FINAL DISSERTATION

Exploring Challenge-Based Learning in a summer school for students in technology: attitudes and pedagogical opportunities.

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Contents

Abstract

This research explores the competences and attitudes developed by students participating in a two-week Summer School program conducted as part of the C-FLEX European Project. The program centers on Challenge-Based Learning, with a special emphasis on tackling challenges related to digital sustainability in the technical field. It aims to highlight the current mismatch that exists between capabilities in innovation, entrepreneurship, and sustainability within the area of technological education.

The main aim of this research is to explore the competences that students have gained or are reflecting upon, as well as the emotional dynamics that are seen throughout their involvement and tries to build a fair narration of the events. The research approach adopted in this study is qualitative in nature, employing diaries as a means of continuous monitoring rather than discrete data collection.

The use of diaries enabled a comprehensive examination of complex stakeholder dynamics, developing perspectives, and areas of disagreement. Moreover, it enabled an examination of the evolution of an innovation and entrepreneurial mentality, together with the development of sustainable capabilities during the course of the program.

Key words

Summer School, Active Learning, Micro-Ethnography, Sustainability, Competences

1 Introduction

1.1 Contribution

This work aims to contribute by exploring the competencies and attitudes developed by students during their two-week experience in a **summer school** organized within the **C-FLEX European Project**, specifically in the context of **Challenge-Based Learning (CBL)** with a focus on **digital sustainability challenges in the technological domain**. The aim is to investigate the competencies students were able to develop or reflect upon, the emotional dynamics that emerged throughout the entire duration of the experience, and to experiment with a qualitative methodology that is typically used in other disciplines for ongoing tracking as opposed to a discrete data collection.

In essence, this work seeks to make three contributions: first, if it is possible to build a *fair narration within the setting of a CBL summer school and what impact social dynamics and emotions had on the whole experience*; second, *what attitudes could be cultivated within this framework in the field of digital sustainability*; third, *what pedagogical opportunities and competencies have been developed by technology students in this specific context.*

1.2 Context and motivations

The technological environment is the focus of this research, and its motivation is **a gap between the educational landscape and the competencies required by the entrepreneurial and innovation sectors** where an urgent need to equip workers with the skills required to confront the new complexities, and challenges posed by wicked real-world problems, is highlighted [35] [86] [32]. These challenges require the capacity to take action that benefits both people and the planet while striving for prosperity, resulting in a transformation of society that will resonate with future generations [19] [87]. It is imperative that these competencies are flexible and adaptable, capable of responding promptly to the continuous and unpredictable changes in the ever-evolving environments, thereby ensuring sustainability not only for individuals but for society as a whole [98].

Education plays a crucial role in developing the mentioned essential competences. **Education for Sustainable Development (ESD)** emerges as a proactive response to the growing sustainability challenges in this context. ESD takes a holistic approach to problem-solving, emphasizing the development of critical thinking and systemic, future-oriented thought. In addition, it acts as a catalyst for translating these competencies into concrete actions, fostering the development of modern frameworks, like the **GreenComp**, applicable across all age groups and educational settings allowing to bridge the spheres of technology, education, and sustainability by forging a vital link that has the potential to reshape our approach to these interrelated fields [99] [98] [47].

To facilitate students' exploration and engagement with wicked, real-world challenges and the development of competencies, a strategic decision was made to employ an active learning approach. In particular, CBL was utilized to allow students to immerse themselves in an enriching context: a multicultural, multidisciplinary summer school with a focus on digital sustainability. This approach enabled students to experience learning within a different context for a prolonged period of time while engaging in extended interactions with peers from diverse regions and engaging with mentors and educators, thereby facilitating the exchange of experiences, knowledge, skills, and dispositions.

Due to the extended duration of this immersive experience and the desire to document the individual emotions and thought processes of each participant, **personal diaries** were used as a sampling method. This approach enabled the gathering of inter-personal dynamics and complex, in-depth, contextually pertinent data, as is typical in social science and in the medical field [81] [49] [38].

1.3 Analysis and Results

The collected data were **coded and cross-referenced** with information gained through different checkpoints, fieldnotes, and other supplementary materials produced throughout the summer school, like posters, drawings on whiteboards, photographs, and audio recordings, enriching the qualitative dataset and providing a comprehensive view of the experiences and reflections of the students during their participation in the program.

The analysis of the data shows that students developed **distinct attitudes based on the groups to which they belonged**. Social dynamics were crucial in forming these attitudes, and each student's profile reflected a particular confluence of experiences and influences. The incorporation of diverse cultural perspectives enriched the summer school's overall experience by adding depth and variety.

Students who participated in the program had the opportunity to **leave their comfort zones and adopt an entrepreneurial mindset**. Communication difficulties inherent in the decision-making process necessitated internal organization and a distinct division of duties and responsibilities. It fostered adaptability to group dynamics and a propensity to compromise, despite differences in behavior. It also increased awareness of personal limitations and encouraged exploration within a futuristic, immersive, multidisciplinary environment. Here, the generation of ideas and the dynamics of relationships were not imposed but rather encouraged through direct confrontations and open dialogue.

The common CBL recurring problems within the literature were found [44]. It also facilitated the development of a unique relationship dynamic among students, instructors, and mentors. This dynamic transcended the traditional learner-expert divide, thereby fostering an environment in which **sharing and collaboration were of the highest priority**. Humanity and mutual respect dominated the scene, nurturing meaningful connections between participants and fueling innovation and progress.

In addition, this work shows how, within this complex educational setting and **pedagogical framework**, students were able to not only cultivate GreenComp skills but also reflect on them, cultivating and refining them through collaborative workshops and interpersonal relationships, emphasizing the practical application and experiential learning that the summer school offered. The information garnered directly from the students, primarily from their personal diaries, proved indispensible for understanding these nuanced and personal developments in a continuous manner. This method also allowed for the reconstruction of the diverse perspectives and narratives of the students' experiences, demonstrating the significant value of this qualitative methodology in the technological field's and how this approach can effectively document the evolution of competencies and attitudes over time.

1.4 Structure of the thesis

The thesis is divided in the following way:

- *Chapter 2 - State of the art*: Examines the technological domain, identifies competence gaps in sustainability, discusses constructivism, active learning, and the chosen research methodology.

- *Chapter 3 - Description of the case*: Provides pedagogical background on the case, how the experience was designed and the rationale behind the choices.

- *Chapter 4 - Research Methodology*: Describes the qualitative inductive approach and details data gathering and analysis methods.

- *Chapter 5 - Results*: Presents quantifiable research findings.

- *Chapter 6 - Discussions*: Qualitative analysis of research outcomes, including pedagogical opportunities and insights.

- *Chapter 7 - Conclusions*: Summarizes key findings, final reflections, and suggests potential future research.

2 State of the art

This work transcends traditional computing boundaries, influencing not only the field of engineering but also technological one. This chapter goes on a journey to investigate the transformative developments in computing education and the evolving learning methodologies, focusing on the innovation that is reshaping the way students are taught, equipping them with competences needed for approaching future and present challenges.

Furthermore it tries to provide a picture of a part of the evolving landscape, focusing on the emphasis on active, sustainable, and high-quality teaching methods. These changes are a result of the evolving needs and demands of the technology industry, which relies on education to bridge the divide between its needs and the skill sets of prospective professionals.

In this document, students specializing in computing and those focusing on technology are regarded as belonging to the same category. This approach is adopted because the distinction between these two disciplines is frequently fuzzy, and they are both closely related to technology and computation. Consequently, any documents encompassing comprehensive categories within the computing domain can also be applied to the technological domain, and all the research and work presented in this dissertation can be regarded as applicable to both areas.

2.1 Domain

The **Computing Curricula 2020 (CC2020)** [35] document contains profound insights that act as the basis for the work presented in the following sections and is essential to comprehending the dynamic and ever-changing nature of the field of computing.

What it wants to share is that, in an era characterized by constant technological advances and paradigm shifts, the definition of computer science is anything but static; it fluctuates in response to the ever-changing landscape of education, the diverse range of computing disciplines, and the ever-changing demands of industry. Today, computer science is not a singular, rigid approach; rather, it is *a complex ecosystem consisting of a range of disciplines and sub-disciplines.*

Professionals are required to possess a variety of skills and competencies within this amount of computational knowledge. In addition to mastery of specific technical domains, a successful computing professional must demonstrate problem-solving expertise, critical thinking skill, effective communication competencies, and the capacity for seamless teamwork.

2.2 Computer Science: competences to develop (CC2020)

Figure 2.1, taken from the document, shows visually the complex landscape of distinct disciplines identified within its pages. This diagram effectively represents the intertwined boundaries between these various domains, emphasizing the expansive character of the computing field. Consequently, one might perceive the definition of computing as an expansive and encompassing category, capable of accommodating a diverse array of sub-disciplines and specialties. A very brief summary of the main points of the different disciplines:

- **Computer Engineering (CE)**: focus on integration of hardware, software and signal processing;

- **Computer Science (CS)**: focus on developing conceptual foundations on computation;

- **Cyber Security (CSEC)**: focus on safety, security and continuity within systems;

- **Information Systems (IS)**: focus on discovery and implementation of organizational changes through computing;

- **Information Technology (IT)**: focus on the building and maintenance of computing infrastructures;

- **Software Engineering (SE)**: focus on development and implementation of large scale software;

- **Data Science (DS)**: focus on large scale data management, storage and retrieval.

The interconnection of various fields within the domain of computing is a fundamental and overarching theme interlaced throughout the entire document. The conventional notion of vertical curriculum development is being replaced by a more horizontal, transversal approach. In this paradigm shift, curricula transcend traditional boundaries, allowing for the sharing of courses and learning objectives across disciplines.
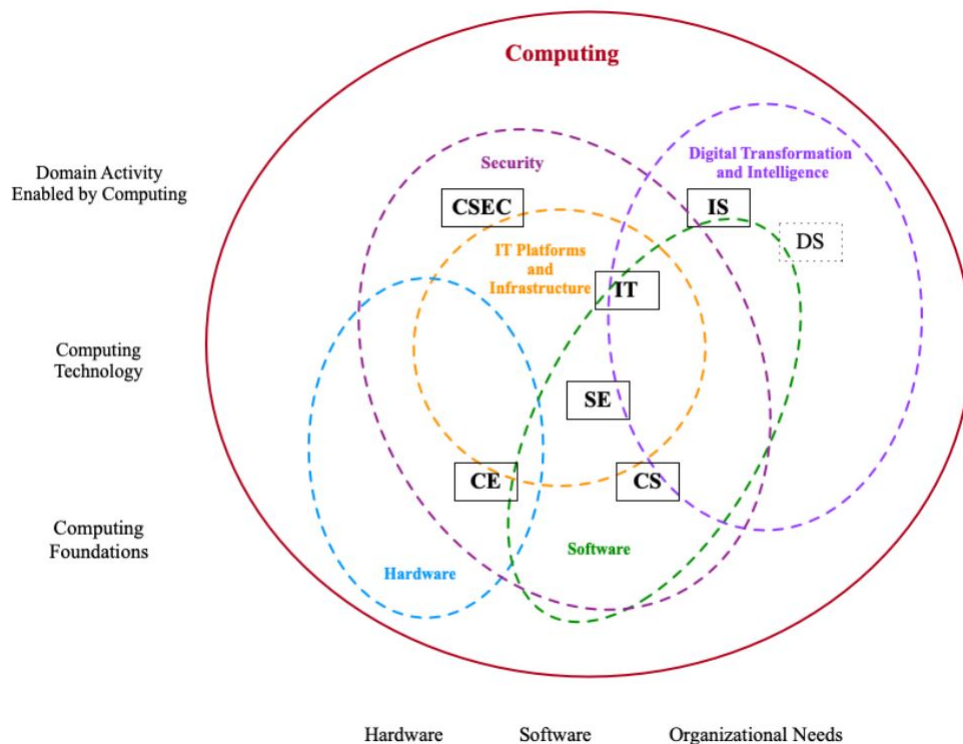
Figure 2.1: A contemporary view of the landscape of computing education from [35]

2.2.1 Competency

Within this complicated landscape, a paradigm shift took place within the CC2020 taskforce: it transitioned from a knowledge-oriented model to one centered on competencies. The document posits that this concept is far from new, dating back to the time of the Giza Pyramids, when competence included a combination of knowledge and various skills. The document then provides a concise definition of competency:

$$Competency = [Knowledge + Skills + Dispositions] \; in \; a \; Task \tag{2.1}$$

Knowledge. The first term in this expression is Knowledge, also referred to as "Know-What". It relates to the understanding and awareness of concepts and content. Typically, knowledge is meticulously detailed within curricula and balanced within academic programs. A crucial distinction exists between *competence*, which is composed of multiple components, and *knowledge*, which by itself is considered "static and inert," requiring the application of skills to be actively utilized and advantageous to a community. Three categories of knowledge are identified: *disciplinary* (pertaining to the academic program), *foundational* (typically acquired through baccalaureate education), and *professional*.
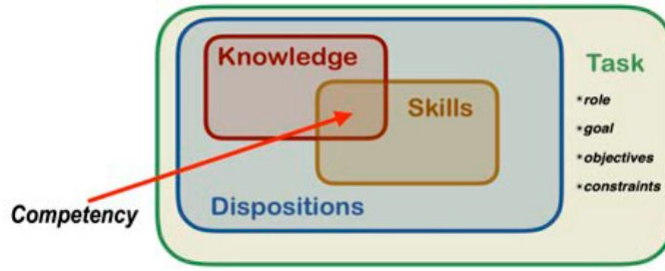
Figure 2.2: Conceptual structure of the CC2020 Competency Model from [35]

In academia and universities, the transfer of knowledge has been a longstanding practice involving textbooks, lecture notes, and exams, as characterized in the guide as the "classical mode for student learning". However, modern technologies such as the Internet provide additional opportunities for acquiring knowledge, such as video, audio, wikis, and experiential learning. In addition, classroom learning frequently entails the transfer of knowledge between student groups. In this context, the boundary between knowledge and skill may blur, as learning to research, explore, and communicate knowledge to others is classified as a skill.

Skills. The second component of the formula is Skill, also denoted as *"Know-How"*. Skills are the capabilities and strategies necessary for interacting with others, and their development takes considerable time and effort. There may be instances where knowledge and skills overlap when the latest ones require a specific element to act upon. Transferring skills is inherently more difficult due to the long process and error-prone nature of their development. Nonetheless, it is essential to outline skill development at the outset of the curriculum and evaluate their effective acquisition at later stages.

Dispositions. The third element in the formula is Disposition, also known as *"Know-Why"*. Dispositions comprise socio-emotional skills, behaviors, and attitudes that define a person's temperament and influence their decision-making when and how to complete a task. Developing dispositions necessitates the concurrent application of knowledge and skills. Choices regarding values and their application within a given context are essential aspects of disposition development. The influence of culture, personal behaviors, and experiences further complicates this process, making disposition transfer more difficult. One suggestion within the document is that cross-disciplinary courses could facilitate the development of diverse dispositions, knowledge, and skills and, in addition, a greater emphasis on social science and psychology courses may contribute to the development of dispositions. However, effective disposition transfer and development can only be accomplished through continuous practice across multiple domains and the progressive accumulation of context-specific tasks.

Task. The final element, encompassing all the aforementioned components, is the task itself. It is within the context of the task that these three elements - knowledge, skills, and dispositions - are concretely applied, leading to efficient and effective task completion.

2.3 Competences and Skill Gap

In this Section, an extensive approach to gaps related to Computer Science and Technical related curriculum can be found with major emphasis on the concept of Sustainability and Green Competences within the Innovation and Entrepreneurship framework.

2.3.1 Innovation and Entrepreneurship within CC2020

Within the context of CC2020, significant definitions that supports the development of transversal competences and a multidisciplinary perspective are the ones of innovation and entrepreneurship, developing a view of a technological expert in various fields instead of only one.

