
5. Facilitate a discussion on how outsourcing might impact students, teachers, and institutions.

📚 Material

Slides explaining outsourcing in digital education and case study examples of outsourced educational services.

Value Proposition and defining MVD

🕓 2 hours

A session to help students understand how to create a value proposition for their challenge and define a Minimum Viable Product (MVD) for testing and iteration.

🎯 Objectives

Understand the concept of value propositions.
Learn how to define a Minimum Viable Product (MVD) to validate ideas quickly.

🔑 Competences

Product development and market-fit analysis.
Understanding how to create and communicate a value proposition.

📣 People

A product manager or startup mentor with expertise in developing value propositions and MVPs.

Encourage students to craft concise and focused VPs and MVDs that clearly communicate their core idea. Emphasize clarity over complexity: every word should add value and avoid unnecessary jargon or clutter.

🐾 Steps

1. Explain the concept of a value proposition and its role in product development.
2. Introduce the concept of a Minimum Viable Product (MVD) and its importance in validating ideas.
3. Guide students through the process of defining their own value proposition and MVD.
4. Facilitate group discussions.
5. Each group presents their Value Proposition and MVD to the class and mentors.

📚 Material

Templates for value proposition and MVD definition and examples of successful MVDs.

Viability through 1st steps, costs, funding sources

🕓 2 hours

A session to explore how to assess the viability of their solution, considering the first steps, cost analysis, and potential funding sources.

🎯 Objectives

Learn how to assess the viability.
Understand how to perform a basic cost analysis.
Identify potential funding sources.

🔑 Competences

Financial analysis and viability assessment.
Understanding funding options for startups or projects.
Strategic planning and decision-making skills.

📣 People

A business strategist or financial expert.

Guide students to think realistically about the feasibility of their ideas. Encourage them to break down their project into manageable steps and estimate costs accurately, considering potential funding sources. Remind them to analyze risks and challenges, offering constructive feedback.

🐾 Steps

1. Explain what makes a project viable and how to assess it.
2. Walk students through the process of calculating startup costs and ongoing expenses for a product.
3. Discuss the different types of funding available.
4. Have students apply viability analysis methods to their challenge, supported by mentors.
5. Each group presents their work to the class and mentors.

📚 Material

Slides and cost analysis templates and examples.

Checkpoint 2

🕒 2 hours

Students will brainstorm potential solutions to a problem statement, focusing on creativity and practicality. They will evaluate each idea using structured frameworks and collaboratively assess risks and assumptions.

🎯 Objectives

Develop comprehension of future impacts and outcomes for each proposed solution. Analyze perspectives, identifying limitations, strengths, and weaknesses. Apply impartial decision-making for selecting a preferred solution.

🔑 Competences

Critical thinking, collaboration, structured problem-solving and risk assessment.

📣 People

Students.

Encourage students to think creatively and practically, generating diverse ideas without judgment.

🐾 Steps

Alone:

1. Write the problem statement on a grid paper.
2. Fill each block with potential solutions, exploring diverse possibilities.
3. Use the WOOP (Wish, Outcome, Obstacle, Plan) framework for each solution.

In Team:

1. Share individual ideas and WOOPs with teammates.
2. Create a risk map, documenting assumptions and potential problems for each idea.

📚 Material

Grid paper, pens, markers, printed WOOP framework templates.

Reference frameworks:

https://spin.atomicobject.com/2020/05/26/design-thinking-2x3/
https://www.ibm.com/design/thinking/page/toolkit/activity/assumptions-and-questions
https://characterlab.org/activities/woop-for-classrooms/

Peer critique

🕓 2 hours

A structured session where students present their projects or ideas and receive feedback from their peers, fostering constructive critique and improvement.

🎯 Objectives

Learn how to give and receive constructive feedback.
Improve critical thinking and project refinement skills.
Build confidence in presenting and defending ideas.

🔑 Competences

Critical analysis and constructive feedback skills.
Communication and presentation skills.
Problem-solving and project improvement.

📣 People

Students and teachers

Remind students to focus on providing specific and actionable feedback, avoiding overly general praise or criticism.

🐾 Steps

1. Explain the purpose of peer critique and how it helps improve projects.
2. Assign one student from each group to visit another group. This student will present their group's work, explaining key ideas, goals, and challenges, receiving feedbacks from peers.

Checkpoint 3

🕓 2 hours

Students will create a story applying their chosen solution in a realistic context, focusing on steps to implement it effectively and addressing assumptions and challenges.

🎯 Objectives

Conduct a detailed assessment of the chosen solution.
Use creative storytelling to envision real-world application.
Develop actionable implementation plans, considering constraints and risks.

🔑 Competences

Creativity, planning, teamwork.

📣 People

Students

Ideas + Suggestions + Methodology (how should it feel and how to interact) + Issues and possible redesign

🐾 Steps

Alone:

1. Develop a story around the solution.
2. Identify a character, setting, and plot; write each on a separate post-it.
3. Define key scenes for the story's progression.

In Team:

1. Share individual stories and select the best elements.
2. Combine into a cohesive timeline and realistic action plan.
3. Document assumptions and organize them into rows, with potential solutions in columns.

📚 Material

Post-it notes, pens, markers, reference guides for storyboarding.

Reference framework:
https://www.ibm.com/design/thinking/page/toolkit/activity/storyboard

Conclusion:

The framework and challenges presented in this guide are versatile and adaptable to your class, offering a strong foundation for designing impactful intensive courses on sustainability in digital education — or in other multidisciplinary topics, if you are willing to adapt our material's structure. Whether used as a complete blueprint or a source of inspiration, these tools can be applied across diverse environments, enabling you to craft meaningful learning experiences tailored to your context. By emphasizing both individual and group dynamics, the guide helps participants to gain personal insights as well as develop critical collaborative competencies.

With these resources, you are well-equipped to create an intensive course that is not only effective but also deeply engaging for everyone.

Section 2: Integrating DEI and Sustainability Challenges into Challenge-Based Learning

Summary

A handbook detailing how DEI impact/sustainability challenges can be integrated in existing extensive CBL courses, or implemented as a self-standing CBL course in interested higher education institutions.

Introduction

There are various guidebooks that describe how to create a C**hallenge-Based Learning (CBL) course**, with each providing useful insights into the process. We've included some references and URLs to assist you have a better grasp of this process. We recommend that you explore these resources before moving on to this chapter, since they provide the underlying information required to properly understand the major components we will be addressing.

In simple terms, Challenge-Based Learning begins with a challenge posed by a third party, commonly known as a **Challenge Provider**. These challenges are typically open-ended, based on real-world situations, and are sometimes referred to as "wicked problems"—complex, unstructured problems with no definite right or wrong answer and are always growing due to their dynamic nature.

CBL distinguishes itself by providing students with more autonomy. Learners have the opportunity to choose how to approach the difficulty, the viewpoints to examine, and the answers they want to adopt. This flexibility fosters creativity and critical thinking while reflecting the difficulties of real-world issue resolution.

According to many frameworks, CBL usually occurs in three stages:

Image from: https://www.challengebasedlearning.org/framework/

To learn more about this method, we recommend reading the following:

- Website: https://www.challengebasedlearning.org
- Guide: https://www.apple.com/br/education/docs/CBL_Classroom_Guide_Jan_2011.pdf
- Guide: https://www.challengebasedlearning.org/project/cbl-guide/

In **C-FLEX** we have fully embraced the CBL framework, involving **multiple key roles**: remote Challenge Providers, teachers who also served as mentors by providing both technical and moral support, and researchers who acted as collaborative partners, studying the environment and collecting data to assess competency development.

Chapter 1: Design principles and structure

We believe that integrating digital education infrastructure and sustainability challenges into your curriculum, whether by improving existing courses or creating new ones, can create a very rich educational environment and provide students with truly transformative learning experiences. This chapter provides a simple guide for educators to build and incorporate C-FLEX themes in ways that best suit their courses, resources, and goals.

We start by examining the core themes of digital transformation in education, addressing key social, ethical, environmental, and pedagogical considerations. Each section then explores how to adapt these themes within a range of Challenge-Based Learning (CBL) models, ranging from courses with little or no CBL features to those that use CBL in full. Additionally, we outline the expertise and collaborative support that may help improve the process, highlighting which experts can provide key insights for solving specific aspects of the challenge, delivering in-depth technical knowledge, and fostering motivation and effective management throughout the process for all stakeholders.

With this booklet as your guide, you will have the tools and insights needed to build a path for your students that is both adaptable and transformative, preparing them to make critical-informed contributions in a digitally connected, sustainable world.

1.1 Select the key themes:

The first step in designing your course **is to explore the core themes and challenges of sustainability of digital education technologies and infrastructure**. Rather than viewing each project area as isolated, consider them as **interconnected lenses** that offers different perspectives on the same challenge.

This section contains a selection of themes that we felt to be particularly significant. These are intended as inspiration, not as prescriptive topics: each theme can be adapted to suit the specific needs of your course and students. Consider these themes as a starting point, a foundation on which to build. **Collaborating with colleagues or field specialists** might help you find additional topics that are especially relevant to your own specific context.

When exploring these topics with students, it's essential to focus on a **manageable subset**, especially if time is limited. Choosing a targeted set of themes allows you and your students to go deeply into each area and interact with the challenges on a meaningful level.

This selection offers a guiding direction for each project area, along with descriptions to clarify the focus of each theme. We hope these examples inspire you as you begin shaping a course.

Technological sustainability

***Guiding idea**: Discussing what makes digital education technologies and infrastructure functional and maintainable.*

Some example themes:

- **Ease of Use & Accessibility:** Ensuring that digital tools are intuitive and easy to navigate for both students and educators, minimizing barriers to use.
- **Device Compatibility:** Making sure that e-learning platforms and tools are compatible with various devices (smartphones, tablets, laptops) to accommodate all users.
- **Scalability and Maintenance:** Choosing technology that can handle an increasing number of users and is easy to update and maintain over time.
- **Data Security & Storage:** Implementing secure methods of data storage, ensuring that personal and educational data are protected.
- **Technological Support Infrastructure:** Providing responsive technical support to assist users with troubleshooting and using digital education tools effectively.
- **Platform Interoperability:** Ensuring seamless integration between various digital tools and platforms (e.g., Learning Management Systems, communication tools) to provide a cohesive learning experience.

Social, ethical and legal sustainability:

***Guiding idea**: Exploring ethical and legal considerations such as privacy, accountability, fairness and freedom of choice.*

Some example themes:

- **Privacy Concerns with Big Tech:** Addressing the risks related to the collection and storage of personal data by major technology companies like Google, Microsoft, and Zoom.
- **Inclusion and Fairness:** Ensuring equitable access to digital education tools for students from various socio-economic backgrounds, including those in remote areas.
- **Data Ownership and Control:** Clarifying who owns and controls the educational data generated, ensuring that students and educators have transparency over their digital footprint.
- **Accountability for Digital Misconduct:** Establishing clear guidelines for addressing academic dishonesty, plagiarism, or other forms of misconduct in digital learning environments.
- **Freedom of Choice in Digital Tools:** Allowing students and educators to choose or adapt the tools they use for learning, avoiding imposed monopolies by a single platform.
- **Legal Compliance with International Data Laws:** Ensuring that digital tools comply with data protection regulations (e.g., GDPR) that may vary by region or country.

Environmental sustainability:

***Guiding idea**: Quantifying the environmental impact of the process of digitalising education.*

Some example themes:

- **Energy Consumption of Digital Infrastructure:** Monitoring the electricity usage by data servers, networks, and devices involved in digital education to understand their carbon footprint.
- **E-Waste from Educational Hardware:** Addressing the issue of electronic waste generated by the continuous demand for new devices (laptops, tablets) and finding ways to recycle or repurpose outdated equipment.
- **Virtual Learning's Role in Reducing Carbon Emissions:** Assessing the reduction in transportation-related emissions due to the shift to virtual or hybrid learning models.
- **Environmental Impact of Streaming and Video Conferencing:** Evaluating the carbon footprint of heavy data usage from streaming video lectures and using conferencing tools, and seeking ways to optimize bandwidth consumption.
- **Digital Learning Materials vs. Physical Materials:** Weighing the environmental benefits of using digital textbooks and resources over printed materials, considering both short-term and long-term sustainability.