Innovation, which can be defined as *"the process of translating an idea or invention into a good or service that creates value or for which customers will pay"* necessitates the combination of diverse

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competencies to address specific societal needs. By their very nature, innovators engage in dynamic and frequently incremental processes, but they also have the potential to challenge established paradigms. Entrepreneurship is the *"capacity and willingness to develop, organize and manage a business venture along with any of its risks in order to make a profit"*. It is a driving force that propels innovation and causes fast transformations in the global marketplace. Consequently, students are compelled to cultivate a distinct mentality that allows them to concurrently assess a multitude of imminent trends while comprehending the ever-evolving environmental landscape. This multidimensional perspective enables learners to recognize opportunities and is rooted in the decisions and proactive actions of those who seek to effect change [46].

In this educational context, educators are in a position to transmit dispositions and cognitive processes to students, cultivating the development of innovative ideas and empowering them with the necessary skills for future careers. In doing so, it fosters the growth of well-rounded individuals who are capable of initiating novel ventures and navigating the complex challenges of a constantly evolving professional landscape [28].

2.3.2 Sustainability

What is less considered within the CC2020, are *modern challenges that industrial environments are facing*. In particular, the following are beginning to take up a central position in all discussions: sustainable development within complex, real-world environments, where equality and social justice, respect for cultural diversity, shared responsibility, and international solidarity. These issues transcend ordinary knowledge and expertise in isolated domains; they represent a growing demand for socio-cultural competencies that the industry increasingly expects and requests from educational institutions [88].

In the document titled *"Identifying Non-Technical Skill Gaps in Software Engineering Education: What Experts Expect But Students Don't Learn"* [54] three crucial non-technical skill and competence gaps have been identified as prerequisites in the software engineering field, but their provision within education extends to other computing disciplines:

- **Commitment to autonomous and continuous learning**: the industry seeks professionals with an ongoing dedication to lifelong learning and the self-motivation to continuously acquire new skills and knowledge;

- **A multiperspective problem-solving approach with a creative spirit**: a holistic perspective on problem-solving, coupled with an aptitude for creative problem exploration and resolution, is highly valued in today's dynamic environment;

- **Solution-oriented thinking with practical implementability**: professionals are expected to think not only analytically, but also with an emphasis on pragmatic, implementable solutions for real-world scenarios.

Furthermore, there is a specific emphasis on educational environments to teach soft and interpersonal skills, called also "practical" skills [86], necessary for an effective collaboration and communication, which can be considered as crucial in working within teams and engaging with people from different fields of work.

Understanding the gap in sustainability competencies demanded by the industry is made more difficult by a shortage of exhaustive studies and documents outlining their specific requirements. The research on [48], conducted in conjunction with a major corporation, identified several educational curricula deficiencies:

1. **Critical Thinking on Complex Sustainability Issues**: The capacity to analyze complex sustainability problems critically and comprehend their interrelationships with other systems;

2. **Problem Formulation and Communication**: Proficiency in articulating sustainability problems and challenges and communicating them effectively within the organization and with external partners;

3. **Understanding Megatrends and Disruptive Drivers**: Knowledge of identifying megatrends and the key drivers of disruption, such as climate change, demographic shifts, and food availability;

4. **Qualitative and Quantitative Competence**: Competence in qualitative and quantitative aspects of sustainability issues, as well as the ability to develop solutions;

5. **Communication with external parties**: knowing how to engage with experts and when to seek assistance and what type of understanding can bring to the solution.

2.3.3 Addressing the Gap

To address these competency deficiencies, a list of essential skills and abilities for facing real-world, complex challenges was developed. Among these, interdisciplinary courses play a crucial role in fostering multiple perspectives and systemic thinking. In accordance with the concept of trans academic education, these courses provide students with the flexibility necessary for adapting to change and the ability to collaborate effectively. In this educational approach, scholars collaborate with non-academic stakeholders at various project stages, necessitating negotiation skills. These real-world opportunities enable students to bridge the divide between sustainability knowledge and action. In addition, they immerse students in professional and civic environments where they can develop their values, perspectives, strategies, and decision-making skills. This is especially important due to the complexity and wicked nature of sustainability problems, as it allows students to engage, explore and investigate them [32].

In conclusion, the literature [32] identifies three distinct clusters of essential competencies crucial for promoting sustainability in the industry, all of which align with the CC2020 principles:

1. **Strategic knowledge (Knowledge)**: Strategic knowledge comprises a set of competencies that are systemic, anticipatory, normative, and action-oriented. As articulated by academics such as de Haan [41], Grunwald [55], and Wiek [104], these competencies include both content knowledge and methodological expertise. Within the domain of strategic knowledge, one must be able to comprehend and analyze the status quo by viewing it through the lenses of the past, present, and future. In addition, this knowledge entails the ability to navigate the diverse landscape of opinions, perspectives, facts, preferences, and strategies, which are all essential for effective future planning.

2. **Practical Knowledge (Skills)**: Practical knowledge revolves around the acquisition of competencies essential for bridging the divide between knowledge and action in the pursuit of sustainable development, echoing van Kerkhoff and Lebel's remarks [32] [101]. This type of knowledge necessitates the practical abilities necessary to connect theoretical insights with real-world applications. It requires taking actionable steps to evaluate the viability and practicability of potential solutions in a variety of contexts of decision-making.

3. **Collaborative (Skills and Dispositions)**: Collaborative competence encompasses a comprehensive set of skills and attitudes that promote effective engagement with stakeholders, the development of shared vocabularies, and the facilitation of participatory research and decision-making processes. This approach to collaboration encompasses partnerships with experts from academia, industry, government, and the public sector. It is underpinned by a value system that places an emphasis on collaboration and encourages the development of an in-depth understanding of sustainability issues, such as solidarity and environmental protection. Ultimately, collaborative competence functions as the driving factor motivating students to actively engage in sustainable projects.

UN Goals and UNESCO. Agenda 2030 presents a unique opportunity to promote sustainable development [48], as articulated in the official website as "a plan of action for people, planet and prosperity" [19].

The concept of **"sustainable development"** is not a recent addition but was first delineated in 1987 by the World Commission for Environment and Development (WCED). The United Nations Economic Commission for Europe (UNECE) refined it as a

> *" strategy for Education for Sustainable Development as being underpinned by an ethic of solidarity, equality and mutual respect among people, countries, cultures and generations; it is development in harmony with nature, meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. "*

[99]

Indeed, the concept of sustainability is deeply ingrained in our consciousness, but the implementation strategies continue to evolve in response to the diverse requirements of societies. Adopting a strategy of continuous learning indicates that environmental conservation is no longer solely a concern for future generations; but can be considered as an imperative matter that requires immediate attention from the current generation in the current socio-environmental context, as stated by UNESCO:

> *" Sustainable development requires us to acknowledge the interdependent relations between people and the natural environment. This interdependence means that no single social, economic, political or environmental objective be pursued to the detriment of others. The environment cannot be protected in a way that leaves half of humanity in poverty. Likewise, there can be no long-term development on this depleted planet. "*

[97]

Solutions to this challenge should therefore go beyond sectoral adjustments thus representing a societal transformation, an economic shift that paves the way for future generations' ecologically sustainable development. These adjustments must incorporate the entirety of society, not limiting to individual level [87]. Furthermore, the ability to adapt to crises is crucial, as evidenced by the 2020 COVID-19 pandemic, which exposed the fragilities of our modern systems. It highlighted the continuous and unpredictable changes in our environment and the susceptibility of our ecosystems to potential, unanticipated threats. [98].

In this constantly changing environment, education plays a central role in determining the future providing students with the essential tools and knowledge required to navigate novel and complex challenges, thereby facilitating a thorough understanding of the upcoming reality. Particularly, sustainability competencies emerge as a keystone in building a better world for the future and fostering the foundations of a sustainable society [48]:

> *" It is widely agreed that education is the most effective means that society possesses for confronting the challenges of the future. "*

[96]

This transformational transition is already occurring in the education sector. Through experiential learning with an emphasis on multidisciplinary approaches, schools are actively indirectly cultivating an entrepreneurial mindset. To instill in students a profound sense of awareness, they are establishing collaborative workgroups to resolve both open and complex real-world challenges and Education for Sustainable Development is the common name for this educational paradigm [59].

ESD-Education for Sustainable Development.

> *" Education should play an important role in enabling people to live together in ways that contribute to sustainable development. "*

[99]

Education for Sustainable Development (ESD) is a response to the urgent **need for education to address the ever-growing sustainability challenges**. It endeavors to foster a complete comprehension and increased awareness, which in turn triggers a transformative action-oriented pedagogical

approach. This transformational process contributes to the achievement of the *Sustainable Development Goals (SDGs)*, with a focus on Goal 4.7, where education can be considered as a promoter of sustainable *"lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity"* [98].

ESD, when implemented in a tangible manner, promotes the development of essential competencies like critical thinking and systemic and future-oriented thinking, and also functions as a catalyst for concrete actions [99]. This approach helps students with the ability to examine emerging technologies with a critical eye and to outline the steps necessary to shape a sustainable future [98]. This holistic perspective encompasses a comprehensive strategy for imagining change across the past, present, and future, enabling transformative actions that immerse students in the real world. It equips them with the skills necessary to analyze structural shifts while focusing on the opportunities and challenges posed by new technologies.

> *"This whole-institution approach to ESD calls for learning environments where learners learn what they live and live what they learn."*

[98]

This contextualized learning approach emphasizes that diversity among communities functions as an amplifier for sustainability, playing a major role in addressing complex, globally evolving challenges and this diversity should not be viewed as a source of problems, but as an important asset to be considered. Educators should therefore maximize the potential of this multidisciplinary diversity. Furthermore, in a world characterized by uncertainty and complexity, the demand for multiple perspectives becomes paramount. This requirement highlights the significance of cultivating *"transboundary competences"* [42], which encompass both **'learn-by-doing'**, in which students engage with real-world problems, and **'learn-by-reflection'**, in which students evaluate their actions critically as a means of continuous improvement. These competencies facilitate the generation of innovative solutions that address the complex problems of our time.

Approaching the mentioned considerations, the competencies that students should develop span a broad spectrum: critical and creative thinking, future-oriented thinking, decision-making, systemic thinking, and interdisciplinary abilities. Aspects such as contextual engagement, collaboration, dialogue, innovation, and active learning and participation are integral to this skill set. ESD is primarily driven by two of these competencies: interdisciplinary teaching and systemic reasoning. They enable individuals to engage in more holistic thinking, enabling them to dissect reality, establish interconnections across multiple dimensions (environmental, developmental, social, economic, and cultural), and contribute to real-world problems that impact society as a whole [36].

On the basis of these pedagogical principles, numerous frameworks have emerged with the overarching goal of cultivating a set of general competences, either in a broader educational context or within specific disciplines of study [36]. A notable example is the **KOM-BiNE framework** [87] (Figure 2.3), which centers around six fundamental actions distributed across three dimensions of action: *Knowing, Acting, Feeling, Valuing, Visioning*, and *Networking*.

Another interesting one is the one developed by Cebrián and Junyent [36] comprises several components:

- Development of different scenarios for future changes;

- Understanding the nature of a problem and its different dimensions within space and time;

- Understand that life is complex and try to identify connections between the dimensions of the problems, and try to recreate the dimensions within a school environment;

- Create the terrain for the development of critical thinking and create questions to identify trends and situations;

- Create awareness and participation for acting for a change;

- Identify, understand and clarify values;
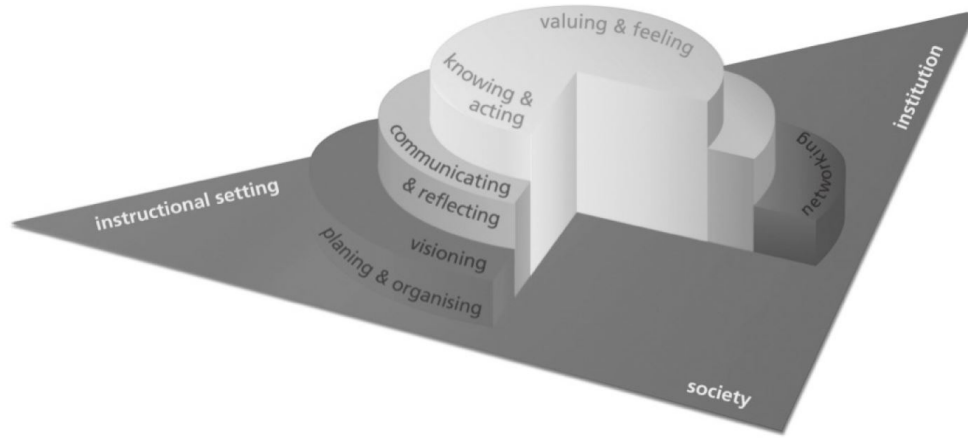
Figure 2.3: The KOM-BiNE model from [87]

- Create a dialogue between different disciplines that are interconnected between each other;

- Promote reflections and the management of emotions in front of problems and situations.

A comprehensive categorization of competences arises in the broader context of ESD, encompassing five macro categories: systems-thinking competence, anticipatory competence, normative competence, strategic competence, and interpersonal competence [105]. These competencies constitute a complete skill set necessary for effectively addressing sustainability's challenges.

GreenComp competences and a blink to a sustainable future. For allowing a greener and fairer transition to a green economy and society, the European Union developed a framework with the goal to create green opportunities and enable the development of competences within four sustainability areas for all the ages and in any educational setting. As stated by the document [47] the main values that provides are:

"

- *A model of sustainability competence areas and competences;*
- *A common reference that everyone working in education and training for environmental sustainability can use, share and refer to;*
- *An initial list of competence components, namely knowledge, skills and attitudes, as examples of how to put the competences into practice;*
- *A common reference basis for dialogue, exchange of practices and peer learning among educators involved in lifelong learning across the EU;*
- *A contribution to help make the competences portable and promote mobility in the EU for a full participation in European society.*

"

Figure 2.4, taken from the official document, contains all the areas and the description of the competences.

This section functions as the chapter's climax, providing a comprehensive understanding of the relationship between the domain of computer technology, or more generally, the technological landscape, and the realm of green competencies. It reflects the appeal for educational systems to respond to this demand by emphasizing the urgent necessity for businesses to develop these competencies within their workforce.

In today's complex environment, the issues humanity faces transcend the boundaries of any discipline: they can be considered as interdependent, complex, and multifaceted, traversing the fields of technology, ecology, economics, and society as a whole. As a result, cultivating green competencies in

Figure 2.4: GreenComp areas from [47]

the computer and technology domain is not a choice but a necessity for businesses seeking to thrive in a world that is constantly changing. Furthermore, it sets an undeniable responsibility on education systems to equip future generations with the skills and knowledge necessary to effectively address these interconnected challenges.

2.4 Teaching Methodologies

The purpose of this section is to establish a foundational understanding of active methodologies, with a particular emphasis on **Challenge-Based Learning**, the approach utilized during the summer school experience. It aims to investigate a methodology that effectively translates the previously mentioned industry demands into a pedagogical framework therefore providing a methodology to fill the previously mentioned gaps with attitudes and pedagogical oportunities.

One effective approach [43] is to equip students with the skills to confront complex problems and drive change within the domains of economy, technological innovation, entrepreneurship, and leadership, while simultaneously instilling a sense of sustainability. To accomplish this, a constructivist learning environment should be established, as traditional lectures cannot impart these essential competencies. Therefore, it becomes imperative to cultivate an entrepreneurial ambiance.

2.4.1 Constructivism

The origins of constructivism, though not precisely traceable, are commonly believed to have ancient roots, possibly dating back to the time of Socrates [23], an era in which communication played a central role in teacher-student interactions. It was believed that knowledge was constructed through a dynamic process involving questioning and interpretation.

Constructivism is linked with the processes of **learning and thinking**. According to Merriam and Caffarella [34], it is concerned with *"how people make sense of their experience"* and is not a static concept since it is constantly evolving. This viewpoint is articulated clearly by Potter who states

> *" The world [...] is constituted in one way or another as people talk it, write it and argue it. "*

[84]

Fundamentally, it is a social phenomenon, an ontological position asserting that their meanings are continuously influenced by social actors. They are not external occurrences that merely transpire; rather, they are actively constructed through interactions among individuals striving to fathom the

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world around them and these interpersonal interactions have the potential to impact an individual's experience[38].

This concept is heavily influenced by Vygotsky's 1978 work [103], which asserts that knowledge develops within a social context and within this context, social actors internalize and individualize knowledge in order to make it their own[23].

These educational principles are established in the academic literature and, as described in the article "Connectivism And Constructivism Approaches To Social Learning Theory" [40], they are a response to the imperative of adapting formal training to the ever-changing landscape of educational technology innovations[63] [92].

Within this academic field, "Review of Constructivism and Social Constructivism" [23] stands out as a particularly insightful literature review. This review examines the primary justifications and prominent authors, and serves as a resource for subsequent reasonings.

Hoover [58] asserted that learning is fundamentally a social process. In this paradigm, students construct new concepts, knowledge and comprehension by actively expanding on their existing knowledge base. This process embodies a cultural partnership in which learning is inseparable from its learning environment (Lave [65]; Brown et al. [31]). In this context, students become the architects of their own learning and experiences, utilizing their prior knowledge and experiences. This independence is the key to unleash the discovery of new principles.

So, learning could be described as a **social exchange and collaborative interaction** rooted in a particular cultural and historical context and it is regarded as a dynamic discovery process. Within this structure, the role of the teacher is to make clear to students that there is a body of knowledge upon which to build and to assist them in its application [76]. This viewpoint is consistent with Hoover's view that learning is not a passive activity, but rather an active process capable of dynamic transformation in response to new experiences or information.

A great summary of the principles of constructivism within education can be found within the Twomey Fosnot work [50]:

- The previous knowledge is the foundation of the learning process;

- Ideas are the result of transformation of ideas;

- Learning is the invention of ideas and not the accumulation of knowledge;

- Meaningful learning is the rethinking of old ideas and the creation of new conclusions which conflicts with the original ones.

These guidelines should serve as the primary structure for developing constructivist curricula [83]. Unfortunately, they are frequently neglected due to a lack of understanding and, consequently, a lack of awareness of their consequences. As described in Brown [30], when these approaches are misapplied, they devolve into a collection of inconsistent and confusing activities. In addition, they overlook critical discussions regarding the epistemological aspects of structuring or connecting these activities, and they lack the foundational principles that define the scientific community.

In the realm of social learning, two additional concepts come into play: *connectivism*, which emphasizes the significance of the ability to seek out existing knowledge while sifting through extraneous information [40], and a *multidisciplinary dimension* that promotes active interactions among participants, both with one another and with the environment they interact with.

In this complex environment, the opportunity for a social ontology study arises[38]. Such an investigation recognizes that researchers are an integral part of the world they seek to investigate and that their representations of reality are subjective and not exhaustive. In this context, knowledge is inherently subjective and not immutable and that

> " constructivist approach recognizes that the categories, concepts, and theoretical level of an analysis emerge from the researcher's interaction within the field and questions about the data "

[37]

2.4.2 Active and X-Based Learning

Active learning incorporates a variety of methodologies and frameworks that emphasize actively engaging students in the learning process, nurturing their individual and collaborative participation. It promotes the implementation of activities that encourage students to think critically about their learning experiences, and thus represents a departure from traditional teaching practices [78] [85].

Active learning is difficult to define in a precise way since it is interpreted differently across disciplines. Intriguingly, even conventional activities such as assignments can be considered active learning if they involve students in an active, participative manner as opposed to a passive, receptive one. It is a *multidimensional concept that can be approached differently by authors depending on the context*. It emphasizes student engagement and participation in the learning process, ultimately resulting in a deeper understanding of the topic [85].

Michael and Modell [73] have categorized a number of the most prominent **active learning strategies** as follows [72]:

- Problem-based / Case-based learning;

- Cooperative/collaborative learning and all types of group work;

- Think-pair-share or peer instruction;

- Conceptual change strategies;

- Inquiry-based learning;

- Discovery learning;

- Technology-enhanced learning.

Some of the strengths of the active learning are summarized below:

"

1. *Learning involves the active construction of meaning by the learner;*

2. *Learning facts ("what" - declarative knowledge) and learning to do something ("how" - procedural knowledge) are two different processes;*

3. *Some things that are learned are specific to the domain or context (subject matter or course) in which they were learned, whereas other things are more readily transferred to other domains;*

4. *Individuals are likely to learn more when they learn with others than when they learn alone;*

5. *Meaningful learning is facilitated by articulating explanations, whether to one's self, peers, or teachers.*

"

[72]

In light of the stated key principles, an array of **"X-Based Learning"** methodologies can be devised to steer learners towards enhancing their 21st-century competencies [21]. The term "X" can be supplanted with a wide range of descriptors, each of which focuses on a particular aspect of competency development: *Case-based learning, Challenge-based learning, Community-based learning, Design-based learning, Game-based learning, Inquiry-based learning, Land-based learning, Passion-based learning, Place-based learning, Problem-based learning, Proficiency-based learning, Service-based learning, Studio-based learning, Team-based learning, Work-based learning*, etc. [14].

2.4.3 Challenge-Based Learning

In the modern age, with modern technologies and new challenges - environmental and health ones - also learning is in constant change, starting from the research of enhancing learning in a variety of settings and bridging formal and informal learning experiences [81]. For this reason, there is a constant increasing adoption from engineering universities of active learning pedagogies, for the development of pedagogical and professional knowledge and skills [44] [95].

Here comes Challenge-Based Learning (CBL) [77]: *a pedagogical approach that engages students in active learning through wicked and real-world challenges.* This concept is considered successful thanks to the collaboration of all participants (students, teachers, mentors, companies) who aims at finding the *"Big Ideas"*, asking for the right questions, discovering and proposing a solution, while developing modern skills and knowledge through a *"Learn by doing"* approach[80].

Its origin could be found from a set of different educational theories and pedagogical methods, in particular as an evolution of experience-based learning [80]. According to the literature, the following evolutions were the pedagogical approaches known as Problem-Based Learning (PBL), Action Learning, Adventure Education, Simulation and Gaming. CBL is therefore described [69] as an evolution of PBL, with a particular focus on on entrepreneurial world and self-regulated learning, following the constructivist and sociocultural approach outlined in the preceding section: learning is active, relational, practical, and situated within the individual and the organization [66].

However, the framework that today is applied across the world, mainly emerged from the *"Apple Classrooms of Tomorrow-Today"* (ACOT2) of 2008 [25], with real exercises and suggestions on how to do it in a 21st-century learning environment.

Definition. CBL has no fixed definition, as said in the article Norrman et al. [80], but from the Systematic literature review done by Leijon et al. [66] emerges that *"the keywords mostly used in the publications where teaching and learning (32 publications), solve challenges (30), real-world problems (27), collaborative (25), and ask questions (22). This is probably due to the strong focus on education and learning through solving challenges or problems"*, and Gallagher & Savage (2020) [51] defined 8 points that characterizes CBL:

- Global themes;

- Real-world challenges;

- Collaboration;

- Technology;

- Flexibility;

- Multi-disciplinarity and discipline specificity;

- Creativity and innovation;

- Challenge definition.

One of the main aspects of this methodology is its cross-disciplinary characteristic, which deals with open-wicked, usually related with sustainability or real life problems [80] and through a learning process that allows students, in multidisciplinary teams, to take their way and innovate and create solutions. In the end, as a definition, cannot be excluded the one that Apple gave in 2008:

> *" Challenge Based Learning is an engaging multidisciplinary approach to teaching and learning that encourages students to leverage the technology they use in their daily lives to solve real-world problems. Challenge Based Learning is collaborative and hands-on, asking students to work with peers, teachers, and experts in their communities and around the world to ask good questions, develop deeper subject area knowledge, accept and solve challenges, take action, and share their experience (Nichols & Cator, 2008, p. 1). "*

Combining all the above mentioned, **CBL is an active, student directed instructional strategy** [93] in which teaching and learning happens in multidisciplinary, real-world problems, gaining skills and through collaborative work solutions could be elaborated and implemented in authentic environments. Or, in brief, as Pérez-Sánches et al. (2020) said that it *"actively involves students in real-life, meaningful and context-related situations"* (p. 6).

How it works. CBL starts with a challenge provided by an external *Challenge Provider*, usually open, based on real-world problematics and usually a wicked problem, a complex, unstructured problems with no visible right or wrong answers which cannot be solved once and for all, since they are in constant change [89]. Students have the freedom to choose how to tackle the challenge, on what viewpoints, on what kind of solution they wish to implement. The *CBL Guide* developed [77] can be considered as a very detailed guide on how to do CBL in class, based on the work done by Apple. In Figure 2.5 of the guide, the three main phases of the process are summarized.

Figure 2.5: CBL framework from [77]

The following will be a brief overview of the framework, but in Appendix A an infographic developed upon the two aforementioned documents gives a clear idea of all the phases in detail with some examples.

Engage. Through this first phase, students will develop a comprehension of what is required to work on, also implying developing a critical view on the challenge given, as well as exploring the problem space for discovering hidden problematics or the root cause within the definition of the challenge. Three phases could be found:

1. **Big Idea**: finding the broad concepts that are important on a global scale and that students could gain a deep multidisciplinary understanding on it.

2. **Essential Question**: From the big themes identified, students should create a set of questions which creates a link between the big idea and everyday life and that could be answered with research.

3. **Challenge**: From the questions developed a call to action could be developed from each one, and these definitions could lead to a solution to the original problem. It should be immediate and implementable.

Investigate. In this phase, students should identify the knowledge they need to tackle for their challenge, and so define activities and resources that they need access to, laying the ground for the challenge's solution.

1. **Guiding Questions**: Students are able to generate questions that identify the knowledge that will need to gain in order to design a solution.

2. **Guiding Activities**: Students, on the identified questions, should design or find a methodology for gaining that knowledge for developing an answer.

3. **Guiding Resources**: Are materials given to support the work of the students by the teacher.

Act. The last phase is where students start to identify multiple solutions, and need to narrow down to a small set and test and assess their validity for developing a final elaborate. The guides suggest encouraging students to select only one solution to develop.

1. **Solution**: The students should choose one solution after having deeply researched and documented the steps to gain that solution. The essential idea here is to present this solution and to inform or convince people of its validity.

2. **Implementation**: A prototype of the solution is developed, tested and the outcomes measured.

3. **Evaluation**: Multiple implementations are compared and the problems are addressed. At this stage a final report is developed and presented.

The two guides also give methodological suggestions on how to perform or suggest tools for conducting the activities in an active environment. Some examples are: brainstorming, use of latest technologies, use working groups for developing a collaborative environment and help students in assigning themselves roles and tasks, schedule expectations by time and milestones.

In the end, this framework aims to break away from the traditional teaching, placing in the first rank active learning strategies for improving the learning process [75]. At the center of this approach there is the idea that students should make something happen throughout the process [62]. The next paragraph will discuss in detail the stakeholders and the interests that each one has in this experience, try to identify possible conflicts, and the benefits and drawbacks of this framework.

The Stakeholders/Perspectives. During a CBL experience, usually there are always three main parties involved, each one with its interests: the students, the teachers and the challenge providers.

Students.

> *" Students enjoy new and unrepeatable experiences. "*

[95]

During a CBL experience, students should be not only the learners, but at the same time they are in the lead of the experience, providing a perfect ground for developing a *T-shaped experience*, or so called horizontal one [95]. It is a self-regulated learning in a constructivist environment with the objective to successfully learn to navigate through experiences, to gain learning outcomes and build a network of new relationships [44]. They become the protagonists of the process, and become able to highlight their personal abilities, as well as flaws, to build something that does not exist and to be able to contribute to the community. At the same time a development of *soft skills* could be achieved, like working in groups, the importance of communication and relationship with other professionals, and to think critically when working within innovation fields [80].

Teachers. Teachers are a fundamental role, but this concept has changes from the idea of someone that transmits knowledge to *the role of a coach and collaborator* who helps students into the discovery process in order to become independent learners [44]. This role helps students to develop habits and new ways of thinking and learning. This is also a consequence of the nature of the wicked challenges: the teacher loses their absolute knowledge of experts, and also transforms themselves as a learner,

since they do not know the answer in priori, and look for their own solutions too [95]. Their new role also consists of making sure that challenges are well defined, giving students to reach the learning goals and to develop skills needed to the marked, and at the same time managing the relationships between students and challenge providers, keeping tight relations, as stressed by Gudonienè et al. [56].

Challenge Providers. They are the experts within the field and the ones that create the description of it. Their interest in engaging within universities, as explained in [80], refers to the need of being resilient and able to transform to changes of vary nature, like societal and ecological ones. One important statement is that the dimension of the company of the challenge provider is not demonstrated to be a crucial factor, instead it is the desire that challenges could lead to new input and innovate in a sector that the stakeholder can benefit from [68].

Stakeholders and risks.   Making a successful CBL experience needs three main ingredients [80]:

- Engaged students;

- Involved teachers and challenge providers;

- Interesting challenges.

Starting with the last point, in order to create an interesting challenge, teachers usually ask companies to create one according to their needs. This implies, as Membrillo-Hernàndez et al. [70] stress in their study, that *"[a] challenge is a real experience with a high level of uncertainty, designed to expose the student to a challenging situation in the real-world environment in order to achieve specific learning objectives"*. This creates **ambiguity**, which forces students to create points of contact with experts to gain knowledge to come up with a solution. The drawback of this opportunity is that ambiguity could also be a cause of frustration that could grow to force students out of their comfort zone, the development of hold complex and contradictory ideas and situations in the best case scenario, or drawn within the increasing complexity of the work to be done. Here it is the main role of teachers and challenge provider, being involved within the process and assuring that everyone is challenged and not drawing, helping within the development of navigating ambiguity, complexity and conflict and allowing a gain of confidence of their own abilities [80].

Within this learning environment, where complexity and uncertainty are predominant, it should not be a surprise that tasks could be difficult, creating tension and friction. In particular, two types of frictions could be identified [44]:

- **Constructive friction** where students feel that they have the competences to meet the requirements and subsequently develop skills like networking and ones related to multiple disciplines.

- **Destructive friction** here the environment does not provide support and students have problems with self-regulation and learning and at the same time fostering a sense of insecurity [79].

Another factor of risk is within the multidisciplinary aspect, where multiple competences and different backgrounds are involved at the same time and forced to collaborate within a team. Here different cultures could collide, and students and teachers could feel uncomfortable [95]. So, the ability of the teacher is to manage this complexity and manage the teamwork to help them to be comfortable within their groups, as Apple writes:

> *" [...] help students become comfortable in their groups, provide guidelines for how to divide the work and give students tools to make meaningful contributions to the success of the team. [...]*
> *Establish a safe space where groups can air issues they are having, and encourage them to work out differences in a positive way. Have each group draw up a contract or outline that clearly states team member roles and perhaps even rules for group discussions that are developed by the students themselves. "*

These are the most critical factors that also influence the final outcomes of the works: how much the students are engaged and how much they think their work is meaningful for making an impact [62]. These were the crucial factors that also meant more or less effort was made by the students for developing their work and managing time, and the role of teacher is fundamental as is able to redirect focus and energies for a better engagement [44].

Incidents. Being a complex framework within a dynamic context implies that incidents could happen, and will happen. Within the paper *"Analyzing student-teacher interactions in challenge-based learning"* [44] there is an analysis of the nature of the types of the incidents that could happen during the experience:

- Incidents could be related to the content of the course and *"how to apply ethics and data analytics in the challenge"*, perceived as unclarity.

- Incidents could be connected to the *uncertainty of the elearning process*, and how the open-ended challenges could be analyzed both as a group and individually, caused by a perception of lack of guidance by the teachers and challenge providers.

In particular the main problem is the openness and freedom that this type of framework could leave, and the lack of previous knowledge how to manage this freedom without any clear guidance and the limited timeframe. Also they give a list of the more common difficulties encountered:

"

- *Establishing an understanding as to what is expected in the course;*
- *Narrowing down the broad challenge to a specific problem to focus on and setting clear goals;*
- *Applying content knowledge (ethics and data analytics) to the challenge;*
- *Diving the tasks among group members;*
- *Managing the time;*
- *Managing group processes.*

"

Within these complications, the role of the teacher becomes a key role to provide support and help in making the necessary adjustments to complete the needed tasks, facilitating the competence transfer between the different students, where they were not capable of managing them.