Pedagogical sustainability:

***Guiding idea**: Piloting needed changes in the teaching and learning, both in results and processes, in assessment and administration.*

Some example themes:

- **Adaptive Learning Technologies:** Integrating personalized learning platforms that adapt to students' needs, helping them learn at their own pace with tailored content.
- **Hybrid and Flipped Learning Models:** Experimenting with pedagogical approaches that combine online and face-to-face instruction to create more flexible and engaging learning environments.
- **Assessment of Digital Competency:** Developing new assessment methods that evaluate not just content mastery but also students' digital literacy and ability to engage in virtual collaboration.
- **Peer-to-Peer Digital Collaboration:** Encouraging collaborative learning through digital tools like shared online workspaces, discussion boards, and group projects.
- **Real-Time Feedback and Formative Assessment:** Leveraging digital tools to provide instant feedback on student progress, allowing for continuous improvement throughout the learning process.
- **Administration of Digital Learning:** Streamlining administrative processes, such as grading, course management, and student support, using digital tools to increase efficiency and reduce workloads for teachers and staff.

1.2 Choose your own type of integrations

After selecting the themes, the next step is determining the strategy for integrating Challenge-Based Learning (CBL) into your course. Rather than a binary choice, **integrating CBL** can be a **flexible** and **incremental process** that aligns with each educator's goals, resources, and teaching style. Depending on your specific context, you might choose not to fully implement CBL right away, but instead lay the groundwork for it or only incorporate some elements of the framework. In this chapter, we outline three main strategies for incorporating CBL into your curriculum, each offering different levels of complexity, student autonomy, and external engagement.

"Challenge Inspired Learning": Adapting Challenges as Problem-Based Learning

In this approach, **challenges are framed as problem-solving activities**, without fully implementing CBL. Here, the teacher leads students in identifying problems and developing potential solutions while adhering to a predetermined didactic goal. This method provides a structured environment, with the educator guiding the activity closely.

By approaching the challenge as a problem-solving exercise, the emphasis remains on assisting students in developing skills such as critical thinking and cooperation, but in a more controlled and outcome-oriented context.

This approach is recommended when:

- The teacher has limited time to prepare the activity.
- There is a lack of extra staff to help with the CBL process.
- The teacher prefers to guide the activity towards specific educational goals, rather than giving students full autonomy to explore and experiment on their own.

Light CBL: Implementation with Teacher-Driven Guidance

In the Light CBL approach, the full CBL framework is applied, but **the teacher maintains all critical responsibilities in the process**. While an external challenge provider is involved, the teacher transforms into a "one-person teamcher", taking on at once the roles of facilitator, mentor, guide, and evaluator, while also managing communication with the challenge provider. This is the main difference from a full CBL approach, where a team shares these roles. In the Light CBL model, the teacher works alone, alongside the **Challenge Provider**, to guide students through their exploration. Although students have more freedom to investigate the complexity of the challenge, the teacher's workload grows, since they must manage every aspect of the challenge themselves.

The approach allows students to experience the core principles of CBL, such as real-world problem-solving and open-ended exploration, but still within the safety net of close teacher supervision and intervention, and without hiring extra staff.

This approach is recommended when:

- The teacher wants to encourage students to navigate complex problems on their own.
- There is a lack of extra staff to help with the CBL process.
- The teacher is comfortable engaging in open-ended conversations and can guide students through unexpected twists in the challenge, assisting them in finding meaningful answers along the way.

Full CBL: Comprehensive Implementation with External Collaboration

The Full CBL model represents a **complete adoption of the Challenge-Based Learning framework**. In this approach, the challenge is pushed not just by the teacher, but also by external stakeholders such as industry professionals, community leaders, or subject matter experts who may offer real-world views to the classroom. These **third-party players** can serve as Challenge Providers, mentors, or evaluators, providing dimension and authenticity to the student experience. Unlike the Light CBL model, this approach involves a team of people (which some have called "teamchers"[1]) working together to guide and support the students throughout the process.

The Full CBL paradigm makes the learning environment more dynamic and representative of real-world problem-solving scenarios, in which students must interact with a variety of stakeholders, consider numerous points of view, and work within the complexity of growing difficulties. In this approach, the teacher's role shifts from primary instructor to facilitator and connector, guiding students in synthesizing information and applying it in practical, meaningful ways.

This approach is recommended when:

- The teacher has access to external experts or stakeholders who can actively participate in the challenge.
- There is enough time and resources to fully participate in the CBL process, including incorporating diverse viewpoints and external criticism.
- The instructor is comfortable with a more decentralized position, enabling pupils to explore, cooperate, and solve problems with less direct interference.

[1] https://cdio.org/files/document/file/43_0.pdf

1.3 Find the key experts

Each challenge often spans multiple domains, making it crucial to have the right expertise to understand all aspects of the problem and develop innovative, sustainable problem explorations and solutions.

If you picked **Light CBL** in the previous phase, you will be on your own and must be prepared to take on any role that the situation demands. We understand that this can be difficult, making Light CBL one of the more complex choices for integration. If you are not comfortable doing so, we recommend trying a different integration strategy.

In a **Challenge Inspired Learning** approach, the process is more straightforward. As the teacher, you will determine the type of problem to explore with your students and the expected outcomes, providing structured guidance throughout the exploration: you are the sole expert required.

In a **Full CBL** approach, you will need to engage with multiple experts, which can result in both a richness of ideas and possible confusion. It will be your fold to facilitate realignment among all participants, ensuring that everyone remains focused on the challenge.

While we have identified some key areas of expertise that are beneficial, we encourage you to tailor this list to suit your specific context. Take the time to carefully evaluate the competencies needed and, if possible, collaborate with colleagues or experts to brainstorm which skills and knowledge would best enhance your project.

	Learners	Teacher	Challenge Provider	Mentor	Field Expert	Relationship Manager
Challenge Inspired Learning	Y	Y				
Light CBL	Y	Y (but more time)	Y			
Full CBL	Y	Y	Y	Y	Y	Y

Key Expertise - Template

We provide here some examples of the key expertises we have just presented in the table above. When we present them below, they will all follow this template:

KEY EXPERT	Description and reasons for involvement (What is their role?)

🎯 OBJECTIVES

How they help students

🔑 KEY COMPETENCES

Key competences (Knowledge+Skills+Attitudes)

How should they interact with the students?

In the C-FLEX project, in particular, we follow the expertise areas that we highlighted in the previous table, which are:

TEACHER	Is the primary facilitator who guides students through the learning process, ensuring the challenge aligns with educational objectives.

🎯 OBJECTIVES

- Facilitate student learning and inquiry.
- Provide content with lessons.
- Coordinate between different stakeholders.
- Ensure alignment with academic standards.

🔑 KEY COMPETENCES

- Pedagogical knowledge.
- Subject matter expertise.
- Facilitation and coaching skills.
- Project Management

Teachers work closely with students and mentors, steering discussions and providing structure while encouraging student autonomy. They keep a level of separation between students and themselves.

Mentors

Mentors are experienced professionals who provide guidance and industry insight to students. They offer practical knowledge and help students understand the real-world applications.

🎯 Objectives

- Guide students through challenges.
- Offer advice based on industry standards.
- Help connect theory with practice.

🔑 Key Competences

- Expertise in relevant fields.
- Coaching and mentoring abilities.
- Industry knowledge.

Mentors collaborate with both learners and teachers, providing insights without taking over the students' role in the challenge. They develop a personal relationship with the teams, and guide them with their expertise when needed.

Challenge Provider

The challenge provider is typically an external organization that presents the real-world problem to be solved. They define the scope of the challenge and ensure its relevance to current industry or societal issues.

🎯 Objectives

- Provide a real-world problem for students to solve.
- Offer context and background on the challenge.
- Clarify expectations and success criteria.

🔑 Key Competences

- Deep understanding of the challenge.
- Communication skills to define the problem clearly.

The challenge provider works with learners, teachers, and mentors to ensure that the challenge remains focused on realistic goals.

Relationship Manager

The relationship manager coordinates interactions between all parties involved, ensuring smooth communication and collaboration, maintaining motivation and enthusiasm among the participants throughout the challenge. They ensure students remain engaged and motivated, especially during challenging phases.

🎯 Objectives

- Manage relationships between the educational institution, challenge providers, and external partners.
- Ensure consistent communication.
- Tackle problems before they become real.
- Boost morale and keep students motivated.
- Foster a positive and encouraging environment.

🔑 Key Competences

- Networking and negotiation skills.
- Strong communication and coordination abilities.
- Empathy and motivational skills.
- Conflict resolution and emotional intelligence.

The relationship manager regularly interacts with students, providing emotional support and encouragement, working closely with teachers and mentors.

Field Experts

Field experts offer specialized knowledge that is crucial to solving specific aspects of the challenge. They provide deep, technical insights that are necessary for addressing particular elements of the challenge.

🎯 Objectives

- Supply specialized knowledge and technical advice.
- Review solutions for feasibility and accuracy.

🔑 Key Competences

- Expertise in specific areas related to the challenge.
- Analytical and problem-solving skills.

Field experts engage with students and mentors during key points, offering expert guidance and feedback on specific technical aspects.

Learners

The learners are the central participants in the CBL process, tasked with tackling the challenge.

🎯 Objectives

- Explore the challenge and develop innovative solutions.
- Collaborate with peers and other stakeholders.
- Apply theoretical knowledge in practical settings.

🔑 Key Competences

- Critical thinking and creativity.
- Collaboration and communication.
- Research and solution development.

Learners work collaboratively with all stakeholders, using the guidance and expertise provided to explore and resolve the challenge, while driving the process with their own creativity and inquiry.

Optimization of involved people

When choosing your key experts, you will need contributions from diverse stakeholders, but **over-involvement can lead to confusion, role overlap, and inefficiency**.

Clear role definitions ensure that each participant understands their responsibilities, minimising misunderstandings and promoting smooth collaboration. Working with a smaller, well-chosen group allows for more focused and efficient communication, reducing delays and ensuring that students receive essential, targeted guidance without being overwhelmed by too many perspectives. A streamlined approach also optimises resource management, helping teachers allocate time and energy effectively and minimising burnout for both educators and mentors.

Below are some guidelines to ensure each participant has a well-defined and essential role in the CBL process.

Step 1: Identify Core Stakeholders

Start by determining the minimum necessary roles for the challenge. These should include:

- **Teacher:** The facilitator and guide for the challenge.
- **Learners:** Central participants responsible for problem-solving.
- **Challenge Provider:** The external source defining the problem.
- **Mentor / Field Expert / Relationship Manager:** Optional, depending on the complexity of the challenge, to offer additional support and expertise.

***Action**: List the absolute essential roles and avoid redundancy.*

Step 2: Define Clear Roles and Responsibilities

Ensure that each stakeholder has a distinct and non-overlapping role to avoid duplication of efforts. For example:

- The **teacher** focuses on facilitating learning and ensuring alignment with educational goals.
- The **mentor** provides technical advice, not general support that the teacher can offer.
- The **challenge provider** supplies the context for the challenge but does not interfere with day-to-day student guidance.

***Action**: Write down specific tasks for each participant, ensuring clarity and avoiding role overlap.*

Step 3: Consider the Complexity of the Challenge

The complexity of the challenge determines how many additional stakeholders are needed. A simple challenge may only require a teacher and learners, while a more intricate challenges might benefit from a mentor or field expert.

***Action**: Evaluate whether the challenge requires specialised knowledge or just general guidance. Only bring in extra stakeholders if their expertise is absolutely necessary.*

Step 4: Monitor Stakeholder Involvement

As the challenge progresses, periodically check if any stakeholder's role can be minimised or adjusted. Some may not need to be involved until later stages, allowing the focus to stay on the core group.

***Action**: Regularly assess if all participants are still needed. Adjust the level of involvement as the project evolves.*

At first look, managing multiple stakeholders may appear hard, but with clear role descriptions and strategic involvement, it becomes manageable. By carefully choosing and defining essential roles, you can create an environment in which cooperation flows smoothly, resources are maximised, and students receive the targeted guidance they need. The key is ensuring that each participant's contribution is purposeful, minimising confusion and enhancing the overall efficiency of the challenge.

1.4 Design the activities

To support teachers in this process, this sub-section provides a clear, easy-to-use template designed to help you plan and implement CBL activities seamlessly.

This guide walks you through the essential steps for designing activities that integrate real-world challenges, from identifying learning goals and selecting appropriate tools to defining roles and assessment criteria. The provided template offers a structured framework that can be adapted to various subjects, challenge complexities, and available resources, ensuring flexibility while maintaining focus on student engagement and collaboration.