Examples in the Literature. Examples of Challenge-Based Learning can be found throughout the educational literature, demonstrating its adaptability and versatility in a variety of settings. However, while CBL is prevalent in general, it can be difficult to locate specific examples of **CBL summer schools**, especially those with a **focus on sustainability**.

Typically, when researching CBL, one may encounter examples that are tailored to highly specialized disciplines, such as robotics [53]. These programs are intended to provide participants with in-depth knowledge and practical experience in their respective fields. Similarly, there are CBL initiatives crafted for doctoral students [82], which often feature rigorous prerequisites and target individuals pursuing advanced degrees.

Moreover, certain CBL programs have a distinct business emphasis [18]. In particular, these initiatives seek to resolve the challenges that businesses confront in the real world and frequently require a solid background in business concepts and management. There are also CBL programs with a focus on technological or environmental problems [100], which attract participants with an interest in these specific fields.

The peculiar part described in this study is its emphasis on digital sustainability education. This CBL initiative, unlike the preceding examples, focuses on the intersection of digital technology and sustainability. It brings together participants from various origins to investigate innovative solutions to urgent global challenges associated with sustainable education. This novel thematic approach distinguishes it from other CBL programs and makes it an important and valuable contribution to the literature on experiential and challenge-based learning.

2.5 Research Methodologies

This section's primary objective is to provide a thorough literature overview of the chosen qualitative methodology and the opportunities behind its selection. The objective is to develop a methodology that fosters a fair narrative, one that includes both the researcher's and the student's perspectives.

Specifically, an experience sampling methodology was implemented on physical diaries for a qualitative approach. The rationale for this selection is elucidated in 4, which contains the specific reasoning for this decision.

2.5.1 Diaries within Literature

Within the *Challenge Based Framework*, Apple [25] suggests to provide the students "the opportunity to document their personal and group experience" and suggests one methodology to do it: journals that could be created in multiple ways, digital ones and more traditional ones. This tool could be used in three ways within social research: as a method of *data collection*, where a structure is given and participants are asked to record on it; as a *document* and as a *log of activities* [38]. Through the following description of this methodology, we will refer to journals with the term of diaries, which better represent the main objectives of the research. Moreover, within the literature, the writing of an experience correlated with personal and emotional reflections, and less operative ones, is usually referred to as a diary.

Definition. The definition of diaries perfectly fits the apple definition: we can refer to *tools that are able to provide information on who writes them, their reflections, their context, their behaviors or the ones that are observing, their feelings, habits routines, values* and can be seen as a valid alternative to self completion questionnaires [57] [38]. Their use is not new, but could be dated back since the Roman Empire, but the modern idea of *"documents of life"* for analyzing social dynamics could be dated back to the second half of the eighteenth century.

It is widely considered among social scientists to be a tool able to provide individual and personal sensitive information and being able to control the research process while gathering data. It is widely used within the health environment, in particular as a tool able to **enhance participants' voices** and able to enrich the data and **making the participant the protagonist**, being in charge of the control of some elements of the process and somewhat balancing the asymmetry between researcher and participant, creating a place for collaboration [57].

We can mention two kinds of diaries: *unsolicited* ones that are written for personal reasons, and *solicited* ones that are requested by a researcher to participants that are aware of the research objectives, and are given guidelines on how the instrument should be used. The last one is seen as one of the main methods used within environments, also educational one, and is widely studied, experimented within the literature and proved as a valuable tool for a detailed description of everyday life[57].

Experience Sampling Methodology. The main way of utilizing diaries, is known as experience sampling or event sampling, and in the past years it has seen a rapid increase in its use for conducting **qualitative research**, where it is helpful for *studying inter-personal dynamics* and that is able to track the evolution through time and at the same time for its richness and depth of quality and quantity data [81] [49].

The idea is that diaries are able to capture feelings, emotions, behaviors, thoughts at the time they are happening, within a specific context, activities, personal conditions, essentially a subjective log of the experiences in life, and usually what appears is that data collected are more precise since

the participants do not have to rely on memory or constructing a retrospective reasoning for writing [102] [29] [38].

This contextualization of the data is the main reason for which experience sampling is chosen, since it provides complementary information that are difficult or needs a great work by the researcher to obtain, and at the same time reduces retrospection that causes memory errors or biases, depicts variations and dynamics over time on multiple angles of a person, for seeing growth over time [49][29].

Design, characteristics and pencil and paper. A famous guideline on how to prepare a research on diaries, is given by Corti in 1993 [39]: provide clear instructions to participants, provide clear timings on how the record should be conducted, provide a checklist of things to help people in writing, provide activities and designated moments to start or finishing a writing phase or simply for a check.

There are two main types of design of diaries [49]:

- Time based that focuses on processes of changes over time within a person. They could have a fixed schedule, but with the risks described of retrospection, or a variable schedule, but with the risk of participant burden.

- Event based where participants write to the diary once they meet the pre-established trigger given by the researcher. This is useful for having a map on a particular event, but the limit is the ability of the participant to identify the triggering events, so with a risk of omissions of data.

Widely discussed is also the format of the diaries, as for example a free-text format diaries within the educational field, or the **Paper and Pencil (P&P) format**, that has the advantage of being completely free as a format, being fast and a common way of taking notes [29].

The process could be facilitated also with the formulation of questions, that could be classified with different types [38]: Personal and factual, where common information are asked like name, age, education, and deal with participants' memory; factual questions about others, where information about other people is asked; Attitude questions are usually commonly used for researching about attitudes; Belief questions, where participants' are asked what beliefs influences them, like religious ones or environmental ones; Normative standards and Values, where participants are asked to indicate what principles or value they value.

In the end, Diaries can suffer of different problematics and the most common ones are: lacking of understanding of the objectives, lack of moments of writings, too much expensive activity rather than other methods and so the level of commitment could be lacking within this activity and an effect of assuefaction could be developed, with less detailed data putted inside. Also from the researcher side a big effort and time needs to be put into research for coding the data and gathering insights [29] [38].

3 Description of the case

The following sections explore the complex pedagogical context in which the described experience occurred thanks to which the choice of a summer school as the setting for this research proves to be crucial. The distinctive learning format of a summer school facilitates a dynamic convergence of people from diverse backgrounds, all meeting in one location to engage in complex interactions.

In contrast to traditional learning environments which pause the learning process with discrete sessions, the summer school environment permits a continuous and uninterrupted analysis of events as they unfold over time. This uninterrupted flow of engagement stands in contrast to the typical flow of fragmented learning experiences in which interruptions and diversions can impede the analytical process.

Students participating in this pedagogical journey did not simply share classrooms; they lived together 24 hours a day and participated in every aspect of the experience, including social interactions. Adding to the complexity, these students came from a variety of technological backgrounds, each with their own perspectives and motivations regarding education. It is important to recognize that the context described here is highly specific and not necessarily representative of the broader educational landscape; rather, it serves as a microcosm - a distinct slice of reality that provides invaluable insights into the dynamics of this particular learning environment.

3.1 C-FLEX Consortium

This work of master thesis is done within the context of C-FLEX[1], a project co-funded by the European Union, in order to investigate *"sustainable futures for Europe's digital education infrastructure"*.

This Consortium is a collaborative initiative comprising **five partner universities and an international non-governmental organization**, all of which are engaged in systematic cooperation across diverse project domains.

- *University of Trento*[2]: it is the project's coordinator and will organize the summer school 2023.

- *University of Rennes*[3]: as a co-leadership position supervising the development of both the online course and the summer school.

- *Delft University of Technology*[4]: which heads the requirements and impact analysis initiatives.

- *KTH Royal Institute of Technology*[5]: which conducts benchmarking initiatives.

- *Eindhoven University of Technology*[6]: which heads the development of the online course.

- *Junior Achievement Bulgaria*[7]: an esteemed NGO that performs a crucial role as the project's dissemination and impact partner, thereby enhancing the project's influence and relevance.

This project's primary objective is to initiate a systemic discussion about the effects and long-term viability of digital education. It is looking into three distinct directions: delving into historical and contemporary aspects as well as future possibilities and directions. In particular, the focus is on

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[1]C-Flex Project. `http://c-flex.eu`

[2]UniTrento. `https://www.unitn.it/`

[3]Université de Rennes — Accueil. `https://www.univ-rennes.fr/`

[4]Delft University of Technology. `https://www.tudelft.nl/`

[5]KTH Royal Institute of Technology. `https://www.kth.se/`

[6]Eindhoven University of Technology. `https://www.tue.nl`

[7]Junior Achievement Bulgaria. `https://www.jabulgaria.org/`

investigating the infrastructure of digital education by conducting educational research and making future speculations.

Through this open discussion, the Consortium contributes to the community in the following two ways:

- From a **research standpoint**, it provides a *"Requirements and Impacts Analysis"* in the form of guidebooks and scenarios. The purpose of these resources is to assist institutions in understanding the implications of digital education infrastructure. In addition, they provide a benchmarking instrument that allows institutions to compare and evaluate the costs and benefits of one technology solution versus another.

- From an **educational standpoint**, the consortium endeavors to translate these ideas into action through a Challenge-Based Learning experience. This is accomplished via an online course that examines the impacts and sustainability of digital education infrastructure, methods of assessment, and the current challenges within the educational landscape. After this initial phase, students are given the opportunity to investigate real-world problems during an intensive interdisciplinary summer school where they are encouraged to propose practical solutions.

Their primary contribution to these reflections consists in providing insightful feedback and direction for educational infrastructure. In shaping the future of education, they emphasize the significance and relevance of values such as *openness*, *accessibility* (in terms of bridging the digital divide and enhancing interoperability and inclusiveness), and *long-term sustainability*.

These objectives are accomplished through four primary dimensions:

- **Technological:** This dimension involves a comprehensive discussion on the technological aspects that render digital education functional and sustainable over time.

- **Environmental:** The project aims to quantify the environmental impact of digitalizing education processes, casting light on its ecological imprint.

- **Social, ethical and legal:** Within these disciplines, the project conducts an examination of critical considerations such as *privacy*, *accountability*, *fairness*, and the *freedom of choice* in the context of digital education.

- **Pedagogical:** This dimension involves the piloting and implementation of innovative teaching and learning strategies. It includes both the evaluation and administrative processes.
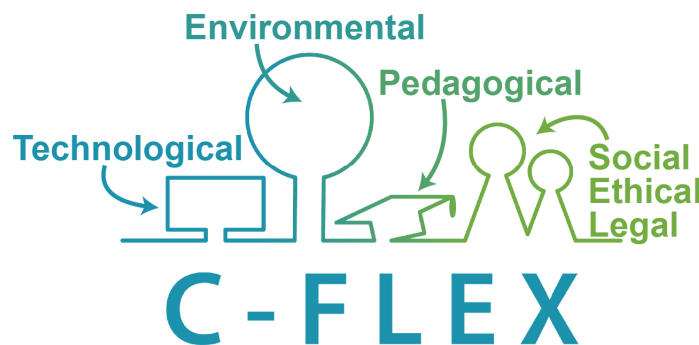
Figure 3.1: The four dimensions and the C-FLEX logo

The group has disseminated its vision within the **"Computing Within Limits"** [11] community via a paper titled *"Conceptualising Resources-aware Higher Education Digital Infrastructure through Self-hosting: a Multi-disciplinary View"* [24]. Currently, they are actively developing the research materials and tools that were previously mentioned.

3.2   C-FLEX summer school

This section provides an overview of the summer school in order to provide a clear context for the participants' experiences.

3.2.1   Program and pre-course

The C-FLEX summer school took place in **Italy**, hosted by the **University of Trento**, spanning **from July 2nd to July 16th, 2023**. This event brought together a group of educators, mentors, subject matter experts, and students from C-FLEX-affiliated partner universities.

The selection of students occurred between February and March 2023, with one of the criteria being the awarding of fifteen complete scholarships covering all expenses. In addition, the program welcomed non-scholarship-receiving participants for a participation fee of 1,000 euros, which covered all associated costs except travel expenses.

The organizers designed an interdisciplinary program that demanded seamless collaboration between students from diverse backgrounds and cultures. **Challenge-Based Learning** was chosen as the methodology to convey the summer school experience. In particular, it was applied to the investigation and proposal of solutions for challenges presented by stakeholders. Students were exposed to the main *"points of friction"* in Digital Education through immersive, real-world experiences. These included tasks such as undertaking activities in remote areas without internet connectivity, instituting active learning pedagogies, and crossing the complexities of interdisciplinary teamwork and the inherent difficulties of the assigned tasks.

Before starting the summer school, students were required to complete an online *"pre-course"* designed to establish a common groundwork. This pre-course consisted of eight two-hour-long sessions. Its overarching goals were the following:

- **Fostering Familiarity**: One of the primary objectives was to facilitate introductions among the participating students, enabling them to become acclimated not only with their peers but also with key members of the organizing staff tasked with administering the summer school.

- **Understanding C-FLEX**: The pre-course aimed to provide a comprehensive understanding of the objectives, topics, and dimensions of C-FLEX, ensuring that all participants were well-versed in the program's core concepts and objectives.

- **Team Formation**: A pivotal step involved in the pre-course was the formation of teams that would collaborate on tackling the various challenges presented throughout the summer school. This ensured that diverse skill sets and different backgrounds were taken into account when forming groups to maximize their effectiveness.

- **Introduction to Challenge-Based Learning**: The pre-course also served to introduce students to the principles and mechanisms of Challenge-Based Learning mentioned in Section 2.4.3, allowing them to understand the methodology's fundamental workings and how it would be implemented during the summer school.

3.2.2   Goals and design elements

Students were introduced to the central themes and objectives of the research group, beginning with the identification that, following COVID-19, digital tools quickly permeated all aspects of education. Nonetheless, it became apparent that the adoption of these solutions by organizations may have been excessively hasty and lacked a comprehensive analysis of their long-term consequences from multiple perspectives.

"What's the legacy of the COVID digital education switch?" was one of the crucial questions posed to students. Fundamental to the group's discussions, which was communicated to the students, was the notion that the infrastructure developed during this epidemiology has become entrenched and destined for long-term existence, and that this infrastructure is utilized not only in post-crisis classrooms of today, but also in future classrooms; however, there has been insufficient consideration regarding its long-term viability.

At this point, the four key research dimensions were introduced, but in the context of this specific question:

- **Technological:** In the context of digital education, it is imperative that the technological infrastructure is not only user-friendly but also designed for long-term sustainability and ease of maintenance.

- **Environmental**: digital education initiatives should prioritize reducing their environmental footprint in accordance with sustainability objectives and best practices.

- **Social, Ethical, and Legal**: In the domain of digital education, the approach must be based on inclusiveness and respect for every individual.

- **Pedagogical**: When it comes to transforming teaching practices, the transition to digital education should be deliberate and well-considered, thereby enhancing the pedagogical experience as a whole.

The organizer developed a set of **explicit guidelines** for the presentation of the first day of the summer school with these four factors in mind. These guidelines not only aimed at focusing on sustainable problem-solving but also prioritized *creating a safe and sustainable environment for the exchange of opinions and ideas*. Particularly, students were informed that every viewpoint deserved to be heard and that achieving consensus among team members was more important than merely seeking the most effective solution.

Teachers also assured students that there would be *no formal evaluations*; rather, the experience was structured as a *pass-or-pass opportunity*. In addition, no numerical grades would be assigned at the conclusion of the course; rather, students would receive feedback on how to improve their work.

Significant effort was devoted to creating a safe environment for all activities, including those requiring physical or social exertion. Students had the option to participate or not to activities depending on their "mood" and simultaneously, they were strongly encouraged to voice any concerns or doubts, and organizers demonstrated a keen willingness to adjust the agenda accordingly.

Transportation was also an integral aspect of the summer school's design. When traveling to and from the summer school, students were encouraged to use *sustainable travel methods*, such as taking trains instead of aircraft, which have a smaller environmental impact. In addition, they were strongly encouraged to use bicycles for local transportation within Trento, as this option was integral to the overall experience.