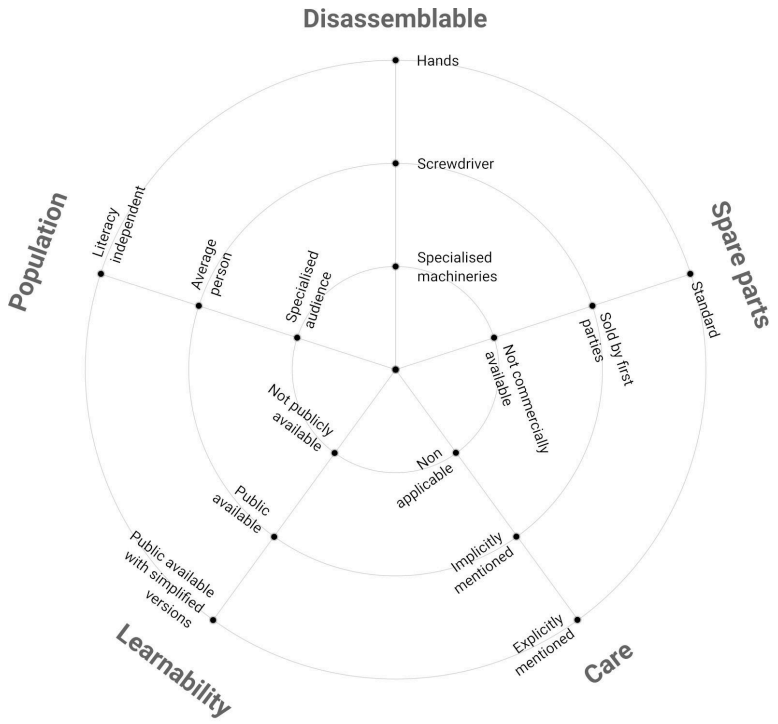
Activities Design - Template

This is the same template used in the previous section for detailing all the activities conducted during the summer school.

Activity 🕓 **X hours**	Description of the activity & Thematics	
🎯 **Objectives**	🔑 **Competences** Key competences to develop (Competence+Skill+Attitude)	📣 **People** Key People needed
Ideas + Suggestions + Methodology (how should it feel and how to interact) + Issues and possible redesign	🐾 **Steps** ❷ ❷	
	📚 **Material** Essential Material + Supporting Material + How to use the material	

Example of activity design: Unmaking electronic

Understanding the sustainability of electronic devices necessitates an examination of many variables, ranging from material sources to end-of-life impacts. This activity guides students to **deconstruct a device**, **investigate its components**, and use a radar graph template to **evaluate sustainability across themes** such as manufacturing practices. By plotting their findings, students visualise the device's sustainability profile. Below, we describe how you can carry out this activity at three levels of Challenge-Based Learning (CBL): Challenge Inspired Learning, Light CBL, and Full CBL.



From work in progress by L. Angeli, M. Bettega, R. Masu and M. Teli; graphics by N. Merendino

1. Challenge Inspired Learning

In this approach, the **teacher guides the students through the process** of deconstructing an electronic device, with the goal of helping them understand its components and assessing their sustainability using a radar graph. The teacher begins by showing how to disassemble a device such as an old smartphone or a small toy, while explaining the materials and components discovered during the process. Throughout the presentation, the teacher emphasizes the environmental impact of each part, such as material sourcing and production emissions. Working as a class, students collectively complete the radar graph, evaluating the device's sustainability based on the criteria found on the radar graph.

2. Light CBL

In this approach, the **teacher links the exercise to the challenges** presented by the challenge provider on electronic sustainability. Students are separated into groups and given a specific device to analyze. The teacher provides guidance and resources while students investigate the device's life cycle, materials, and production procedures. Through group discussions and critical thinking, students develop their radar by exploring many different perspectives and trade-offs. The teacher supports students in creating radar graphs to visualize the sustainability of their assigned devices.

3. Full CBL

In this approach, **teachers collaborates with an external experts** who provide presentations on sustainability across diverse industries, providing new insights and views while guiding the exercise. Teachers shift into a supporting role, assisting rather than leading the process. Students, working in interdisciplinary teams alongside professionals from the electronics sector, engage in in-depth conversations and handle complex challenges such as designing more sustainable devices or developing effective recycling programs. Divided into groups, students, together with the experts, analyze different technologies and create their radar graphs to describe their results. This collaborative work allows diverse interpretations from each group, resulting in larger debates around sustainability themes.

Section 3: Creating Meaningful Challenges for CBL courses

Summary

This section outlines key strategies for integrating Challenge Providers into Challenge-Based Learning. It introduces a practical template for crafting engaging challenges, along with valuable tips and criteria to guide their selection, ensuring meaningful and impactful learning experiences.

Chapter 1: What is a Challenge Provider?

As a reader of this document, you may be familiar with teaching methods such as Problem-Based Learning (PBL), Team-Based Learning (TBL), or other *Something*-Based Learning, which we like to refer to as "XBL". With this XBL label, we wish to underline that educational research hasn't yet built a strong consensus on what defines this family of educational methods, that however at the same time share a common feeling.

Challenge-Based Learning (CBL) is the latest entrant that led to its own subfield of research, as we discussed in the other parts of this Handbook. For the purpose of this part of the Handbook, we draw your attention to its most defining characteristic: the presence of an **external stakeholder** in the learning process, taking the role of the **Challenge Provider** (CP).

What "external" means is already non-trivial. Previous experiences (our own, those in our network, and those reported in the literature) adopt different definitions: some call "external stakeholders" people coming from different organisations. For example, if CBL is done in an institution and the CP is a non-university affiliated NGO, business, or public administration, those are clearly external stakeholders. But the line can get blurry quite quickly. Is a university-incubated startup an "external" CP? Is a highly independent research lab within a different university external? What if the lab is within the same institution? What if the CP is a consultancy that is analysing the same university where the challenge is carried out?

In this guide, we opt for the broadest possible definition of CP externality: *a Challenge Provider is "external", and thus creates a "valid" challenge for CBL activities, as long as the students can clearly identify the CP as someone who is not part of their teaching team*. The externality of the CP in CBL, ultimately, is supposed to serve to be an added value for the students. In C-FLEX, we think that the definition above is enough to provide added value to the students, so this is the spirit that the rest of this document will follow.

If you want to go deeper in this reflection, in Section 4: Challenge Collection of this Handbook, you will see some examples of the challenges that we used in our own activities. One of them was designed to play with the idea of externality. We invite you to refer to that section to read our comments on where this idea worked and where it didn't.

The rest of this document, though, will be spent on describing the peculiarities of the C-FLEX challenge sourcing process, which rely on two elements:

1. Defining a tight but simple grid for the description of each Challenge (what we call the “Challenge Template”).
2. Defining a process to co-create the Challenge Template together with the CP.

Before we dive in the details of the template and the challenge co-creation process, though, we wish to answer a common question.

Chapter 2: How do you find Challenge Providers?

Many colleagues that wanted to approach CBL asked us the question of how to find CPs. When one hears about “polished” CBL experiences, they often involve high-profile CPs, or a large number of CPs. The reality is, though, that neither is necessary.

If you go back to the definition we provided above, the issue of identifying CPs boils down to identifying actors that the students can plausibly see as different from the challenge’s teachers — and who have an interesting challenge to pose!

When our consortium was ideating the C-FLEX project, we had the intuition that investigating the sustainability of digital education and its infrastructure was at the same time a novel field, and one where we ourselves could learn from other specialists. When we were looking for CPs, then, we looked for these experts: who in our network could have perspectives on sustainability of digital education that would be valuable for us — and our students? And with whom did we envision the possibility of continuing these conversations and collaborations in the future?

We used the challenges as a low-commitment common field to experiment collaborations with new perspective colleagues, or to consolidate collaboration with one’s network. What best way to gauge each other professionally, after all, than working on a small common project? Co-creating and running challenges can, in this way, create an alignment between the interests of the students, their teachers, and the CPs.

As a key step — and a small innovation that we piloted in C-FLEX — we propose that the challenge’s teachers and the CPs should collaborate from the very beginning, co-constructing the challenge in the form of a Challenge Template, that we now present.

Chapter 3: The Challenge Template

The Challenge Template that we present here represents the synthesis of many experiences shared in the C-FLEX consortium. It is heavily inspired by the work of some of our consortium members in redesigning the capstone course for the EIT Digital Master School Innovation and Entrepreneurship Minor[2], our experience in the C-EXTENDED project[3], the ECIU consortium[4], and our own experience teaching using CBL.

One of the goals for the C-FLEX summer school, though, was to design a template that that was **as small as possible**, to facilitate the low-intensity collaboration mode that we presented in the section above. We now present and comment the Template, that we encourage you to reuse and adapt in your own context.

The template is divided in different sections, and for each section we propose a short guide on what the goals of each section are, and how to write it.

3.1 Basic info

Step 1	**Goals:** Provide the students with **essential information** and a **quick overview** of both the company and the challenge. **How to write:** **Keep it simple**; only include the most important details and nothing else.

Your company/organisation: .....
Title of the challenge: .....
Summary keywords: .....

[2] https://masterschool.eitdigital.eu/innovation-entrepreneurship-minor
[3] https://sites.google.com/unitn.it/c-extended/home
[4] https://www.eciu.eu

3.2 Brief information on the challenge

Challenge context:

Step 2

Goals: Give students a context of the challenge. By the end of the reading, they should know WHO gave them the challenge (**who is the Challenge Provider**), the motivations their provider may has to offer them a challenge (in other words, **WHERE the challenge comes from**).

How to write: Provide a concise overview of who their challenge provider is in **10-15 lines**, tailored for **people unfamiliar** with your organisation. Describe its **structure**, **main goals**, and **biggest problems**. You can use the questions as a guide, or you can choose different methods depending on how you like to communicate.

What kind of organisation are you representing?
(e.g., an NGO, a SME, a research unit, ...)

What kind of people work in your organisation?
(e.g., engineers, scientists, educators, younger, older, European, American, ...)

What expertises does your organisation gather?
(e.g., data science, education management, environmental engineering, ...)

What's your organisation's broad mission/value proposition?
(e.g., provide insights to stakeholders, manage education programmes, manufacture electronic devices, ...)

What connections do you see between the sustainable digitalisation of education (C-FLEX's broad theme) and your organisation's work?
(this question should be adapted — or entirely omitted — based on your own context where you aim to offer the challenge)

Challenge description:

STEP 3

Goals: Reading this section, the students should understand **WHY you want to propose a challenge** and, broadly, **WHAT the challenge is**. Ideally, the outcome of students working on one of your challenges should be a reframing (not necessarily a solution) of some problems you're facing.
How to write: You're free to express the challenge in **10-15 lines** in any way you prefer, but we consider the following elements quite helpful.

1. **Clear relevance:** challenges should represent "big ideas"
2. **No obvious single solution:** challenges should be open-ended
3. **A call to action:** the description of each challenge should end with a prompt for students to work on them

What are some possible outcomes you see for the students' work on your challenge?

STEP 4

Goals: Reading this section, the students should get an idea of **what level of commitment** the challenge requires. Ideally, the students should feel that the challenge is "tough" enough to require some real effort to be tackled, and feasible enough to be faced in the space of your teaching activity.
How to write: **Keep it simple**, and if you can, write in very general terms. This way, you can let the students choose their own path and not let you affect their work.

(e.g.: a reflection report, a policy survey, an MVP, ...)

Challenge material for inspiration (optional):

STEP 5

Goals: Give the students some kind of material that will get them engaged and inspired about your challenge.
How to write: Prepare a collection of mixed media and different types of resources, including websites, articles, books, and videos.

Chapter 4: The Challenge Co-Creation Workshop

A key step in our process was the definition of a common moment where all the CBL teaching staff and CPs could meet and work together on creating the first draft of the template we presented above. We want here to walk you through the workshop structure that — for us — took the form of a half-day hybrid activity.

This workshop is designed to help teachers and CPs collaborate and co-create a meaningful challenge for students to tackle in a CBL course. By following this structured process, teachers will be able to develop a well-thought-out challenge that is relevant, engaging, and aligned with learning objectives.

The workshop foresees several phases.

4.1 Preparation: Pre-Workshop Requirements

Before the workshop begins, each CP should:

Prepare a Potential Challenge: Come to the session with a rough idea of the challenge they want to propose.

- **Title:** A tentative title for the challenge.
- **Pitch:** A brief, 30-word description of the challenge idea.
- **Inspiration Material:** One or two pieces of inspiration, such as videos, articles, or other project examples that relate to the challenge.

Throughout the process, participants are supposed to take ample informal notes, which will then be shared with the whole group to aid the CPs in finalising the challenge proposal.

4.2 Workshop Process: Step-by-Step

Step 1: Team Division (10 minutes)

Action	Match the CPs and teachers in small teams. Each CP defines a team, to which should also see the participation of at least one teacher.
Purpose	Working in teams fosters collaboration, generates diverse perspectives, and encourages constructive feedback. Not all CPs are, themselves, teachers! Having a teacher "mirror" the CP helps the CPs set realistic expectations with respect to what level the students can achieve, and exchange ideas.

Step 2: Company/Organization Description (10 minutes)

Action	In a smaller breakdown meeting divided in the various teams, each CP describes the organisation that will figure as the de facto CP and orally introduces the idea of the challenge by: • Explaining the problem the organisation is facing and the context in which it exists. • Describing the organisation's mission, values, industry, and main goals.
Purpose	This helps frame the context in which the challenge will take place and gives teachers an understanding of the challenge's background. The teachers, by asking follow-up questions, should help the CP making sure that the challenge is clear to understand, decently scoped, and free of technical jargon or fine-grained contextual elements that may hinder its understanding.

Step 3: Cross-Check and Peer Feedback (15 minutes)

Action	Teams reconvene in plenary. Each CP orally presents their challenge, and other teams give oral feedback focusing on clarity, relevance, and alignment with educational outcomes.
Purpose	Peer feedback allows for adjustments and improvements to ensure the challenge is robust and engaging for students, and once again helps ensuring the idea is immediately easy to grasp.

Step 4: Ideating Possible Outcomes (20 minutes)

Action	Teams go again in breakout sessions. Each CP proposes potential outcomes or solutions that students could work towards in solving the challenge. A particular focus should be given on: • What types of deliverables might be expected (e.g., a prototype, a campaign, a strategic plan)? • What are the desired competences or knowledge students should develop? As CPs propose these outcomes, teachers should give feedback with respect to their feasibility. Will students be able to deliver to that level? Should the delivery's ambition be raised? Lowered?
Purpose	Define what success might look like and the competencies students will gain from solving the challenge.

Step 5: Cross-Check and Peer Feedback (15 minutes)

As above, teams should reconvene in plenary and have a moment of peer feedback.

Step 6: Inspiration Material Sharing (15 minutes)

Action	CPs should share the inspiration material prepared in advance (e.g., videos, articles, or project examples). Discuss how these materials could influence or shape the challenge. Teachers should contribute by adding their own inspiration material, and add to the list any material that students may need as a preparatory activity.
Purpose	Generate creative ideas and inspiration by drawing connections between existing materials and the proposed challenge, encouraging further refinement. Also, make sure that students have the needed basics to tackle the challenge effectively.

Step 7: Finalising the Challenge Title (10 minutes)

Action	Based on the discussions and feedback, each team refines their original challenge title. Aim for a clear, concise, and engaging title that captures the essence of the challenge.
Purpose	The title should be compelling and provide a snapshot of the challenge, helping to attract student interest and communicate the challenge's focus.

Chapter 5: Challenge selection

How many challenges do you need for your CBL activity, and what happens if you have more — or less — than your identified number?

In the C-FLEX summer schools, we had a dedicated setup that ensured that we had no more and no less challenges than we needed: four project inquiry dimensions; four teams of students; four challenges. This, however, was an advantage of having received dedicated funding, and performing a pilot project, and our experience of performing CBL activities shows that most of the times, things aren't so linear.

First of all, you should think about how many challenges you need. **If sourcing challenges is hard, consider the option that all students may work on the same challenge!** In the literature, incidentally, this is often referred to as "Multi-Challenge-Based Learning"[5]. If the challenge is open-ended enough (and you address this problem properly during the co-creation workshop), there should be a potentially infinite number of solutions that students may propose to the same one challenge. As long as you have a number of challenges which is less than the number of student teams, you should be fine! Discuss the arrangements with your CPs and check who can accommodate multiple teams.

You may also find yourself in the fortunate, but somewhat awkward, situation of having more challenges than student teams in your CBL activity. This, then, will require dropping some challenges. We suggest that, if you are in such situation, you should give priority to:

1. The challenge which has *the most accessible CP*;
2. The challenge which is *most clearly described*;
3. The challenge which has *the most clear possible outcomes;*
4. The challenge which is *the most open*.

Our experience (in C-FLEX and beyond) shows that all other possible choices (e.g., prioritising "famous" CPs; prioritising "big" CPs; prioritising challenges that have follow-up opportunities such as internships; prioritising paid challenges; …) will lead to many headaches. We also invite you in not being shy in dropping out a challenge if you think that it will not fit well with your educational vision. There may well be unsolved misalignments even after the co-creation workshop. Remember that, first of all, this is a *learning* activity, so the highest priority should be focused on the students' learning, even at the cost of other "neatness" factors.

[5] https://ieeexplore.ieee.org/document/10578578

Conclusions

In this sub-Handbook, we covered these three main points:

1. What defines an “external” Challenge Provider, and how can you find CPs?

A CP is “external enough” when the students can identify the CP as being clearly someone different from their teachers.

2. How do you write an engaging challenge description, ensuring that CPs and teachers can cooperate effectively?

We proposed a simple template to write a challenge brief, and a workshop-like activity that can be used to co-create the template by engaging CPs and teachers.

3. What is the ideal balance of challenges in a CBL activity, and how does one choose what challenges they should use in their courses?

*Challenges should always be selected prioritising **potential for student learning,** reflected in the ability to form a productive relationship with the CP, and the challenge’s clarity.*

We hope these reflections can be useful for your CBL journey, and invite you to continue reading our materials if you want to go more in depth!

Section 4: Challenge Collection

Summary

In this document, we present an edited collection of the challenges we co-created with our partners in the 2023 Summer School. They may serve as inspirations, to be reused 1:1, or as a worked example of our processes.

Foreword

This sub-Handbook is dedicated to presenting the Challenge Descriptions that the C-FLEX project has co-created with our external partners, and that were offered as challenges in the 2023 summer school.

If you're wondering about how we came to this document, you can refer to our previous sub-Handbook, where you find a detailed description of the process that led to the challenge, including templates that you may reuse or adapt for your own CBL activities, and a possible process to co-create Challenges with external stakeholders.

Case collection

In the pages that follow, you will find commented, filled version of the case descriptions that we provided to our students as part of the summer school the C-FLEX project organised in 2023. We hope they may be useful for you in some of these ways:

- As a worked example of our processes in action: we will point out in full transparency points of success — but also of failure!
- As documents to be adapted in your own CBL offering: if you can't find your own challenge providers, why not start from these ones?
- As points of reference for your own challenge collections: in our project, we had the chance to do a "full run" of our proposed co-design process. If you're trying to implement your own, our own challenge collection might be a good benchmark to evaluate if you're on the right track.

C-FLEX/U-Hopper challenge

How to improve the sustainability of the C-FLEX online pre-course?

Introduction commentary

We open our challenge collection with what is possibly the most unconventional of our challenges.

The challenge proposed by our external stakeholder follows the philosophy of "dogfooding": how could C-FLEX apply its own research learnings to the courses they are teaching?

The question makes a lot of sense. During the co-creation meeting we felt that the challenge had a strong point in having very clear outcomes, but that at the same time the students may have struggled with understanding who their challenge provider was.

Evaluation of outcomes

This challenge ended up being way trickier than anticipated. As foreseen, the students felt partially confused about who "embodied" their Challenge Provider: was it the summer school's teachers? The project's coordinator? Their institutions? Erasmus+?

What surprised us, though, is that even after resolving this (by explaining the role of the external stakeholder), the project's structure was too hard for the students to grasp. Cooperation projects are highly complex artifacts and organisations, where even partners often need to have alignment calls to make sense of how work is proceeding. Students cannot be expected to grasp a project's depth in a short time, especially in the context of an intensive course.

At the end of the experience, though, we have to say that the process was highly valuable: we were able to play with the boundaries of what a challenge provider's externality might mean, and get an external perspective on our own processes. The students were able to contribute a draft analysis framework for digital education technologies that we — as project partners — found to be a relevant starting point for our own reflections.

Our main learning from this challenge is that, especially with students who are not familiar with CBL, **challenges should be simple and easy to grasp at a glance, and include as little jargon/insider knowledge as possible**. Complex structures may seem to add more added value, but are often a hit-or-miss, depending on individual student and teacher attitudes.

If you are curious to go more in depth on the results of the students, you can refer to sub-Handbook e, where we present some of the commented outcomes of the students' work.

Basic info

Your company/organisation: C-FLEX
Title of the challenge: How to improve the sustainability of the C-FLEX online pre-course?
Summary keywords: sustainability, online pre-course, assessment, recommendations

Brief information on the challenge

Challenge context:

WHO? C-Flex is a consortium that brings together different stakeholders (academia + NGOs) across Europe that focus on evaluating existing digital education tools and creating strategies for making them more sustainable in a broad sense. People working in the project include engineers, scientists, educators at various european settings.

Following the "practice what you preach" approach, C-FLEX is striving to make one of its key results, i.e. its online pre-course, *more* sustainable. Sustainability has to be understood along the four dimensions defined by the project (technological, pedagogical, social/ethical/legal, environmental) as well as a fifth dimension related to the *economical* sustainability of the initiative and the course itself.

WHY? An organisation/alliance working on sustainability in digital education should be able to assess its own performance. That is why we ask the students to make an assessment and analyse it.

Challenge description:

How to make the summer school pre-course more sustainable?

WHAT? Explore the five dimensions of sustainability and perform a sustainability analysis of the course. Provide suggestions for improvement of the pre-summer school online course.

Some examples of potential interest include, (however please feel free to explore other ideas)
Explore the five dimensions of sustainability and perform a sustainability analysis of the course.

Preparation – students should be *more* familiar with sustainability before they come to the course. Were students properly prepared? What could students do next year to be better prepared?

Pedagogical variation of pre-course (aiming for students to experience different pedagogies)
If your group were to be employed as consultants to the project team next year, what would you suggest for each "pedagogy" of the pre-course to improve. Please consider all five dimensions of sustainability for each pedagogy.

Technical challenges in participating?
What could be done for students located in places with limited internet connection/limited bandwidth?
Does the pre-course facilitate for disabled students? Was this issue even investigated?

Financing of the pre-course (and the summer school)
While this year's pre-course and summer school is entirely financed by the EU grant, what could finance future incarnations of the pre-course and summer school?

Could the pre-course have been carried out in a more sustainable way?
Consider the challenge of having students spread over several countries (or continents)?

What challenges can you pinpoint concerning Social/Ethical/Legal issues?
While the use of the internet enables a lot of interaction possibilities there are several obstacles in using technology. An example: all photos posted on Facebook belong to Facebook. All movies posted on Youtube belong to youtube etc. How will this influence the pre-course?

What are some possible outcomes you see for the students' work on your challenge?

Expected results include**:**

- Sustainability assessment (along the 4+1 sustainability dimensions)
- Gap analysis
- Presenting state-of-the-art examples for online courses that the pre-course could strive for.
- A set of recommendations for improving sustainability, ideally with an estimate of the impact of each single intervention/change and prioritisation thereof.

Challenge material for inspiration:

C-FLEX public information (website, social media, publications etc.).
YouTube videos by Osterwalder on BMC

VU Amsterdam challenge

Higher education for all: addressing drawbacks and benefits of hybrid learning

Introduction commentary

As our "pedagogical" challenge, we proposed a reflection on so-called hybrid learning, namely those situations that see, in the same teaching activities, students participating remotely and students participating in presence.

This reflection stemmed from some shared history between the C-FLEX coordination team and our colleagues and CPs in VU Amsterdam. With our shared interest about computing sustainability, we have seen the emergence of hybrid-format conferences, promoted in particular as a way to mitigate the high carbon emissions that come from long-distance/short-duration travelling which is associated with academics attending conferences. Our observation, though, was that when we looked at the effectiveness of these conferences, they were hardly successful for both audiences: hybrid conferences either ended up catering more to the in-presence attendees or to the online ones.

A particular implication of this situation, then, was also that while hybrid conferences were proposed as a solution to work towards decarbonisation, few people discussed the pedagogical — but also social! — limitations of the model. Indeed, when a conference switches to online mode, this may come at a high cost in privacy (due to the terms and conditions of the platforms on which the conference is hosted) or even in access (not everyone has access to the fast and stable internet connections that are needed to watch streamed talks).

The challenge we propose here, then, is an extension of these reflections applied to the "standard" classroom setting.

Evaluation of outcomes

One of the greatest obstacles we faced in running this challenge was to get students aligned with the sometimes ambiguous vocabulary that is used in the digital education space. One of the largest misunderstandings was the difference between *hybrid* education and *blended* learning.

Realising the need to disambiguate this terminology led us towards adding a session dedicated to vocabulary-building in the field of digitised education (briefly described in R4b). The final outcome of the students' work ended up being far less tangible than we had imagined when we drafted the challenge — maybe because the team of students that worked on this ended up being skewed towards a more technical background. Nonetheless, we realised that the ambiguity in terminology extended beyond the team working on this specific challenge, and the inclusion of this extra session ended up being highly beneficial for all participants.