All of these initiatives were carried out in an interdisciplinary environment in which research and teaching mutually influence one another, creating a symbiotic feedback cycle at each interaction and thereby enhancing the effectiveness of the entire system.
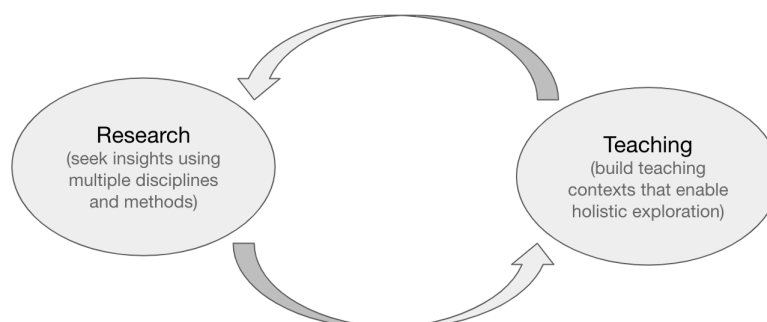
Figure 3.2: The goals of the summer school experience presented to the students, taken from the presentation slides

3.2.3 Participants and inclusive selection

This program's intended enrollees included students from all partner universities. During the pre-course phase, students were required to self-identify with the dimension that most resonated with them: *maximizing entropy*, while ensuring a proportionate representation of diverse competencies, *knowledge foundations*, *academic fields*, and *originating universities*, was the primary criterion guiding the selection procedure. Throughout the selection process, applications that were overqualified, underqualified, incomplete, or lacked admissions requirements in English were thoroughly reviewed to ensure the **program's inclusiveness and the diversity of its participant pool**, with the goal of generating as much entropy as possible in order to have a large diversity of competences in addressing the challenges.

Throughout the course of the experience, a variety of mentors and instructors contributed, each providing unique responsibilities and competencies to the experience. The figures present could be divided into 3 groups: *academics*, *practitioners* and *university staff*. In order to give the reader a better understanding of the diversity of the figures presented, an unordered list of some of them will be provided in Subsection 4.3.2. This will not be an exhaustive list, but rather a small representation of the competences that worked together: project managers and project developers, PhD student, education innovators, researchers, ecosystem advisors, entrepreneurs, co-founders of pre-accelerators, assistant professors, employees, associate professors, and even a Minister of Innovation and Growth. In addition, the diverse backgrounds of these people included engineering, economics, management, linguistics, music and human interaction. The overarching objective was to provide students with an abundance of diverse skills and experiences while embarking on a journey together.

The **maintenance of a level of ambiguity regarding the roles of the people involved** was a design element to prevent the early formation of a hierarchy between students and mentors. Roles were only disclosed when absolutely necessary, ensuring that the educational journey and not positional distinctions remained the primary focus.

Respecting each individual, regardless of what they did, on a fundamentally human level was also central to the design philosophy. Every effort was made to accommodate the unique sensitivities and preferences of each individual, without forcing them to participate in activities outside their comfort zones. The objective was to provide the necessary freedom and space for everyone, thereby fostering an environment that was less formal and academic and more human, personal, and inclusive, one that resonated with all participants.

3.2.4 Structure

Challenge-Based Learning was the main teaching method utilized throughout the summer school to address the proposed challenges. This methodology was implemented over the course of two weeks, with each week serving a distinct purpose. In the first week, students were required to study and analyze the given challenge, culminating in the formulation of both a problem statement and an opportunity statement. The second week required a more hands-on, creative approach, in which students pursued potential solutions, analyzed them critically from multiple perspectives, and constructed compelling narratives for presentation.

As we can see from Figure 3.3, the path through these phases was supported by a structured methodology that highlighted important stages and their interdependence:

1. **Deep Democracy**: During a compelling lecture, the initiation part introduced students to the concept of Deep Democracy. This idea emphasized the significance of initiating dialogue based on mutual respect and a constructive approach within a group composed of individuals from diverse backgrounds. Through an interactive lecture, students were prompted to consider this concept, which fosters a safe space where all voices, including those of minorities, are respected. This first day was designed to facilitate collaborative group dynamics and emphasized the significance of active listening valuing diverse perspectives.

2. **Problem Discovery**: During the second phase, students dug deeper into the challenge supplied by the challenge provider in an attempt to locate the true problem contained within the challenge description.

3. **Problem Space Exploration**: During the third phase, students examined the challenge through the lens of the four dimensions to identify any issues that were not apparent from the challenge provider's initial description. Following the exploratory phase, students were entrusted with synthesizing their findings into a problem statement that would provide direction for their work.

4. **Opportunity Space**: Building on the Problem Statement, students were tasked with identifying all potential opportunities presented by the problem, allowing them to discover latent opportunities or potentially refine the problem they intended to solve.

5. **Solution Space**: Once they had a comprehension of potential opportunities and problems, students converged on a singular solution space and problem, analyzing the potential outcomes for each option they had explored.

6. **Solution Concept**: At this stage, students were required to conceptualize and develop a solution concept that could be implemented by the challenge providers, meaning that it had to be feasible and not utopian.

7. **Analysis of Costs and Sources of Funding**: The solution was evaluated from a business perspective by analyzing its costs and potential funding sources.

8. **Building the Storytelling, Presentation, and Demo**: With all elements in place, students crafted a compelling narrative for their challenge provider, along with a demo and presentation.

9. **Final Delivery**: At the conclusion of this process, a comprehensive report covering all preceding stages was compiled and presented to the Challenge Provider.
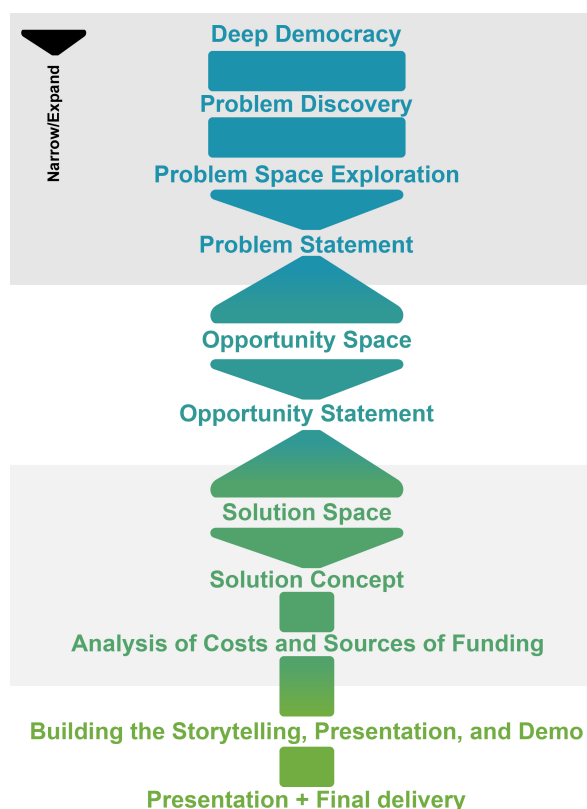
Figure 3.3: The phases of the learning path, in particular can be seen the narrow and the expansion stages

3.2.5 Program

One significant challenge the organization encountered during the planning of the summer school was how to handle unexpected events and maintain flexibility without imposing a sense of haste or rigidity upon the schedule. Figure 3.4 represents the description of the activities' plan.

12 Feb 2023	~1st Mar 2023	7–28 Mar 2023	June 2023	2–16 July 2023
Application Deadline	Pre-course Kick-off	Intro to sustainability of Dig. Edu	Presentation of challenges	Summer School!
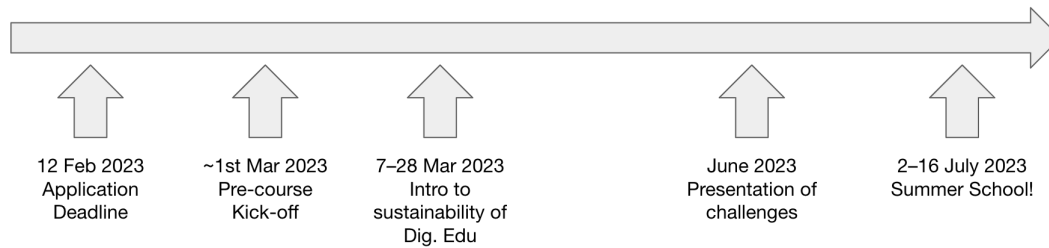
Figure 3.4: The timeline of the full experience, taken from the presentation to the students

To address this issue, an intentional decision was made: students were not initially provided with the actual schedule. Instead, a brief summary of the schedule was presented at the beginning of the summer school, emphasizing its fluid nature. Students were informed that the schedule existed, but that it was subject to change; they were also instructed not to worry about it. They were only expected to recognize the existence of a loose guideline and not be excessively worried about it.

The main schedule was divided into four thematic areas, with each area being distributed as evenly as possible over two weeks:

- **I&E Workshops**: These consisted of group activities, analytical sessions, and checkpoints.

- **Thematic Lectures**: These lectures covered a variety of subjects and were delivered to the complete class. Topics included Deep Democracy, Open Source vs. Proprietary Software, the economic dimension of sustainability, challenges related to sustainable energy systems, ReCluster, Unmaking electronics, the implications of outsourcing digital education, and justifying the value of EdTech.

- **Social Activities**: These were organized experiential activities such as the welcome orienteering to explore San Lorenzo in Banale, climbing with an alpine guide, trips to Lake Molveno and Lake Garda, an Italian cooking lesson, evenings at the university nautical center, and a closing dinner.

- **Free Time**: These were instances in which students were granted complete freedom, typically in the early evening and some afternoons.

In addition, the two-week summer school was conducted in two separate locations, facilitating a seamless transition from problem analysis to solution ideation.

This first week's objective is to build a team with a common background on the school's topics and to explore the challenges and problem space. Can be therefore considered as a very reflective week, but with moments of outdoor activity, immersed in nature also for teaching lessons: in fact, the setting permitted park lessons and activities. The second week took place in Trento, and a biking trip with the alternative of taking a bus was planned to get there. The journey includes a stop at Lake Garda along a panoramic road. During the second week, students were required to select and propose a challenge solution and develop a critical perspective on it. This assignment was more labor intensive than the previous one and took place in an urban context.

3.2.6 Typical Day

For the two distinct environments, the typical day was also diverse. During the first week, the hotel served breakfast in two separate locations, and activities began around 9:00 with a lesson or activity lasting until 12:30-13:30, with a break around 11:00 to switch types of activities. Students and instructors had lunch together in the hotel's main structure, where students and teachers typically

congregated. The afternoon activities typically began at 14:00 and ended at 18:00, and consisted primarily of group work or social activities. Dinner was served between 19:00 and 20:00, and students were free for the last part of the evening.

During the second week, the students stayed in the residence hall "San Bartolameo"[8] of the Opera Universitaria of Trento, and had to travel by bicycle to a nearby bakery for breakfast, and then to the city center, where the teaching lessons were held at the School of Innovation[9], with a 10:00 a.m. starting time. As in the previous week, there was a combination of instruction courses and group work activities, which were always conducted within the main building. The catering service served lunch within the School of Innovation around 13:00. In the afternoon, there was a more focus on group activities, rather than unstructured or convivial ones, in particular in the last days. Students were allowed to depart or remain after 18:00 and were given dinner vouchers.

3.2.7 Challenges

Four challenges were presented to the students, and during the final online meeting, the teams formed during the pre-course indicated their first, second, third, and fourth preferences for the challenges. The teams were allocated a challenge according to their stated preferences. The central theme of the problems received from stakeholders was **digital sustainability in educational settings**. The actual challenges given to the students could be found in the Appendix B.

Disclaimer: The following section is arranged at random, with no preference given to the category of content or its creator.

Digital education infrastructures within the context of very diverse groups. The challenge presented by Kiron Open Higher Education GmbH centers on the complex landscape of digital education infrastructure in the context of exceptionally diverse student populations. This is both a challenge and an opportunity for Kiron's digital education framework, as these students come from a variety of cultural contexts and have varying levels of maturity and expectations. The goal is to enable students to envision what an ideal Digital Education Infrastructure should entail, while utilizing the diversity of learners as a resource to drive learning success and sustainability.

The students are tasked with a comprehensive analysis, transcending the technological sphere to encompass teaching practices and the distinct requirements of individual students and various student cohorts within diverse educational settings.

Higher education for all: addressing drawbacks and benefits of hybrid learning. This challenge is presented by the Vrije Universiteit Amsterdam, which is investigating the advantages and disadvantages of hybrid education and conferences. Due to the rapid expansion of educational programs and budgetary constraints, it has become difficult to bring every student together physically, prompting this initiative. In this hybrid educational landscape, the difficulty lies in the incorporation of suitable tools, the enhancement of student engagement, the guarantee of inclusivity, and the optimization of energy consumption.

It is expected that students will identify the advantages and disadvantages of hybrid education in terms of sustainability and quality concerns across four dimensions: technical, environmental, economic, and social sustainability. In addition, they are required to compile a collection of pedagogical hybrid modules and evaluate them in various contexts.

Maastricht University international & sustainable: can we have it both? Maastricht University, renowned as the university with the most international reputation in the Netherlands, faces a dual challenge. They strive to reduce their carbon footprint, not only from their personnel but also from their international student body, whose travel choices indirectly contribute to the university's environmental impact. The primary concern is whether Maastricht University can maintain its internationalization status while also committing to sustainability.

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[8]UniTrento - Studentato San Bartolameo - Opera Universitaria. `https://www.operauni.tn.it/alloggi/studentato-s-bartolameo`

[9]UniTrento - School of Innovation. `https://www.soi.unitn.it`

Students are required to produce a reflective report delineating strategies to prevent or mitigate the environmental impact. In addition, they should provide university administration with a list of recommendations to effectively resolve the issue.

How to improve the sustainability of the C-FLEX online pre-course? This challenge is presented by an external challenge provider and focuses on enhancing the sustainability of C-FLEX's online pre-course. Students must conduct a sustainability assessment, a gap analysis, and a review of the state of the art. Each recommendation for enhancing sustainability should be accompanied by an impact and priority estimate.

The difficulty involves five facets of work: technological, pedagogical, social/ethical/legal, environmental, and economic. In addition, students are encouraged to investigate six areas: preparation, pedagogical diversity, technical challenges and solutions, future financing, international expansion, and social/ethical/legal issues pertaining to online content ownership and internet accessibility.

4 Research Methodology

The research study included three distinct but interconnected fronts. The first aspect was to *create a fair narrative of the overall experiential journey*. The purpose of this narrative was to analyze which aspects of the process were effective, which were less so, and the complex social dynamics that emerged among the participants. Understanding the complexities of these social dynamics was crucial for identifying opportunities for enhanced learning in this particular context. The second aspect of the research was to understand what *attitudes could be developed within a collaborative CBL setting* that served a diverse collection of students from different backgrounds and regions. The third aspect of this research focused on the *development of students' pedagogical opportunities and competencies in sustainability*. From these three fronts, three research questions could be formulated:

> *" How could a fair narrative in the setting of a CBL summer school be built, and what impact did social dynamics and emotions have on the whole experience? "*

> *" What potential attitudes may be cultivated within the framework of a summer school program focused on CBL in the field of sustainability? "*

> *" What pedagogical opportunities and competencies have been developed by technology students in this specific context? "*

The multifaceted approach used within this work enabled to gain valuable insights into these areas, thereby contributing to the larger discourse on effective educational methodologies and the development of essential skills in a world that is constantly changing.

4.1 A Qualitative Inductive research approach

The research approach selected for this study is rooted in the qualitative definition:

> *" An approach to documents that emphasizes the role of the investigator in the construction of the meaning of, and in, texts. There is an emphasis on allowing categories to emerge out of data and on recognizing the significance of the context in which an item being analysed (and the categories derived from it) appeared. Also called 'ethnographic content analysis'. "*

[67]

and

> *" Research that emphasizes words rather than quantification in the collection and analysis of data. As a research strategy it is inductive, constructionist, and interpretivist, but qualitative researchers do not always subscribe to all three of these features. Compare with quantitative research. "*

[38]

At the core of this decision is the primary objective of this study, which is **to analyze complex phenomena**, referred to as experience in this work, within their natural domain. The mentioned goal is to observe the events, but it is also an attempt to explain and interpret complex social dynamics as well as individual and group perspectives.