Basic info

Your company/organisation: Vrije Universiteit Amsterdam
Title of the challenge: Higher education for all: addressing *drawbacks* and benefits of hybrid learning
Summary keywords: hybrid learning, sustainability, higher education, socio-technical

Brief information on the challenge

Challenge context:
VU Amsterdam is a leading research university in Amsterdam, known for its academic freedom and diverse programs. It has approximately 34,000 students and employs around 4,500 staff members in 9 departments. The university offers hybrid education, combining on-campus and online learning. It also hosts hybrid conferences, blending in-person and virtual participation. For more information, you can visit their website: https://vu.nl/en/about-vu

One of the research groups at the Department of Computer Science is the group led by Patricia Lago on Software and Sustainability (S2). Her research group aims to address the sustainability (and in particular environmental) impact of software systems and the development processes behind them. Their mission is to provide human centred education, improving society by providing the sustainability-aware skills and competences it needs in software engineering and in general in the creation and evolution of digital solutions. They explore ways to make software more energy-efficient, reduce its carbon footprint, and enhance its overall sustainability and sustainability impact. The group investigates various aspects such as software architecture, design, and development practices, considering both technical and socio-ecological factors. Their work contributes to creating more environmentally conscious and sustainable software solutions.The group has investigated accessibility and effectiveness in conferences and workshops [1], and are working with IEEE towards zero-carbon scientific conferences.

Patricia Lago adds: “Thanks to the digital transformation of higher education, and the Covid-19 pandemic, we could experiment with techniques for virtualization and hybridisation of higher education. These bring many benefits (e.g., accessibility, affordability) and drawbacks (e.g., lack of engagement, learning ineffectiveness). We have noticed similar pros and cons in conferences, too [1] where we are still looking for a sustainability balance [2].”

VU Amsterdam as a university is exploring hybrid education and investigating pedagogical, environmental, social, and technological aspects. This includes integrating appropriate tools, enhancing student engagement, ensuring inclusivity, and optimising energy consumption.

As part of Aurora (https://vu.nl/en/about-vu/more-about/aurora), VU Amsterdam is exploring the European Universities Alliance for ways to offer education and conferences in a hybrid fashion. A hybrid approach combines both in-person and virtual elements, allowing presenters, teachers, and participants to attend either in person or remotely. It offers a flexible and inclusive format that accommodates different preferences and circumstances. In a hybrid conference or course program, some attendees virtually join through online platforms or video conference tools, while others physically gather at a specific venue or even at different venues. The program typically includes a mix of live presentations, discussions, workshops, and social opportunities that can be accessed both on-site and online. Hybrid education and conferences enable wider participation, reduce travel costs and carbon emissions, and provide opportunities for remote collaboration.

Challenge description:

Higher Education for all: Addressing drawbacks and benefits of hybrid learning in order to reach more people and create more impact.

Campuses aren’t big enough

In the last decades universities in the Netherlands experienced rapid growth. At the same time the budgets have stayed the same, doubling the student population without having more educational facilities and buildings. The opportunities to have all students at one location or having them all online are becoming scarce.

Covid-19

With the hastily introduction of technological solutions due to covid, a number of improperly designed pedagogical solutions has been introduced and lead to decreased effectiveness (or efficiency), i.e., either they don’t work, or they take much more time. Furthermore, as the pandemic subsided, students exhibited hesitancy in gathering for in-person activities, sometimes only joining online, lacking the necessary skills and habits to connect with their peers in person, despite feeling the need to do so. Despite the university's specific aim to promote social cohesiveness, this impact is undermining

students' overall sense of belonging and their ability to form strong social bonds within the university community.

What are the possible benefits and drawbacks of hybrid learning?
In this challenge, we aim to identify the benefits and drawbacks defined in terms of "sustainability-quality (SQ) concerns" [2], i.e., concerns in the four dimensions of technical, environmental, economic and social sustainability; and envisage the mix of SQ concerns that may characterise examples of educational modules, so that we can assess their effectiveness in terms of educational sustainability.

For example, think of the educational module "online lectures": they allow students to attend them remotely (hence bringing potential benefits in terms of affordability) but require sufficient technical support (in terms of connectivity and bandwidth); and may decrease the level of engagement with negative effects on learnability.

What are some possible outcomes you see for the students' work on your challenge?
A list of educational hybrid modules (topic and format), characterised by a list of potential benefits and drawbacks. These are each defined in an operational way, and classified in one of the four dimensions of sustainability, the economic aspect, and impact. Modules should be evaluated in the different contexts: as part of a regular university course, as a standalone module and part of a conference, as part of an inter-university program of a European Universities Alliance.

Challenge material for inspiration:

1. Funke, M., & Lago, P. (2022). Let's Start Reducing the Carbon Footprint of Academic Conferences. In International Conference on ICT for Sustainability (ICT4S): [Proceedings] (pp. 160-171). (ICT4S; Vol. 8). IEEE. https://doi.org/10.1109/ICT4S55073.2022.00027
2. Lago, P. (2019). Architecture design decision maps for software sustainability. In IEEE/ACM International Conference on Software Engineering: Software Engineering in Society, ICSE-SEIS 2019 - Proceedings (pp. 61-64). IEEE. https://doi.org/10.1109/ICSE-SEIS.2019.00015

Maastricht University challenge

International & sustainable: can we have it both?

Introduction commentary

The challenge presented here falls into the category of so-called “grand challenges” — a challenge where students are helping the CP tackle a problem that is often larger than the organisation itself.

In this case, our colleagues at Maastricht University wanted to explore the struggle that emerges from being a university with a strong vocation to internationalisation and sustainability at the same time.

Evaluation of outcomes

First-order answers, of course, may have easily gone in the direction of leveraging digital technologies as a techno-solutionist way out of the problem. With the students, however, we explored an alternative, namely leveraging the experiential nature of study abroad experiences to elicit long-lasting behavioural change in exchange students.

The solution that students ended up proposing was a programme based on developing biking skills for all students going to U Maastricht, leveraging the image of the Netherlands as “the country of bikes”. The idea the students proposed was that exchange students who got used to riding their bikes safely while in Maastricht may carry over their newly-acquired habits to their home country. In the summer school where this challenge was first used, we included a mid/long distance bike trip, with the intent of showing students that they can take a more sustainable approach to mobility, even in situations where one would normally expect to prioritise comfort. We like to think that the context of the programme helped the students believe in their proposed idea. The complete material produced by the students is published on the project’s website.

Basic info

Your company/organisation: Maastricht University, an international university in the Netherlands
Title of the challenge: Maastricht University international & sustainable: can we have it both?
Summary keywords: University internationalisation, sustainable travel

Brief information on the challenge

Challenge context:

Maastricht University is the **most international university** in the Netherlands and, with nearly 22,000 students and 4,400 employees, is still growing. The university distinguishes itself with its innovative education model (Problem-Based Learning in small-scale tutorial groups), international character (more than 100 nationalities) and multidisciplinary approach to research and education. UM has quickly built a solid reputation. Today, it is one of the best young universities in the world and can rightly call itself *the* European university of the Netherlands (https://www.maastrichtuniversity.nl/about-um-0).

Challenge description:

The challenge is twofold: can Maastricht University develop its **internationalisation** status while being **sustainable**?

Internationalisation is embedded in the DNA of Maastricht University. As a result, air traffic is often unavoidable. The **air traffic by employees** is an important component of the **CO2 footprint** of the organisation, the reason why university started the campaign 'Take the green seat' in 2021. This initiative focuses on raising awareness, promoting alternatives to air travel and facilitating voluntary compensation through an internal fund (https://www.maastrichtuniversity.nl/about-um/sustainability/operations/mobility).

Apart from strengthening internationalisation policies, Maastricht University aims to integrate **sustainability** in the DNA of the entire organisation by 2030 (https://www.maastrichtuniversity.nl/about-um/sustainability), through research and education and leading by example in its operations. However, what about the CO2 footprint of the **international student population**? Although students may live in the Maastricht area, they have to travel between their home country and the Netherlands by plane, train, car or bus; often several times a year (e.g. Christmas break). This might have a significant impact on the CO2 footprint of the university.

In terms of climate policy and reporting, at Maastricht University CO2 emissions coming from employees and students' travelling can be considered as "Scope 3 emissions". **Scope 3 emissions** are the result of activities conducted by assets not owned or controlled by the reporting organisation, indirectly affecting the organisation's value chain. See more details in Figure 1 below. (https://www.epa.gov/climateleadership/scope-3-inventory-guidance#:~:text=Scope%203%20Resources-,Description%20of%20Scope%203%20Emissions,scope%201%20and%202%20boundary).

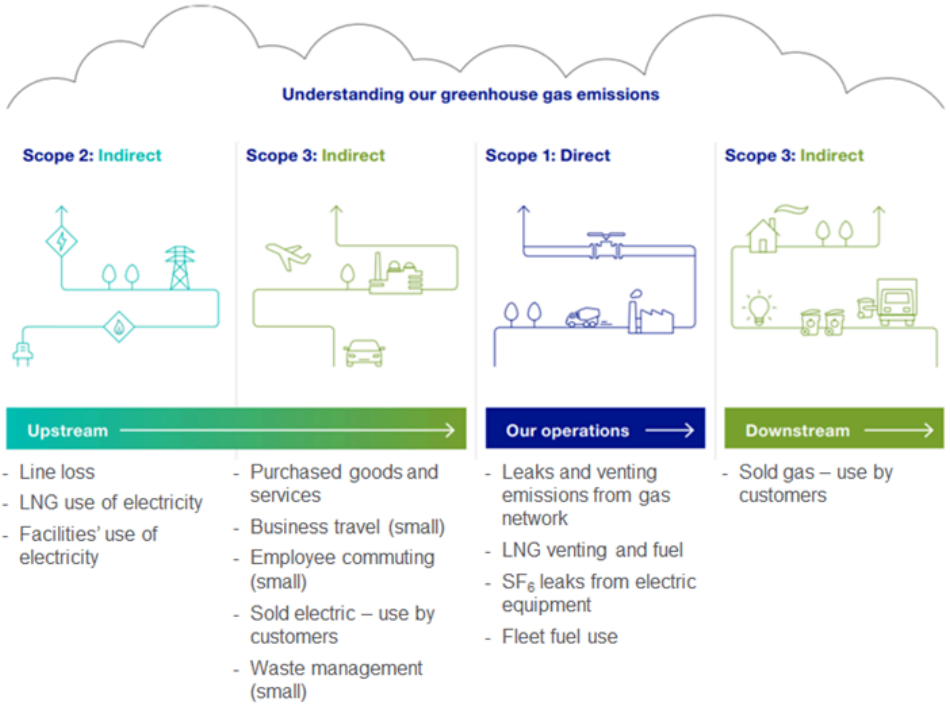


Figure 1. Understanding greenhouse gas emissions.

The challenge we are facing: internationalisation is a strategic goal of Maastricht University, but it also wants to become sustainable. How to deal with this dilemma?

- It is difficult to reach an "international" institution status and simultaneously avoid high CO2 emissions due to travelling (both students and staff).
- Internationalisation involves getting onsite. So, there is a conflict between internationalisation and being sustainable.
- Can Maastricht U, as an international university, become "climate-neutral", in particular in terms of students' international travels?
- Should the students´ travel choices be a matter for the university or for the students?

What are some possible outcomes you see for the students' work on your challenge?

- A **reflection report** on how to prevent and/or compensate environmental impact from travel
- A **set of recommendations** for the university management on how to tackle this issue
- The report and recommendations could be extended to also include the staff´s travel, both between the university and home and to other universities, conferences etc.

Challenge material for inspiration:

- https://www.ed.ac.uk/sustainability/topics/travel/sustainable-travel-policy-2021
- https://intra.kth.se/polopoly_fs/1.749950.1600689803!/Guidelines%20for%20meetings%20och%20travel.pdf
- https://staff.admin.ox.ac.uk/travelling-for-work/travel-policy
- https://www.uva.nl/en/about-the-uva/about-the-university/sustainability/sustainable-operations/sustainable-travel/sustainable-travel.html?cb

Kiron challenge

Digital education infrastructures within the context of very diverse groups

Introduction commentary

The challenge that we received from Kiron, an NGO based in Germany working on online education from migrants, is another textbook example of the ideal CBL activity — though this time working on a more narrow problem contextualised in the CPs' activities rather than at a large scale.

In the challenge, Kiron wonders how the digital infrastructure that supports their operations may support — or hinder — the NGO's activities, given that the infrastructure is often Western-centric, and the community of people that use it in Kiron's network are often non-Western.

Evaluation of outcomes

The student team's solution, that we more in depth in the next sub-handbook, R4e, focused on the introduction of an in-presence programme aimed at creating a physical community for Kiron students to mirror their participation in Kiron's online education offering.

Of all the challenges we proposed, we think this represents the most linear process, and the one that yielded the most replicable and reusable result. If you are thinking about adopting CBL in your own courses, we suggest you start from here!

Basic info

Your company/organisation: Kiron Open Higher Education GmbH (www.kiron.ngo)
Title of the challenge: Digital education infrastructures within the context of very diverse groups
Summary keywords: diversity, cultural differences

Brief information on the challenge

Challenge context:

- Kiron is an NGO, 8 years old company, with around 20.000 students right now
- Approx. 65 employees - engineers, learning designers, student support, fundraising etc.
- Headquartered in Berlin, Germany, plus one regional office in Amman, Jordan
- Their goal is to make access to quality education for refugees and underserved communities as inclusive as possible.
- They created Kiron Campus, an online learning platform for refugees worldwide and underserved communities in the Middle East.
- Strong focus on digital literacy, computer and business science as well as language learning
- Community building is very important for disadvantaged groups.
- At the same time, the student body becomes more and more diverse in terms of cultural background and skills - having more students from Africa, Asia and the Middle East.

Challenge description:

- Student groups at Kiron have become ever more diverse, creating additional challenges for Digital Education Infrastructure (DEI) and facilitators, adding more complexity that needs to be addressed in the educational process. Students have different cultural backgrounds, different maturity, different expectations. On the other hand, the growing diversity also provides opportunities as it offers new perspectives. If we manage this right, diversity can also improve the student experience and the learning success.
- The objective is to understand what a DEI looks like (i.e. should look like) that transforms the challenges of (very) diverse groups into an asset and driver for learning success and sustainability? The infrastructure should be considered in terms of both technologies, as well as teaching practices. In particular, the group should analyse the different needs of individual students and diverse student groups in educational settings like lectures, seminars, MOOCs, group work and home work.

What are some possible outcomes you see for the students' work on your challenge?
(e.g.: a reflection report, a policy survey, an MVP, ...)
Recommendations for Kiron, perhaps the draft design of one or two new educational programs (without content of course), maybe one including synchronous online formats (like Google classrooms) and one for self-paced online learners.

Challenge material for inspiration:
Websites, articles, books, or any material that could get the students inspired about your challenge.

1) Kiron Annual Report. https://kiron.ngo/uploads/Annual_Report_2020_Kiron_9ea602ef9d_a16139ffcd.pdf

2) Banks, J. A. (2015). Cultural diversity and education: Foundations, curriculum, and teaching. Routledge.

2024 Challenge

Sustainable transformation of the “Introduction to Computer Systems” University course at a global, state, and university level

Introduction commentary

For the 2024 pilot summer school, we decided to try a different format. Instead of having multiple challenges, we co-created one single challenge, originating from a teacher at TU Eindhoven who, crucially, was otherwise external to the consortium’s activity.

As a partial legacy to the 2023 C-FLEX/U-Hopper challenge, this challenge also asked students (and, implicitly, their mentors) to apply the lessons learned in the rest of the project to redesign the Challenge Provider’s own course, reflecting at various levels.

Evaluation of outcomes

Since we also changed the form of delivery expected of students — from 2023’s slides and reports to 2024’s posters and videos — the type of outcomes that were expected of the students also had to inevitably change. Since the students had to focus not only on identifying the problem and possible solutions, but also on acquiring the know-how that made them able to produce their results in the correct format, the outcomes have emphasised creativity and lateral thinking over soundness of the results strictly speaking.

All in all, however, we are still satisfied by the outcomes of this work, as we had the clear impression that the students clearly understood their challenge, and indeed provided creative possible solutions

BASIC INFORMATION

Your company/organization: Technical University of Eindhoven
Title of the challenge: Sustainable transformation of the “Introduction to Computer Systems”
University course at a global, state, and university level
Summary keywords: Sustainability, educational course transformation

BRIEF INFORMATION ON THE CHALLENGE

Challenge Context

Introduction to Computer Systems is the first course in the Systems learning line of the Bachelor Computer Science Engineering.

- The course is composed of lectures and practical sessions.
- Total hours of the course are 140, including 58 hours of classes and 82 non-contact hours (this time is given for background reading, completing practice exercises, preparing for practical sessions and revision for the final examination. It is assumed to spend at least 4-8 hours per week on activities
- The idea of the course is to look at the structure and working of general-purpose processors that can execute
- computer programs, spanning the conceptual gap between simple switches on the one hand and the abstract
- machine that constitutes a "computer" on the other.

The course learning outcomes are the following:
1. Represent, transform between, and perform basic mathematical operations in various number systems, particularly those utilised in the design and operation of microprocessor systems.
2. Model and design, using recognised nomenclature and diagrams, digital circuits and fundamental microprocessor components.
3. Implement machine code instructions onto an abstract representation of a given processor architecture.
4. Translate short high-level language algorithms to assembly language programs.
5. Summarise, using appropriate technical nomenclature, key concepts related to the design and implementation of microprocessor architectures.

Challenge Description

Students working on this challenge have to provide reflections to how orient the course and its supporting digital infrastructure towards openness, accessibility (in terms of reducing the digital divide, and increasing interoperability and inclusivity) and sustainability (environmental, ethical, technological) at a global, state, or university level. The work has to be done through four analysis dimensions of the C-FLEX project: technological, environmental, social, and pedagogical.

What are some possible outcomes you see for the students' work on your challenge?

1. Sustainability assessment along the 4 dimensions
2. Gap analysis
3. Creating recommendations for improving the sustainability of the specific course "Introduction to Computer
Systems", or other similar educational courses, at a global, state, and university level

Challenge material for inspiration:

Study & Assessment Guide of the course "Introduction to Computer Systems"(2IC30 Computer Systems 2023-2024) of the Bachelor Computer Science Engineering TU Eindhoven.

Environmental dimension: https://greenspector.com/en/videoconferencing-apps-2022/

Calculate your emissions
https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines

Pedagogical dimension: (in combination with neurology)
https://www.coursera.org/learn/uncommon-sense-teaching (in combination with the technological dimension) https://www.coursera.org/learn/getinmooc

Social dimension: (privacy) https://www.coursera.org/learn/history-privacy-laws and https://www.coursera.org/learn/privacy-eu

Research methodology: (how to setup your research)
https://www.coursera.org/learn/statistical-inferences

Conclusions

The challenges we presented in this section showcase a broad variety of what can be achieved in a CBL context, in a spectrum that ranges from the most unorthodox form of challenge to the most typical one. While we will go more in detail about the practical reusability of the students' outcomes within the next sub-handbook, we want here to highlight how the goal of these challenges has always been the students' *learning*.

When performing CBL activities, one might be tempted to evaluate their effectiveness in terms of the added value they provided to the institution hosting the challenge or to the CP. We believe, however, that we should resist this framing: the students' learning should come first, even at the cost of less-reusable results. As it happened for some of the challenges we presented, sometimes even abandoning the goal of achieving reusable results to focus on the maximisation of learning for the team working on the challenge — and the whole cohort — may be the right choice.

Section 5: Outcomes Showcase

Summary

In this document, we present an edited and commented collection of some of the work our students performed during the C-FLEX summer schools. We hope they may serve you as an inspiration, but also as a worked example on how we coached our students.

Introduction

What students delivery in CBL is fundamentally different from standard exams — or other active learning methods such as PBL — for one main reason: it is extremely open-ended! CBL's emphasis on self-direction and broad challenges leads to a situation where teachers may provide a challenge with a clear idea of its intended outcome in their mind, but then students may completely upturn the challenge's direction. While this is intended by design, it's never easy to cope with this!

In this sub-handbook, we want to show you some examples of what our students produced during the C-FLEX summer schools. If you followed the sub-handbooks sequentially, this will be the last piece of the puzzle. As you will see and read, sometimes this last piece fitted neatly and sometimes, honestly, it didn't. The reason we do this is to emphasise that this whole journey is, more than anything, a learning process. We encourage you not to look at these results with a "quality assessment" mindset, but rather to try to see how they represent the last step in the students' own journey through our activities. As teachers, mentors, and organisers, our job was not to push students to perform properly and satisfy the CP's requirements, but rather to encourage the students to grow and learn.

Sometimes, this meant that we needed to abandon our originally-foreseen plan, and accept that the students need to work on their own version of the challenge — which maybe is just to learn to work in a very diverse team. We will, then, walk you through our students' work, highlighting the main decision points, showing you how their outcomes maps to our activities, and what we think they learned from the process.

We provide here two examples from the two-weeks summer school that we conducted in Summer 2023, and an example of the outcomes of the 2024 summer school, which followed the same model, but compressed in one week, and for which you can read more in one of the other project's handbooks, in the *Section 3: Creating Meaningful Challenges for CBL courses*.

In both cases, we will not include the full products of the students' work, since they were not intended for publication; rather, we will just include some extracts of their work, commenting them. We hope you enjoy the reading!

2023 Summer School

For the 2023 Summer School, we asked students to produce two artifacts: a 10' presentation that summmarised their journey on the challenge, and containing a Minimum Viable Prototype (MVP) of their solution, and a short reflective report.

The presentation was in a guided, "closed" format: students were asked to roughly retrace their steps in the summer school. This, in practice, required the students to discuss their identified problem, their proposed solution, the needed resources to implement it, and the impacts that they foresee.

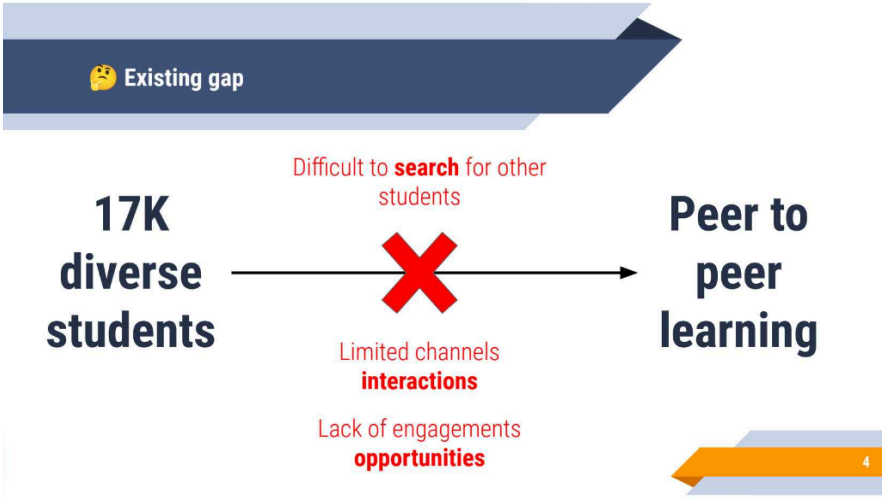
Kiron Challenge

We consider the work of students on this challenge one which had a neat fit between our expectations of how it could be developed, and the solution that the students proposed. Our ethnographical study also showed that this team was effectively able to cooperate, identify the problem, and propose a solution.

In the following slides, taken from the students' final presentation, you see how, for their problem/opportunity statement, the students decided to adopt one of the classical strategies of entrepreneurial thinking: they dually framed one of the main features of their challenge provider as one of their issues — and also as one of their opportunities.

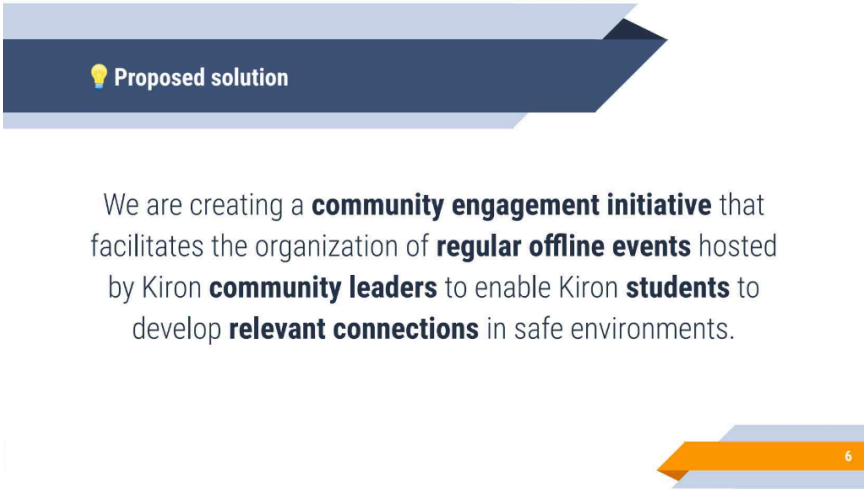
In practice, they focused on the idea of diversity in online learning: Kiron, as a large online platform, is home to a host of highly diverse students, but the "MOOC" format of the platform makes it challenging for them to connect with each other.