In addition, the nature of the data to collect is emotional and intensely personal for each participant, which result of not being of numerical nature; rather, they were richly textual, loaded with emotions, experiences, and graphical representations.

This meant that in order to conduct an objective numerical study, a fully controlled and artificial experiment is required, as well as an intimate knowledge of the participants, which could lead to a loss of "naturalness" of the phenomenon, which is desired for this type of research but extremely difficult to obtain due to the complexity of identifying the variables worthy of investigation within this particular context. Rather, comprehending and responding to the research questions hinged on the domain of actual life experiences.

Due to the limited number of participants, the quantitative data generated by the analysis **could not be subjected to conventional statistical scrutiny**. However, from a qualitative standpoint, **the insights** gained from this analysis **were highly relevant and contributed significantly to the achievement of the research objectives**.

Given these compelling reasons, it was determined that a qualitative research design was the most suitable. Within this qualitative structure, the chosen methodology is distinctly inductive. In contrast to deductive research, which typically entails assessing pre-existing theories, the context and objectives of this study necessitated a methodology that could account for the absence of such theories, as mentioned in Chapter 2. The data were inherently linked with the experiential context, making inductive analysis the most appropriate method.

In conclusion, the decision to adopt a qualitative and inductive research approach was based on the research's complexity, the highly personal and emotional nature of the data, the impracticality of controlled experiments, and the suitability of qualitative methods for gathering meaningful insights from a small participant pool. This methodology corresponds with the overarching objective of investigating the phenomenon of 'experience' in its natural habitat and explaining its complexities.

4.2 Methodological definition

The following work can be classified as ethnographic because it reflects the definition's core concepts.

"

We consider ethnography to mean a research method in which the researcher:

- *is immersed in a social setting for an extended period of time;*
- *makes regular observations of the behaviour of members of that setting;*
- *listens to and engages in conversations;*
- *interviews key participants (often referred to as informants) on issues that are not directly amenable to observation, or that the ethnographer is unclear about (note that in-depth interviews are a separate thing to both participant observation and ethnography);*
- *collects documents about, or relevant to, the group;*
- *seeks to develop an understanding of the culture of the group and people's behaviour within the context of that culture;*
- *and writes up a detailed account of that setting.*

"

[38]

Given the relatively brief duration of this particular experience, the classification of this work could be legitimately questioned, as the length of the experience was two weeks. It is essential to recognize that the nature of this investigation is being conducted by a Master's thesis student who, while certainly committed and enthusiastic, may have limitations in terms of field expertise and familiarity with specialized terminology.

Given these factors, it seems prudent and intellectually honest to designate this research as a **micro-ethnography**. This designation is not only consistent with the inherent constraints of the study but also aligns more harmoniously with the framework defined in *"Bryman's Social Research Methods"* book. Within this framework, micro-ethnography is distinguished by its emphasis on smaller, more manageable initiatives that delve thoroughly into particular aspects of the overall experience.

4.2.1 Overt and Participation

As a strategic approach to participant observation, a methodology that prioritizes transparency regarding the researcher's role and the nature of its activities has been implemented. This strategic decision was carried out during the first morning session, which conveniently coincided with the formal request for participation in the study and the exhaustive explanation of the research project itself. A more thorough explanation of this methodological decision will be provided in Section 4.4.

This specific strategy was carefully chosen to correspond with the program's overarching principles and values. The most important of these principles is an **unwavering commitment to openness** in all interactions with participants. The goal of clearly defining the responsibilities and functions of the researchers is to cultivate an environment of trust and transparency and at the same time, as Gans (1999) stated that participant observation

> " is the only one that gets close to people. In addition, it allows researchers to observe what people do, while all the other empirical methods are limited to reporting what people say about what they do. "

[52]

In addition, this strategy was designed to address the potential difficulty of balancing the dual responsibilities of the researcher-student, who would have otherwise had to face a challenging summer school coursework with his active participation in the research study.

This methodology presented an enticing opportunity to foster a more genuine and meaningful relationship between researchers and students and this was made possible, in part, by the researcher and participants' similar ages. By emphasizing the openness of roles and expectations, the aim is to cultivate genuine relationship without compromising the necessary delineation of roles and responsibilities throughout the study. At this point, when the researcher's identity has been disclosed to the students and the researcher is free to determine the extent of the participating observer's involvement, "Bryman's social research methods" shows the possibility of choosing from six distinct levels of participation which can be found in Table 4.1.

Table 4.1: Levels of participation

Role	Definition
Overt full member	Assumes the role of a complete member within the group.
Participating observer	Participates in the primary group activities but maintains a distinct status from that of a full member.
Partially participating observer	Similar to a participating observer, but the researcher's active participation in the group's main activities is not equivalent to being a full member. In addition, the observation process may not be the primary data source.
Minimally participating observer	Participates minimally in the fundamental activities of the group, and whether observation serves as the primary data source remains variable.
Non participating observer with interaction	Characterized by a strict observer role devoid of active participation in group activities, where interactions with group members lack the characteristics of personal relationships, relying heavily on documents as the primary data source.

Due to the small age difference between the researcher and the students, there is a risk that the researcher is susceptible to the phenomenon known as **"going native"**, in which the researcher assimilates fully into the group, abandoning their identity as a detached observer and adopting the role of a full participant. This concern played a significant role in the decision-making procedure, resulting in a strategic approach that incorporated the most advantageous aspects of both extremes. Therefore, the strategy involved a dynamic oscillation across the entire spectrum of participation levels. During select activities, the researcher adopted the role of an **overt full member**, cultivating genuine relationships and actively participating in first-hand experiences alongside the students. On other

occasions, the researcher shifted to a **minimally participating** or even entirely **non-participating observer** role, particularly when early signs of 'going native' surfaced or when the observation itself was more important than personal interactions with the participants.

The integrity of the students' work was safeguarded by the deliberate decision to encompass the full spectrum of participation. During crucial moments of discussion and idea development, the researcher's outside perspective proved invaluable for identifying small differences in member interactions. Simultaneously, by completely immersing oneself in various social and group activities, the researcher forged strong relationships with the participants, thereby cultivating a friend/colleague with a mission attitude, which is consistent with what methodologists suggest: the importance of making a positive impression on the community in order to establish trust [94].

In contrast to the observer-analyzer-judge dynamic, this approach fostered an environment characterized by relaxation and reduced tension, thereby contributing to the creation of a more friendly and harmonious atmosphere.

4.3 Data Collection

This project's data collection phase spanned two weeks during the summer school session, from July 2nd to July 16th, 2023. Nevertheless, the groundwork for determining the methodological approach, objectives, and materials began approximately one month before the start of the summer school. The initial question that led to the following design choices was:

> *How can we gather data on attitudes, pedagogical opportunities, social dynamics and emotions in a very dynamic environment and being at the same time an engaging, reflexive and an opportunity to growth experience?*

As stated, the problem was multifaceted: there is a **desire to collect data that were purely personal and complex**, such as emotions and thoughts, and at the same time there was a **desire to collect data that are only visible to those with a complete external and inside view**. All of this was desired in a highly dynamic context in which we wished to trace the evolution of these characteristics over time in a continuous manner, rather than at discrete intervals, in order to form a picture that evolves over time. Furthermore, an additional layer of complexity was introduced in the form of designing a methodology that struck a balance between not being overly complex and time-consuming for the participants, while simultaneously fostering an environment that was engaging, enjoyable, simple, and personalized. The overarching goal was to transform the participants from passive observers who might provide superficial data into active participants in the research process. This transformation aimed at establishing a cooperative and interactive environment in which the participant-researcher relationship transcended the traditional vertical hierarchy and embraced a more horizontal orientation, so that the participants become the primary protagonists of the research process.

To meet all of the requirements and adhere to a qualitative approach which valued every insight that could emerge from the students at various stages of their experiential journey, an elaborate triangulation of methods was developed. Throughout the two-week summer school, events were analyzed using a confluence of diverse methodological techniques and instruments [94], and their findings were synthesized and seamlessly linked. In order to provide the reader with a fundamental comprehension of the data collection tools, Table 4.2 provides a brief overview; however, the following sections delves deeper into the selection criteria, how the tools were developed, and their limitations.

The originality of this methodology derives from the fact that it *departs from conventional approaches in this specific context*. Typical data collection techniques involve the use of standardized questionnaires and retrospective interviews conducted after an experience has concluded. This method, on the other hand, aims to create a dynamic, real-time record of the unfolding experience as it occurs.

This deviation is significant because it provides the research process with immediacy and authenticity. Instead of relying on post-experience recollections and reflections, this method attempts to document events, emotions, and interactions as they occur organically during the experience itself. In doing so, it seeks to provide a more vivid, nuanced, and contextually rich comprehension of the topic,

thereby avoiding the potential pitfalls of memory bias or selective recall that may be encountered by retrospective methods.

In essence, this approach embraces the notion that experiential insights are most effectively gathered in the moment, enabling researchers to delve into the raw, unfiltered essence of the participants' experiences, which may otherwise be diluted or distorted when recounted at a later time. This methodology is thus a pioneering endeavor to bridge the gap between research and lived experiences, providing a novel lens through which to investigate and comprehend the subject's complexities in their natural context.

Table 4.2: Data collection tools

Name	Description
Diary	This method was chosen primarily due to its ability to be completely customized and personalized. The physical format, as opposed to a digital one, and allowing students to be free or inspired by queries devised by instructors and researchers during the day were two of the method's key decisions. Due to its personal nature, the diary was selected as the primary and only tool where students could take notes and reflect on their collaborative work. This is also the primary method for collecting data.
Checkpoints	This method was chosen primarily due to its ability to conduct a check, as the name suggests, at a specific time during the summer school, compelling the students to respond to some of the developed research questions. It can be viewed as a questionnaire, and in a sense it is, but the answers, which were intended to be more personal, were to be written in the diary, so they were constructed and conceived as a distinct element, but they were an integral part. The forms of the checks differed as well: there was always an emotional check consisting of a few questions, but the third activity could vary based on the emotions and activities of the previous days, as the entire summer school experience was not static.
Field Notes	The researcher opted for this method as a supplementary instrument to provide guidance while inspecting the diaries. It had two objectives: first, to record "operational" elements such as activities, daily events, general mood, and weather; and second, to document participant behavior, interactions, personal reflections, and engagement with other participants. This instrument played a crucial role in the analysis phase by adding a temporal dimension to each moment and constructing both a personalized student perspective and an outside observer's perspective. Nonetheless, it remained a secondary tool in this study, serving predominantly to cross-reference the data acquired for the analysis phase.
Other Material	Certain items produced by students during the activities were photographed, recorded, or, when possible, digitized to aid in the analysis phase. Furthermore, in the interest of comprehensive analysis and for cross-referencing with the diaries, final questionnaires were employed.

4.3.1 Validity and reliability of data

During the data collection phase, the potential shortage of usable data for undertaking a comprehensive analysis of the diaries became a significant source of concern. As described in Chapter 3, every step, suggested activity, and posed question was entirely optional within the context of the summer school. Students were free to choose whether or not to participate in these research-related activities.

Several measures were implemented to resolve this potential lack of data. A variety of data collection methods were used to ensure that at least one form of data would be available for research purposes, and the researcher meticulously collected field notes. In addition, the researcher, along with some of the summer school instructors, actively engaged students in discussions regarding their experiences. The purpose of these discussions was to inquire about *how the overall experience was progressing, how students were doing with their diaries, and to provide straightforward explanations of the rationale behind the selected approach.* The strategy was characterized by total honesty and a

genuine desire to assist students, including the provision of suggestions when necessary. In addition, indirect checks were conducted to determine if participants were in fact using their diaries or if an alternate strategy was required.

Regarding the validity of the collected data, it is essential to note that, in accordance with the research's open-ended objectives, the specific form of data collected became less relevant. The primary objective was to collect a diverse multitude of data to create a more accurate and comprehensive depiction of the overall experience. The incorporation of multiple data acquisition methods, including information from "other material" allowed for a flexible strategy. This adaptability permitted the data analysis strategy to be modified in the event that data was lacking from a particular method. In essence, the research was designed to be adaptable and resilient, ensuring that potential limitations in the collected data would not compromise the validity of the findings.

4.3.2   Research consent and data privacy

The research consent, as specified in Appendix C, authorizes the researcher to collect multiple types of data at the conclusion of the summer school. This entails retrieving the Diaries, referred to as logbooks-journals in the text, as well as any summer school-related deliverables. Additionally, it enables the researcher to record field notes, which provide insight into the perspectives of participants.

The collected information serves multiple purposes, including facilitating a reflection on the implementation of the summer school experience, evaluating participant satisfaction, and supporting internal and research-related goals. It is clearly stated the people who will be able to see the data in non-anonymous form:

- *Tommaso Carraro*, the Master's thesis student and primary researcher.

- *Jessica Lucchetta*, the PhD student assisting the research group and contributing to the researcher's education.

- *Lorenzo Angeli*, the Assistant Professor overseeing this work.

- *Martijn Klabbers*, an education innovator who provided valuable input and ideas during the summer school.

- *German Varas*, an education analyst and Co-Supervisor, who is also responsible for reviewing this work.

It should be noted that individuals not listed here will only have access to this information in an aggregated or anonymous format and this applies even to C-FLEX consortium participants. In addition, all data collected are managed in strict accordance with the European regulation on the protection of personal data (GDPR, EU Regulation 2016/679) therefore participants had the option of changing their consent preferences at any time [1].

The process of obtaining the consent began on the very first day of the summer school, concurrently with the presentation of the course goals and research objectives and after that moment, each participant and non-participant was given a diary. This approach was designed to promote inclusivity and gave students the freedom to decide whether or not to participate in the research, while still encouraging them to participate in all activities, with the option to keep their data for personal use only. In addition to the consent paper, also a `Readme.md` file with all the details was given and has been attached to this work as Appendix D.

This supplementary document was intended to provide an in-depth understanding of the research, introduce the researcher, and describe the safeguards in place to protect participant data. This document's layout was deliberately tech-oriented and meticulously tailored to its intended audience. Symbols and figures reminiscent of popular arcade video games such as Pac-Man[2], Space Invaders[3], and Snake[4] were used as separators and visual elements, lending a playful yet relevant touch.

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[1] GDPR - Article 17. `https://gdpr-info.eu/art-17-gdpr/`

[2] Pac-Man. `https://en.wikipedia.org/wiki/Pac-Man`

[3] Space Invaders. `https://en.wikipedia.org/wiki/Space_Invaders`

[4] Snake. `https://en.wikipedia.org/wiki/Snake_(video_game_genre)`

The content of the supplementary document is structured into sections:

- **Introduction to the Researcher**: This section offers insights into the researcher's background and his role in the study.

- **Pedagogical Objectives**: The second section elaborates on the two primary pedagogical objectives of the study, elaborating on their significance and purpose.

- **Guidance for Participants**: The third section provides explicit instructions for how participants should approach what they write in the diary. It emphasizes that it is the researcher's responsibility to make meaning of the data and explicitly states that consistency is not required. Participants are strongly encouraged to concentrate on their personal experience, writing primarily for themselves, and have complete discretion in selecting themes and methods for documenting their experiences. This facet is elaborated upon in the Diary approach on Subsection 4.3.4.

- **Data Handling**: In the final section, it is reiterated that participant diaries will be collected with their permission. An infographic is provided to illustrate, using computer science terminology, how the data will be processed. The first "firewall" is the researcher, whose responsibility it is to remove or anonymize any sensitive information, including that pertaining to professors. Subsequently, there is another level of firewall, namely Lorenzo Angeli and Jessica Lucchetta, who will access the data in a partially aggregated and cross-referenced form. The third firewall is the point where data becomes entirely aggregated and anonymized.

This meticulous approach to obtaining consent and delivering exhaustive information to participants not only ensures transparency but also respects their autonomy and privacy throughout the research process. Furthermore, this three-step firewall was implemented primarily to ensure a privacy level known as the *"Principle of Least Privilege"* [91] in computer science, where at each stage the people have access only to the information they need, having the least privilege needed for the task at hand.

To ensure data security, the physical documents are in the researcher's sole possession and have been read and digitized solely by the researcher. Digital copies required for coding analysis were encrypted and hosted on the researcher's personal computer within a Windows virtual machine without an internet connection. University services such as Gmail and private Apple Notes were used to share results-related notes.