Notice here how they framed the problem...

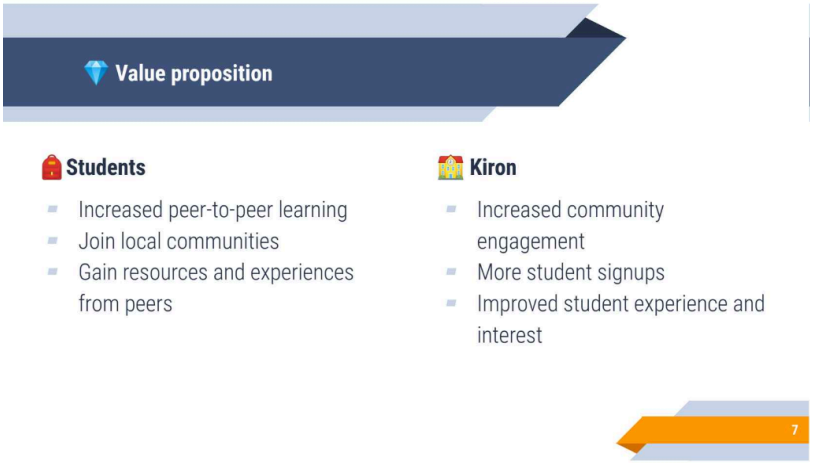


…reframed it as an opportunity…

…and finally transformed it into a solution that logically flows from the premises…



…with a matching value proposition:



The students, in their report, comment the solution in this way:

For our students, this new avenue offers manifold benefits. It not only accentuates peer-to-peer learning but also allows them to assimilate into local communities more seamlessly. Moreover, by immersing themselves in these gatherings, students stand to gain invaluable resources and insights from their peers, enriching their academic and personal trajectories.

From Kiron's perspective, this initiative is a stride towards nurturing deeper community engagement. By creating these offline touchpoints, we anticipate a surge in student sign-ups, indicating a broader reach of our mission. Furthermore, the enriched experiences that these events offer promise to elevate the overall student interest and their satisfaction levels with our offerings.

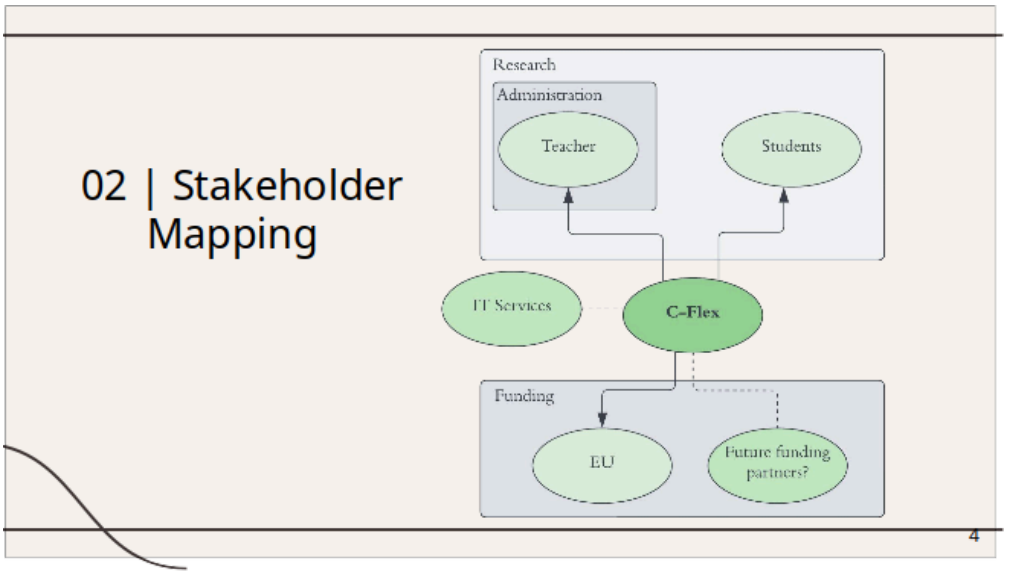
C-FLEX/U-Hopper Challenge

This is, instead, one of the challenges that was harder to understand, both for the students and mentors. In our ethnographical study, we see that the team that worked on this challenge also somewhat struggled to make sense of it, and had trouble navigating the challenge's landscape. In spite of these challenges, however, we think the final solution worked out quite interestingly!

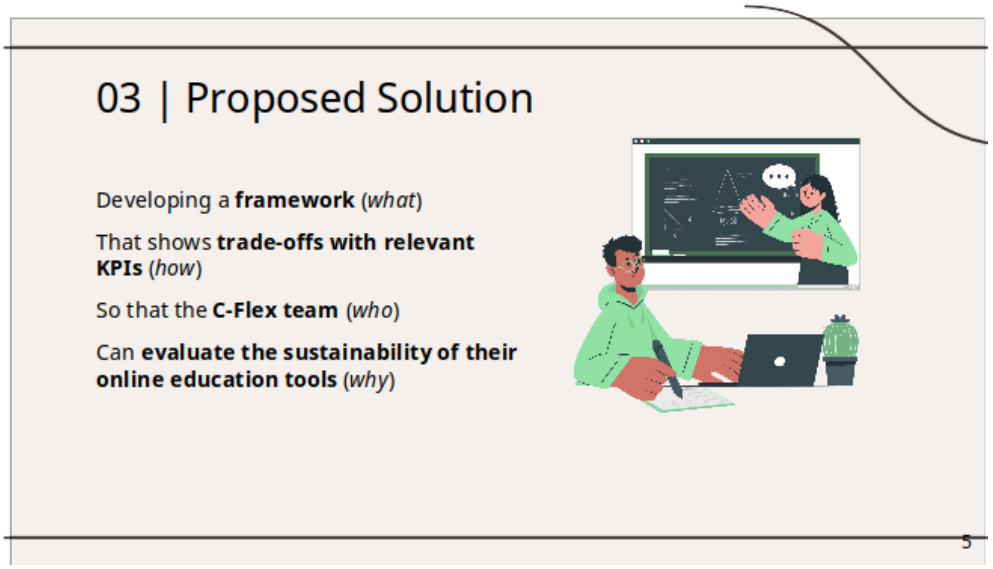
In the slides, you can see how the work of the students relies more on an "emergent leadership" and "sensemaking" pattern: rather than following tightly the proposed presentation scheme as for the team before, the students adopted a "low-hanging fruit" approach, applying their pre-existing knowledge in the form of close-ended exercises to build a possible solution.

The final outcome was more abstract compared to the previous one: a prototype of a framework for the analysis of sustainability of digital education solutions.

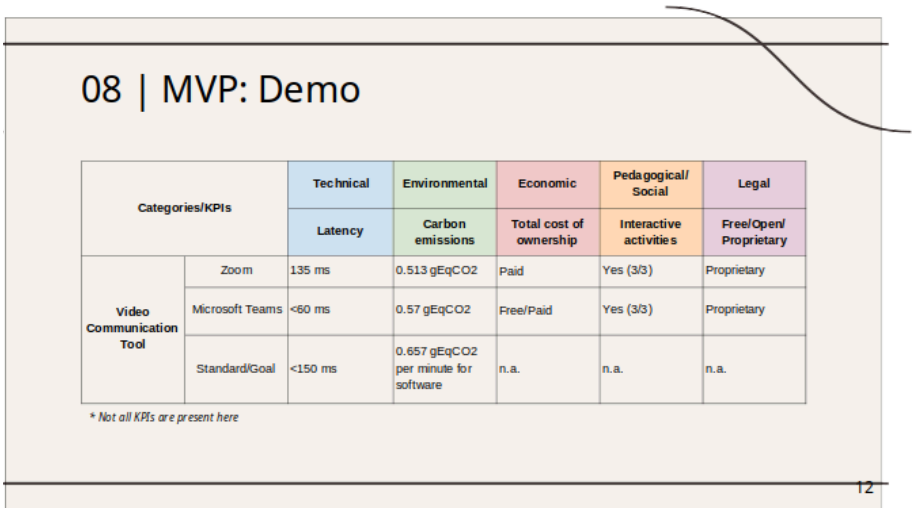
Their problem framing already takes the form of a structured exercise: a deductive stakeholder mapping.



Their solution applies the stakeholder mapping (in part) to solve the initial challenge's formulation…



…and their MVP, which takes, once more, the form of a structured exercise:



Categories/KPIs		Technical	Environmental	Economic	Pedagogical/ Social	Legal
		Latency	Carbon emissions	Total cost of ownership	Interactive activities	Free/Open/ Proprietary
Video Communication Tool	Zoom	135 ms	0.513 gEqCO2	Paid	Yes (3/3)	Proprietary
	Microsoft Teams	<60 ms	0.57 gEqCO2	Free/Paid	Yes (3/3)	Proprietary
	Standard/Goal	<150 ms	0.657 gEqCO2 per minute for software	n.a.	n.a.	n.a.

** Not all KPIs are present here*

In their report, the students comment their solution in this way:

The primary takeaway from this endeavor is the realization of the intricate interplay between technical and social aspects within the realm of digital education. This interdisciplinary approach not only addresses technical functionality but also delves into the broader social dimensions of technology adoption. The framework's assessment of KPIs facilitates a holistic evaluation, fostering a conscious decision-making process. Through this project, we learned that sustainable digital education requires thoughtful consideration of diverse factors,

acknowledging that a well-rounded evaluation ensures that technical excellence harmonizes with societal and environmental responsibilities.

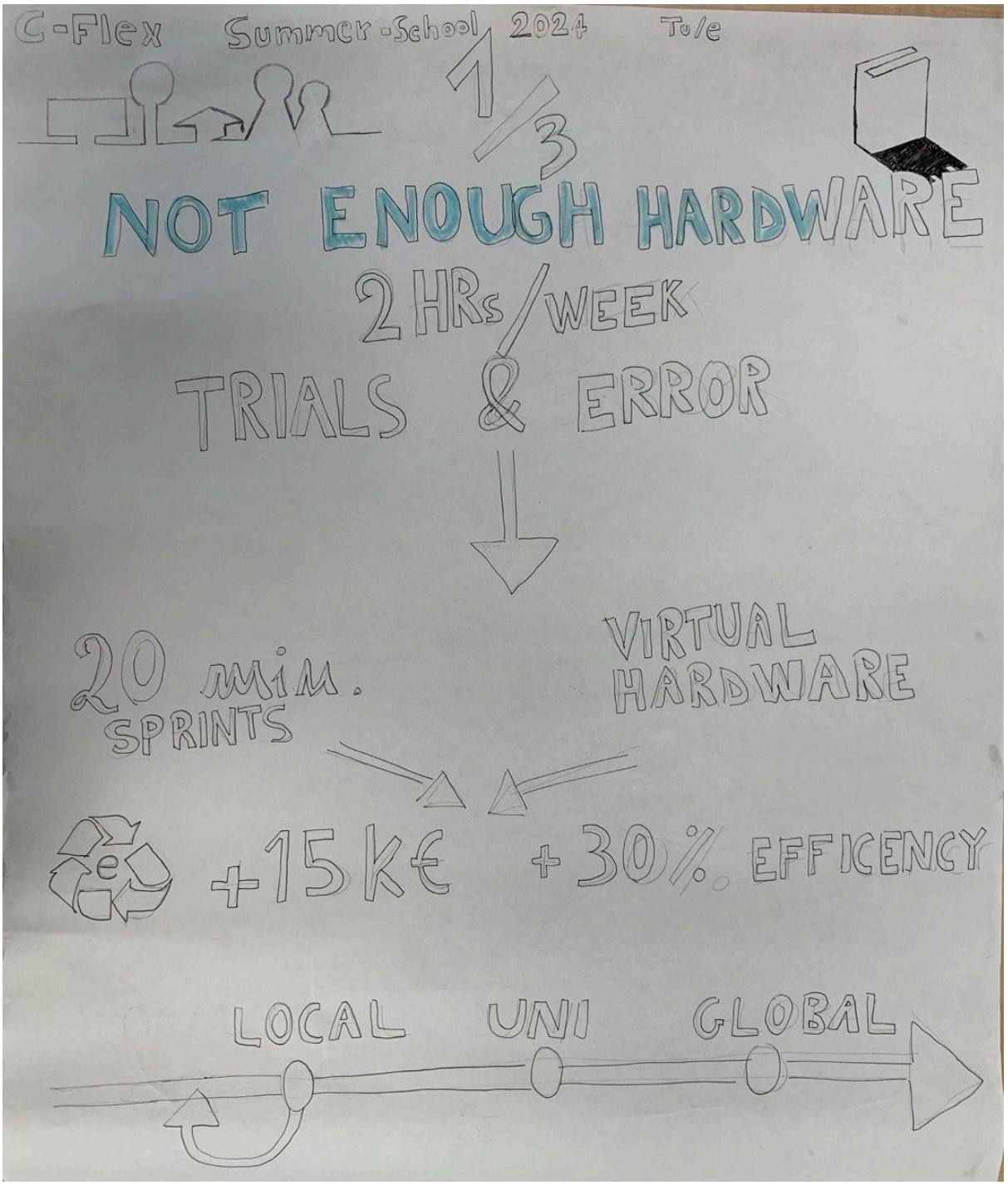
Showing that, in spite of the struggles they may have encountered in tackling the challenge, the students were able to clearly make sense of the overall project's context, and coping with what made the project itself a suitable challenge to begin with.