The anonymization procedure included clustering participants at random and assigning group numbers at random. **Only the researcher knows the actual arrangement of students and groups.** In the final phase of result generation, findings from various methodologies were aggregated and the primary results were summarized without disclosing individual-specific characteristics that could lead to participant identification.

4.3.3 Presentation of the research

The presentation of the research was conducted during the presentation of the summer school of the first day, the 3rd July 2023, since the evening of the 2nd July weren't designated any activity and the students were let free for accommodating and setting from the travel.

The presentation, which can be viewed in Appendix E, was crafted with a light-hearted and engaging tone, using comical references to attract the students' attention. In order to establish an initial connection between the researcher and the students, it was delivered in an approachable, informal manner. This approach intended to present the researcher as an ordinary, relatable student, nurturing a sense of friendship as opposed to a formal, authoritative role. The principal topics addressed in the presentation were:

- Facilitating a meaningful evaluation, regarded as a means of reconstructing the narrative of their summer school experience in order to evaluate its efficacy and effects.

- The significance of drawing conclusions based on actual experiences as opposed to preconceived notions.

- Clarifying the qualitative nature of the research and delineating the rationale for not prescribing a set of questions for the students, while advocating for continuous data collection as opposed to discrete, retrospective assessments.

- Describing the research procedure and outlining the tasks assigned to the students.

- Emphasizing the autonomy of students in decision-making, including participation choices.

- Encourage students to write independently, viewing the research project as an opportunity for creative idea exploration.

- Reiterating the researcher's function in narrative reconstruction.

- Addressing concerns regarding privacy by describing the measures in place to ensure diary confidentiality.

- Emphasizing that the research is a collaborative endeavor to which students can contribute actively.

Students received diaries, research consent forms, and a `readme.md` file after the presentation and they were encouraged to answer the first two questions:

- Why are you here?

- How does it feel to go from meeting online to in-person?

The purpose of these questions was to provide initial guidance for beginning the writing process. In addition, the first question was included in the final questionnaire given at the conclusion of the summer school, allowing for cross-referencing of data for a comprehensive analysis.

4.3.4   Diary

The primary data acquisition method utilized throughout the summer school was the use of diaries within the given context. This method was chosen due to its distinct advantages over more conventional approaches, as described in Hilário's article titled *"The use of diaries for understanding the experience of health and illness"* [57]. This diary-based methodology has several noteworthy advantages:

- **Amplification of Participant Voices**: It enables participants' perspectives, including those of marginalized groups, to flourish, thereby empowering them.

- **Equalizing Research Dynamics**: This approach promotes equitable participation by minimizing the inherent power disparities between researchers and participants. It positions participants as co-researchers, mitigating paternalistic researcher attitudes.

- **Facilitation of In-Depth Exploration**: Diaries facilitate the generation of profound and nuanced insights, fostering rich and profound reflections on the gathered data.

- **Emotional Insight**: Diaries are particularly well-suited for documenting the emotional dimensions of participants' experiences, whereas traditional methods may neglect the emotional aspect.

- **Safe Space for Confidential Sharing**: Diaries create a safe space for participants to share openly their personal experiences and emotions, ensuring their confidentiality.

- **Embracing Sensory Abstraction**: They permit the encapsulation of sensory experiences that may be difficult to articulate using conventional means.

Collectively, these characteristics endow this methodological instrument with the capacity to provide a nuanced depiction of emotions, personal behaviors, and the lives of individuals, filling the research endeavor with a profound epistemological dimension. Diaries have an ontological dimension as well, functioning as both registration instruments and logbooks.

To elucidate this dual function, a distinction of categories have been chosen:

- **Logbook**: The name was chosen to emphasize the diary's practicality, as it allows students to document any thoughts or ideas in an unstructured manner, thereby creating a comprehensive document of their work-related notes and musings.

- **Journal**: In contrast, the term 'journal' was used to convey the intimate and reflective character of the diary. Here, students could engage in deeper thought and more sophisticated reasoning.

A solicited diary approach [61] was employed to adhere to these principles. In the `readme.md` file and during presentations, it was made clear that the researcher would read the participants' diaries with their permission. Ultimately, this strategy promotes a holistic experience that incorporates the dual dimensions of personal reflection and exhaustive record-keeping.

Design elements. The two primary design elements encompass the following: first, *the use of experience sampling*, which captures the emotional states, behaviors, and subjective life experiences of participants [102] in near-real-time in order to facilitate the study of their personal experiences; second, *the incorporation of free-text or*, more precisely, *free-form writing*, which allowed students to utilize the tool according to their preferences, including the freedom to choose when and how much they wanted to write. This aspect of freedom's design is intrinsic to the context of the summer school, particularly within the pedagogical framework that gave students the option to participate or not. This pedagogical design extended to include the freedom of form in the case of diaries.

Students were instructed explicitly that the research did not expect uniformity or consistency in their work, as the goal was to collect genuine and spontaneous insights from them, with no predefined expectations, other than that they were to write about their own feelings, ideas, and experiences during the summer school, essentially crafting their personal narratives. It was also clarified that the researcher was responsible for interpreting and reconstructing the students' experiences, while the students' participation was limited to experiencing them.

This design decision was made with the intent of observing the continuous evolution of the summer school experience, as opposed to capturing discrete periods in time. In addition, the concept of empowering individuals and granting them control over the research process had already proved to be an effective method [71] [74].

In order to maximize the effectiveness of the logbook instrument during the summer school experience, students were instructed not to use personal notebooks or computers for note-taking, even during group work sessions. During the Innovation and Entrepreneurship (I&E) Workshops, students were reminded to bring their diaries and were encouraged to use them for their work in order to maintain their motivation to utilize the tool. Simultaneously, in order to cultivate personal reflections, a series of **open-ended questions** were disseminated on the Telegram group in the morning and evening, along with engaging resources such as videos or websites. These questions were tailored based on the previous day's events. This design decision was influenced by the principles outlined in the book *"Bryman's social research methods"* [33], which emphasize that broad questions generate unique and sometimes unanticipated responses without proposing answers, thereby allowing exploration of areas with limited knowledge. This strategy positions the responsibility for identifying and emphasizing significant areas of interest on the participants. Some examples of questions are:

- How would I describe the process to make sustainable decisions?

- How can I train myself formulating questions to painful problems?

- How was the team work?

- What challenges did you face?

- How can I harness my creativity and become a creator of value instead of the consumer of it?

- And have you considered how you communicate (verbally and non-verbally)?

The final element of the design was the **option between a physical and digital diary**. This decision was made with the intention of selecting the most streamlined and effective method, while ensuring that it met all the aforementioned criteria. The need for rapid note-taking, the flexibility to employ various styles such as drawings, maps, and connections, the ability to incorporate additional physical materials generated during workshops (e.g., post-it notes for collaborative reasoning), and the creation of a space free from the influence of technology were of particular importance. In pursuance of simplicity, accessibility, and efficiency, a physical diary was selected and specifically, a MUJI notebook[5] with a refined and minimalist design was chosen. On its pages, grid lines were favored over regular white ones considering the necessity of creating maps and text-based entries.

Limitations.   As mentioned in Section 2, in the existing literature, numerous limitations associated with this instrument have been extensively discussed. First, the required level of commitment and dedication from students is a significant limitation that is rarely encountered in other research methods [29]. This expectation applies not only to participants, but also to researchers' analytical efforts. Despite the fact that this lack of commitment and dedication was partially mitigated by the multifaceted methodology employed in this study, with diaries serving as the primary but not exclusive element, it is imperative that this motivational deficiency have to be addressed more thoroughly in future endeavors. There is therefore a discernible decline in student diligence over time, necessitating a deeper examination of this issue. The implementation of clearer guidelines and the establishment of dedicated time periods or daily activities within a structured schedule is an attractive strategy, as proposed by Corti in 1993. Moreover, the incorporation of digital instruments could make this process more efficient.

4.3.5   Checkpoints

With checkpoints we refer to three moments within the summer school program when students are given the opportunity to discuss their work and ideas with their teammates. They can be considered as **significant events**, as they were recorded in diaries or with external instruments, and could be regarded as the most essential time-specific data source. The main goals for checkpoints' activity were:

- Assisting students in conducting a critical analysis of their work to identify voids, flaws, and improvement opportunities.

- Ensuring the incorporation of all necessary components and correcting any errors or omissions on their challenges.

- Conducting a comprehensive evaluation of their accomplishments in order to broaden their overall perspective.

- Encouraging students to reflect on their emotive involvement with their work and resolve any concerns.

- Encouraging the formation of both a retrospective view and a prospective view of their work.

They were designed with both the individual and the team in mind. The activities were divided into two-time frames: one for individual reflection and the development of personal reasonings; and the other one for exchanging ideas with the team and gaining a better comprehension of the project's status.

The three moments were scheduled following three key activities that reflected the objectives of the checkpoints, and each checkpoint consisted of a common component and a unique activity that was tailored to its particular purpose:

- The first checkpoint has two objectives: first, to ensure that the problem space has been sufficiently investigated, and second, to help students develop a thorough comprehension of the current task and the underlying concept.

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[5]MUJI IT Department, "Taccuino in Carta Riciclata A5 — MUJI Online". `https://www.muji.eu/product/recycling-paper-notebook-dark-grey-a5-7160.muji`

- The second checkpoint's objective is to assist students in investigating and analyzing the identified solutions.

- The third checkpoint's objective is to assist students in developing a coherent narrative.

Design elements. The micro-activities that composed the idea for the checkpoints can be found in Table 4.3. The discussion at hand focuses on the conceptualization of ideas within the initially proposed framework that can be found in Appendix F. Due to the need for increased flexibility during the summer school program, the decision was made to completely reconstruct these ideas. This strategic adjustment was primarily necessitated by time constraints and the desire to prevent redundancy in the teaching processes. The following is a discussion of the actual design elements that were finally incorporated into the program.

Table 4.3: Micro-activities

How are you?	Checkpoint Goals	Activity + Open Questions	
Emotional + Open Questions	Mindmap + Open Questions	Alone	Teamwork

A design element that was always present refers to the fact that checkpoints were made without the presence of teachers and mentors, only with the researcher and an assistant. This design element was chosen with the intention of creating an atmosphere in which students could feel at ease and free while participating in the activities. It served to emphasize the students' primary role in the design process, thereby empowering them to influence the course of action and, additionally, this arrangement allowed students to freely and frankly communicate themselves, even in the presence of educators.

The program's introductory activity was designed to prompt students to evaluate their emotional experiences through a two-dimensional lens. This evaluation was inspired by Putlink's emotional wheel [12], which provides a comprehensive spectrum encompassing the positive and negative aspects of emotions. The investigated factors included:

- *The level of positivity and negativity they experience.* Positive emotions include joy, love, and hope, whereas negative emotions include sadness, anger, and fear.

- *Their level of "activity" or emotional intensity.* Excitement, anger, and anxiety are examples of active emotions. Sadness, boredom, and contentment are examples of passive emotions.

The implementation of this multifaceted approach was intended to provide students with the means to analyze and interpret their emotional responses with nuance. It provided them with a valuable resource for introspection, allowing them to better comprehend the emotional landscape and level of engagement with the material.

Checkpoint 1. For the first checkpoint, which followed the emotional assessment activity, students were given the assignment to create a mind map in their personal journals that documented their individual journeys and team efforts. This task required careful tracking of their decisions, the ideas they considered, and the crucial decisions surrounding their selections and rejections.

Within the context of this checkpoint, this particular activity held exceptional significance: it was an effective tool for uncovering potential disparities in the team's shared vision, highlighting differences in perspective among its members. In addition, it enabled a detailed investigation of the origins of ideas within the team, casting light on who had contributed to the ideation process and how these ideas originated. At the same time, each team member was able to reflect on their individual contributions to the overall challenge.

- Where did I begin (put the keyword inside a box)?

- Where did we begin as a group?

- What did we considered until today?

- Did we make any big choice/process/topic/change?

- What we have chosen (circle the keyword)? And what we have discarded (cross your keywords)?

- What is my vision on the challenge?

- Who in the team has the most different view from mine? And why?

Following the individual creation of mind maps, teams were instructed to regroup and engage in a collaborative discussion, sharing and analyzing the visual representations they had constructed. The objective of this group activity was to leverage the collective creativity and insights of the team members as they designed a poster that reflected their collective vision and ideas.

Throughout the poster-making process, teams were encouraged to utilize their complete range of creative abilities, infusing their presentations with novel concepts, capturing visuals, and inventive design elements. This phase of the activity allowed teams to demonstrate their artistic and conceptual abilities by transforming their insights and discussions into a visually compelling story.

Each team was then tasked with presenting their poster to the congregated teachers upon completion. This presentation phase provided teams with a valuable opportunity to convey the substance of their collaborative journey and the key insights gained from their mind map discussions. It was an opportunity for teams to articulate their ideas and insights in a clear and engaging manner, providing teachers with a thorough comprehension of their collective thought process and creative output.

Also here some guiding questions were given:

- What is your initial problem statement?

- What are the main findings from the 5 "why" activity on your problem statement? How did the problem statement evolved?

- What critiques have you received? (Think about the mentoring session of yesterday afternoon) How did the problem statement evolved?

- What are you missing for your problem?

- What are the different viewpoints that you have on your problem statement? What are the ones that you have discarded? And the ones that you have chosen?

- What is your final problem statement? How is different from the initial one?

Checkpoints 2 and 3. During the second week of the program, the second and third checkpoints were strategically arranged. At this point, the curriculum had shifted from a primarily theoretical emphasis in the first week to a more hands-on approach with a variety of practical lessons and immersive classes. As a result, students were utilizing their diaries actively to document their experiences, record insights, and capture emergent ideas.

Given this change in the program and the increased emphasis on hands-on participation, it was decided to change the checkpoint structure. As a consequence, the traditional scheduled tasks were reduced, and the emotional assessment component became the primary focus. This involved continuing the emotional activity and incorporating questions that were designed to induce reflective responses from the students. This condensed approach was chosen to maximize the use of students' time and energy while preserving an effective structure for self-evaluation and reflection.

The open-ended questions for the second checkpoint were more learning-focused, with the following questions:

- Write the most recent interesting thing you've learned?

- Is there something you've been intending to learn or try, but haven't had the opportunity to do so yet?

- From your personal point of view, how is the work on the solution of challenge going?

The final checkpoint centered on collecting information about the entire summer school and requiring students to reflect critically on their experience:

- How did you feel before the presentation?

- Do you believe your work is useful and long-lasting?

- From your personal perspective: How did you feel working within your team during the summer school program? Has there been any imbalance in the team?

- What's the biggest challenge that your team had faced?

- What's a valuable piece of feedback you've received from a teacher, and how have you applied it to your work?

- Have you learnt anything useful from this summer school? What are you bringing with you?

Limitations. As previously mentioned, the last-minute modifications to the method's design, necessitated by time constraints and the changing requirements of the summer school program, revealed some flaws in its original conception. The researcher's initial thought of activities tailored to this pedagogical context was deficient due to these flaws, which were revealed by the experience.

In retrospect, it is evident that the method could be significantly improved by reevaluating its fundamental components. For example, creating a repository of quick and simple activities, ideally tailored to synchronize with the program's schedule, is one way to enhance the program. A deeper consistency between these activities and the course's overall content should also be a primary consideration and this would ensure that the method complements and enhances the program's primary learning objectives.

Ultimately, it appears that the method's lasting efficacy resides primarily in its capacity to collect data on participants' emotional experiences. Through the incorporation of thought-provoking open-ended questions, it is able to direct participants' attention to specific aspects of their journey.

To completely optimize this method for deployment in a context characterized by high-density experiences, including dedicated moments and precise schedules, a comprehensive redesign and reevaluation are necessary. The method should evolve to better align with the routine of such immersive learning environments, while preserving its fundamental advantages and addressing the noted design limitations.

4.3.6 Field Notes

This methodology served as a supplementary data source, employed to enrich the primary methodology. The researcher carefully compiled field notes in a variety of formats, including handwritten entries on personal devices, audio recordings of relevant summer school discussions, and photographic and video documentation containing valuable contextual insights.