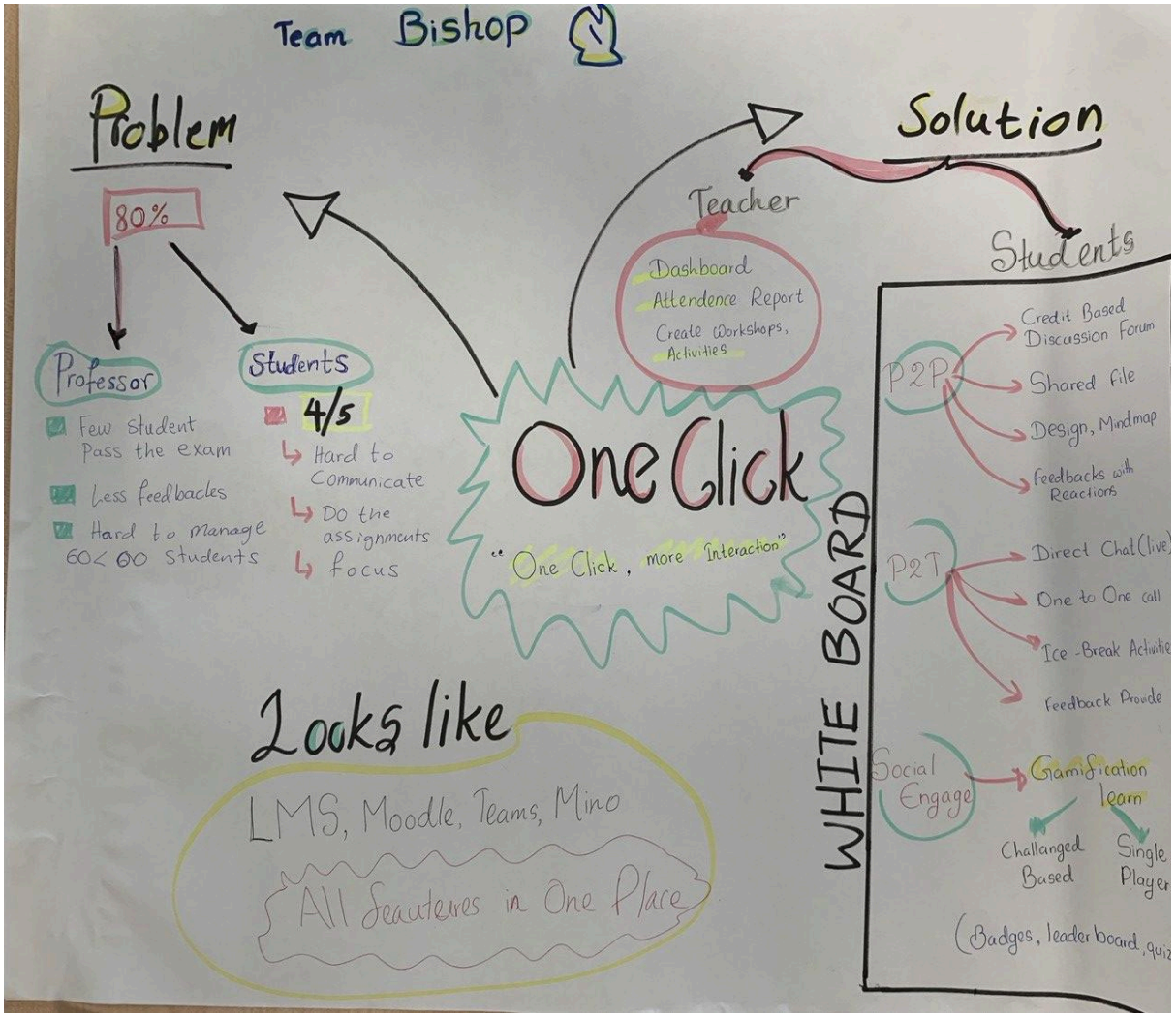
2024 Summer School

For the 2024 pilot, we tried working on a completely different approach in terms of deliverables. Rather than asking for a presentation and report, the students worked on making a pen-and-paper poster and a video. This, in turn, required that the students acquired an entirely different skillset, focusing not only on solving the challenge, but also on acquiring the necessary know-how to build their final deliverables.

As all students worked on the same challenge, we present here the example of the work of one student team.

POSTERS


C-Flex Summer-School 2024 Tu/e
1/3
NOT ENOUGH HARDWARE
2 HRs/WEEK
TRIALS & ERROR
20 min. SPRINTS
VIRTUAL HARDWARE
+15k€
+30% EFFICENCY
LOCAL
UNI
GLOBAL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80%
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Students
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Hard to Communicate
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Teacher
Dashboard
Attendence Report
Create Workshops, Activities
One Click
"One Click, more Interaction"
Looks like
LMS, Moodle, Teams, Mino
All Seauteres in One Place
WHITE BOARD
Students
P2P
Credit Based Discussion Forum
Shared File
Design, Mindmap
Feedbacks with Reactions
P2T
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Feedback Provide
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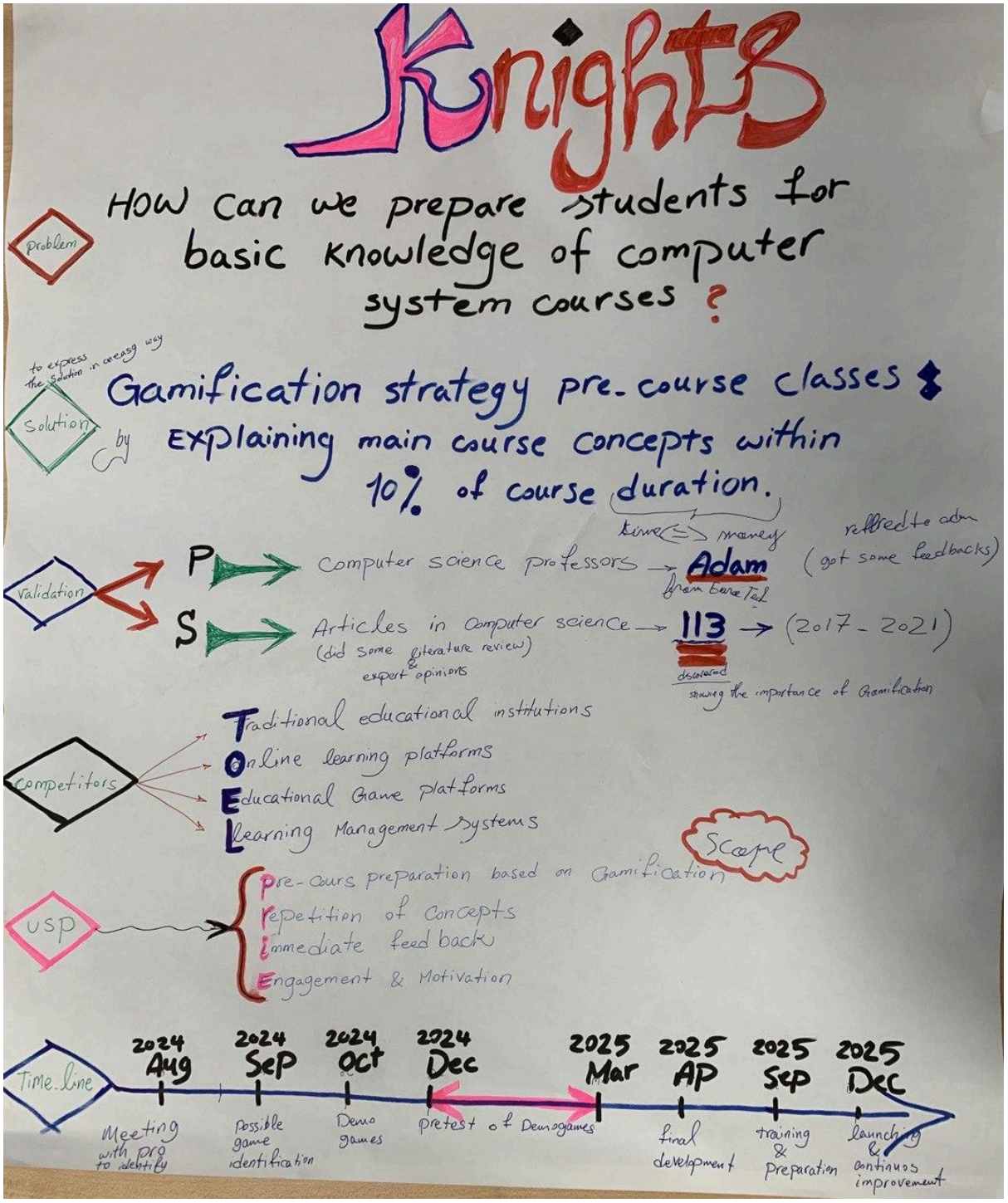
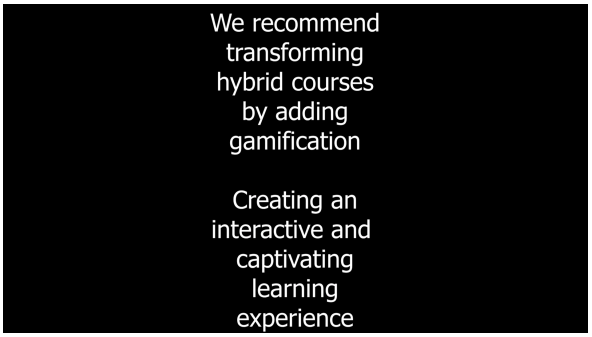
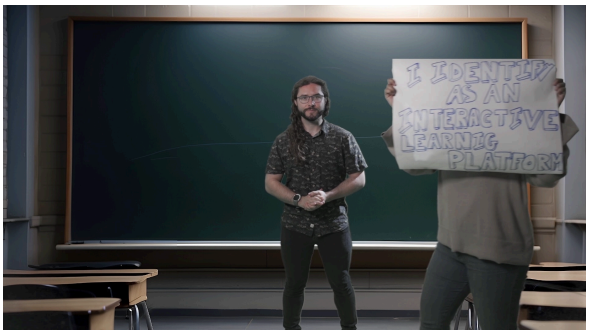

Knights
Problem
How can we prepare students for basic knowledge of computer system courses ?
to express the solution in an easy way
Solution
Gamification strategy pre-course classes by explaining main course concepts within 10% of course duration.
time <=> money
Validation
P
Computer science professors → Adam from Bare Tail
referred to adm (got some feedbacks)
S
Articles in computer science → 113 → (2017 - 2021)
(did some literature review) & expert opinions
dedicated showing the importance of Gamification
Competitors
Traditional educational institutions
Online learning platforms
Educational Game platforms
Learning Management Systems
Scope
USP
Pre-cours preparation based on Gamification
Repetition of concepts
Immediate feed back
Engagement & Motivation
Time-line
2024 Aug
Meeting with Pro to identify
2024 Sep
possible game identification
2024 Oct
Demo games
2024 Dec
pretest of Demogames
2025 Mar
2025 Ap
final development
2025 Sep
training & Preparation
2025 Dec
launching & continuos improvement

VIDEOS


We recommend
transforming
hybrid courses
by adding
gamification
Creating an
interactive and
captivating
learning
experience


I IDENTIFY
AS AN
INTERACTIVE
LEARNIG
PLATFORM


DISCLAIMER
EXAMPLE SOLUTION
MAY NOT REFLECT
REALITY

Conclusions

In this sub-handbook, we showed you some of the possible outcomes that can emerge from the process we described in the other sub-handbooks. As you have seen, the results are very different in medium, feeling, and more! They all, however, share the same genesis: the CBL structure that we piloted in the C-FLEX project.