These field notes were composed in real-time, concurrently with the unfolding events and actions. Subsequently, each set of notes was subjected to a review process, usually on the same evening, with the intention of enhancing the initial observations with details.

The overall purpose of deploying this methodology was twofold. First and foremost, it served as a tool for examining the researcher's perspective for possible biases: by meticulously recording events, this strategy intended to reduce subjectivity and increase the overall objectivity of the research. The second objective was to create a more complex and multifaceted narrative of the events themselves: this required capturing nuanced details, such as meteorological conditions, the emotional climate, and the dynamics within teams as observed from an external vantage point. In essence, these field notes provided an indispensable window into the larger context, enhancing comprehension of the events under consideration and allowing for a deeper examination.

4.3.7 Other tools

Before and during the summer school, additional supplementary materials were created. Access was granted on the first day to a **"Survival Toolset"** containing a collection of helpful websites for assisting students with the practical development of their challenges that can be found on Appendix G. Particularly, the toolkit contains references to online design software, free resources, and websites for conducting research.

It was developed a set of future-focused activities, which can be seen in Appendix H, however they were not utilized during the assessments for the aforementioned reasons, nor during the regular classes since the activities had already been defined. These activities were carefully chosen from online resources with the intention of facilitating the discovery, problematization, and solution generation processes, with a focus on multiple perspectives of the challenge.

4.4 Data Analysis

The data analysis was conducted using the aforementioned data sources, with a particular emphasis on using Diaries as the primary data collection and analysis method. For the purposes of **cross-referencing**, supplementary data sources such as field notes, checkpoints, and student-generated materials (e.g., posters and questionnaires) were considered as secondary sources. This decision to classify the sources was made only after a thorough review of all student diaries revealed their pervasive use, indicating a sufficient data pool for conducting the research.

It is essential to observe that the following sections of this work do not necessarily contain direct results and discussions derived exclusively from the primary methodology. Since diaries alone may not provide a comprehensive overview of the experiences, but rather a personal perspective, it was necessary to cross-reference with other materials to gain a comprehensive understanding of the topic.

As previously mentioned, the selected research methodology for this study aligns to a qualitative inductive approach in which insights originate directly from the data. The approach consisted of multiple sequential phases and utilized multiple individuals for checks on the work. The following steps were carried out:

1. A preliminary round of diary categorization was conducted.

2. Simultaneously, the contents of the diaries were summarized by day and student in a table.

3. Some works, such as the creation of posters and I&E Workshops, were cross-referenced with the collected tangible works, photographs, field notes, and diaries. This was accomplished by group.

4. A day-by-day summary of the experience was compiled.

5. A check with Lorenzo and Jessica was conducted on the objectivist view on the summer school.

6. A second round of coding was conducted.

7. The opportunities developed by the experience were discovered and written.

8. A second check with Lorenzo and Jessica was performed on the discovered opportunities.

9. A third round of coding was conducted, and competences were coded.

10. Competences and a fair tale, balancing the two previous views, was written.

11. A third check with Lorenzo and Jessica was conducted on the fair tale.

12. The software ATLAS.ti was utilized to extricate the results, which were then summarized and shared with German.

13. Using the obtained feedback, the results were revised and the thesis was written.

Initially, each student's collected data was considered relevant and interesting. Nonetheless, as the documents were compiled, their significance was evaluated in relation to student data. These documents were meticulously cross-referenced and aligned with the objectives of the research and this methodical approach prevented data loss and pinpointed precise moments, such as when documents were written and decisions were made. Nonetheless, this strategy required the management of massive amounts of data for analysis. In light of this obstacle and security and privacy concerns, research was conducted solely with software tools, and never on paper. Notably, the following software applications were utilized during the analysis of the documents:

- ATLAS.ti[6] for the coding and analysis of them.

- Apple Notes[7] for fast creation of documents to share.

- Microsoft Office Word[8] and Microsoft Office Excel[9] are utilized for the construction of result documents and the analysis of numerical results.

- Zotero[10] for managing and exploring research papers in accordance with research objectives.

- Charts.livegap[11] for creating charts for the demographics.

ATLAS.ti was the dominant tool utilized for analysis among those enumerated above. This decision was primarily motivated by its central role in data coding, especially given that the data existed in a digital format comprising exclusively of images. The robust analytical capabilities and data filtering tools of ATLAS.ti were essential in this regard. Alternative free or open-source tools, such as QualCoder[12], were evaluated prior to the analysis phase. However, it was discovered that they lacked certain functionalities or had a more complex and time-consuming methodology, rendering them unsuitable for the task at hand.

4.4.1 Coding

The coding of diaries was done only with Atlas.ti software. All the code techniques that will be described in this subsection, are taken from the book *"The coding manual for qualitative researchers"* [90]. The whole work of coding described in the introduction of this chapter was characterized by multiple steps for the coding process.

The first step is the initial coding, where techniques were used to identify parts of the text, breaking down the texts in discrete and manageable parts. The following are the main used methods:

- **Descriptive Coding**: used to assign a label that summarizes the part of the text, providing an inventory of topics for the following steps. Multiple themes could be developed on the same section of the text, so, for simplicity of the managing of the images that needed to be coded, if the block of text was small and the themes were correlated between each other, multiple codes could be applied to the same piece of the image.

- **In Vivo Coding**: When a topic or a single noun was too difficult at this stage to identify, this method was used.

- **Emotion Coding**: Last method used for this step was the coding of the emotions, for after analyzing the experiences of the participants.

The second round of coding was characterized by a rename of the previous coding, adding new ones where needed, and merging the ones that had the same meaning. At this stage, In Vivo Coding was removed and reformulated. The main methods used at this stage are the eclectic code and in particular focused Coding.

All these steps were repeated three times for ensuring that all data that concerned the goals of the research was coded, and were clearly divided into groups and categories that were easy to understand. The main text coded could be divided into the following Categories and Groups:

- **Process**: With this category, the goal was to gather insight on how and when diaries were utilized. The following are the groups used for dividing the coded content:

  - **Days**: With this group, codes were divided by day and the main goal was to get to know when participants used their diary, but only if explicitly stated by them (for example writing the day). This group has a big limitation and flaw, since the students suffered from a progressive overwhelm on things to do during the summer school, and so progressively did not clearly state the day on which they were writing.
  - **Style**: Within this code group there are all the codes inheriting the style used by the students to work on their diary in particular if there were drawings, maps, texts or other material like post-it or white pages or erased contents. Also, the change of direction of the writing of the diary was coded inside this group.

- **Individual**: Within this category all the experiences are coded and the goal was to get to know about what content was inside the diaries. The following are the used groups:

  - **Competences**: With this code group, the GreenComp competences [47] that can be read at page 14-15.
  - **Emotions and feelings**: within this category the emotions and feelings were coded, as well as the intensity of the emotions.
  - **Organized experiences and activities**: Within this group all the experiences, activities, lectures were coded and they were divided in the four thematic areas described in subsection 3.2.5.
  - **Reflection on topics**: within this group are coded recurring personal reflections and themes among the diaries.

Table 4.4 provides a more detailed description of all categories, groups and coded used for this research.

Table 4.4: Coding categories, groups and codes description

Category	Code Group	Code	Description
Competences (GreenComp)	Acting for sustainability	Collective action	To act for change in collaboration with others.
		Individual initiative	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.
		Political Agency	To navigate the political system, identify political responsibility and accountability for unsustainable behavior, and demand effective policies for sustain-ability.
	Embodying Sustainability Values	Promoting nature	To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems.
		Supporting Fairness	To support equity and justice for current and future : generations and learn from previous generations for sustainability.

		Valuing sustainability	To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.
	Embracing complexity in sustainability	Critical thinking	To assess information and arguments, identity assumptions, challenge the status quo, and reflect : on how personal, social and cultural backgrounds influence thinking and conclusions.
		Problem Framing	To formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.
		Systems thinking	To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems.
	Envisioning sustainable futures	Adaptability	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
		Exploratory thinking	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.
		Futures literacy	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
Individual Experience	Activity	High Involvement	In Plutchik's Wheel of Emotion is the equivalent of intensity: how intense is the emotion. This code is applied only when it is clearly written in the text the intensity of the emotion.
		Low Involvement	In Plutchik's Wheel of Emotion is the equivalent of intensity: how intense is the emotion. This code is applied only when it is clearly written in the text the intensity of the emotion.
		Medium Involvement	In Plutchik's Wheel of Emotion is the equivalent of intensity: how intense is the emotion. This code is applied only when it is clearly written in the text the intensity of the emotion.
	Emotion	Confused	This code is added when the emotion is identified in the text

		Disagreement or criticism	This code is added when in the text a disagreement or a criticism is identified
		Future	This code is added in the text there is a suggestion for a future idea
		Misunderstand	This code is added when the emotion is identified in the text
		Need More time	This code is added when in the text is stated the need for more time.
		Negative	This code is added when a negative emotion is identified in the text
		Neutral	This code is added when the emotion is identified in the text
		Positive	This code is added when a positive emotion is identified in the text.
		Thoughtful	This code is added when the emotion is identified in the text or when there is personal reasoning made by the students.
		Tiredness	This code is added when the emotion is identified in the text
	Free Activity	Bike Trip	This code is added when there is text related to the bike trip
		Company Interview	This code is added when there are notes relating to an interview with a company made by the groups
		Food	This code is added when there is a mention of dishes or foods in the text
		Future Steps/Plans	This code is added when the roadmap is there
		Letter to Tommaso	This code is added when there is a letter or text directed directly to Tommaso in the text
		Meme Challenge	This code is added when there is a direct mention of the meme challenge in the text
		Setting (Ita/Lake...)	This code is added when Italy, the landscape, places and environments are mentioned in the text.
		Tommaso Evening/Activity questions	This code is added when there is text related to the open questions given during the day or evening by Tommaso (the researcher)
	I&E Workshop	Problems	This code is added when there is text relating to the understanding of the challenge, not relating to exercises, but to moments done independently in groups.
		Solutions	This code is added when there is text relating to the conception of a challenge solution, not relating to exercises, but to moments done independently in groups.
		Final questions	This code is added for questions asked on the last day
		5 Whys	This code is added for the 5 whys activity

		Checkpoints	This code is added when there is activity linked to the checkpoints activity.
		Final Presentation	This code is added when there is something related to the final presentation
		Fundings	This code is added when there is text relating to fund activity
		MVP	This code is added when there is activity related text on the MVP
		Opportunities	This code is added when there is activity related text on opportunities
		Poster	This code is added when there is a section that includes the poster design preparatory activity done in a team.
		PS Environments	This code is added when there is a section about the activity of having different viewpoints on your problem statement
		Value Proposition	This code is added when there is the Challenge Value Proposition, and text related to the activity
		VUCA	This code is added when there is text related to the VUCA activity or notes on what was said in class
		Worst Possible Solution	This code is added when there is text related to the worst possible solution activity
		Peer Critique	This code is added when there is feedback from students in the text
		Teacher	This code is added when there is feedback from teachers in the text
		Problem Statement	This code is added when there is text related to the Problem Statement search activity.
	Social Activity	Orienteering	This code is added when there is text related to the orienteering activity
	Thematic Lecture	Activity - Free Software	This code is added when the text speaks about the Free Software Activity
		Deep Democracy	This code is added when deep democracy is mentioned in the text
		Exercise - Unmaking Electronics	This code is added when there is text related to the device repairability activity
		Existence god	This code is added when the existence of god is mentioned in the text
		Learning Typologies	This code is added when there is a mention of different types of learning in the text
		Björn	This code is added when notes relating to the lesson are clearly identifiable in the text
		Carlo	This code is added when notes relating to the lesson are clearly identifiable in the text

		Ozge	This code is added when notes relating to the lesson are clearly identifiable in the text
		Raul&Mela	This code is added when notes relating to the lesson are clearly identifiable in the text
		Martijn De-bate	This code is added when notes relating to the debate are clearly identifiable in the text
	Notes/Topics	Education theme	This code is added when something related to the education is mentioned in the text
		Free will	This code is added when there is an argument about free will in the text
		Judgment-how to be a better human	This code is added when there is an argument about being a better human in the text
		New Perspectives	This code is added when the desire for new perspectives is mentioned in the text
		New words Learned	This code is added when there is a list of words or translations of new words in the text
		Relationships	This code is added when there is text in the text that directly refers to the desire to cultivate new relationships or how these have been
		Safe environment	"This code is added when there is a direct mention of the concept of ""safe environment"" in the text
		Talking about feelings	This code is added when there is reasoning in the text about what could be journaled at the level of feelings
		Team Dynamics	This code is added when in the text there is a reference to teammates, strategies to be employed to overcome obstacles in the team... Everything team related.
Process	Day	10/07	When a section of the diary is marked for this day, this code is added.
		11/07	When a section of the diary is marked for this day, this code is added.
		12/07	When a section of the diary is marked for this day, this code is added.
		13/07	When a section of the diary is marked for this day, this code is added.
		14/07	When a section of the diary is marked for this day, this code is added.
		15/07	When a section of the diary is marked for this day, this code is added.
		3/07	When a section of the diary is marked for this day, this code is added.
		4/07	When a section of the diary is marked for this day, this code is added.
		5/07	When a section of the diary is marked for this day, this code is added.

		6/07	When a section of the diary is marked for this day, this code is added.
		7/07	When a section of the diary is marked for this day, this code is added.
		8/07	When a section of the diary is marked for this day, this code is added.
		9/07	When a section of the diary is marked for this day, this code is added.
	Style	Change direction diary	This code is added when the direction of diary use changes.
		Drawings	This code is inserted if there is a drawing.
		Erased	This code indicates that a portion of text has been removed by the students.
		Map	This code is added when a map or graph is drawn
		Native Language	When students write in their native language, this code is appended to the text.
		Post-It	This code is added to post-it notes attached to the diary
		Text - Diary	This code means that the linked portion of text is of diary type
		Text - Notes of the Day	This code means that the linked portion of text are notes of the day relating to reflections made on the challenge or on the lessons
		White Page	This code is added in the presence of one or more blank pages between two pieces of text, even if they are not connected to each other.

4.4.2 Data Cross Reference

The process of coding the diaries served **to identify key topics discussed within the diaries, disclose how the diaries were utilized, cast light on students' work activities, and provide a more quantifiable perspective on their emotional states**. This coding did not, however, provide a comprehensive description of the summer school experience since it provided a structural framework but lacked content-specific insights.

To solve this limitation, all data that was being coded was also **summarized in text format concurrently with the coding phase**. In addition, relevant text segments were **extracted and organized into four tables, one for each student group**, where the columns were the days and the rows the students, and at each intersection contained data extracted from the students' diaries.

The incorporation of field notes was essential for determining when to place the summarized text, especially given that not all diary entries were chronologically marked and some were written retroactively.

This categorization by group, day, and student enabled an analysis of content that the coding alone could not provide: direct insights from the students themselves, as well as an assessment of whether emotions and observations were unique to certain groups or individuals, or were shared by all. Concurrently, activities in which supplementary materials, such as posters, were produced were cross-referenced with the concurrent activities and thoughts of the students, resulting in a deeper comprehension of the experiences within their contextual frame.

This method of cross-referencing, coupled with the researcher's personal field notes and reflections, allowed for the construction of a daily summary. This summary highlighted the strengths and shortcomings of each activity and enabled an examination of recurring themes and social dynamics within and between student groups. It provided insight into the evolution of these dynamics over the

course of two weeks and ultimately led to the identification of the overarching themes that defined the summer school experience.

4.4.3 Results Extraction

The results of the analysis are derived from the two previously mentioned analytic methods: **coding and the tabular Cross Reference**. These data served as the basis for constructing a Janus-like perspective with multiple facets, similar to the concept described in *"Science in action: how to follow scientists and engineers through society"*. This method involved induction, extrapolation from the central themes and findings, and the identification of pedagogical possibilities. Subsequently, three distinct narrative perspectives were developed: one grounded in practicality, based on a quantitative and objective interpretation of the data; another that emphasized opportunities, positioning pedagogical insights as the central focus; and a third that sought to strike a balance, developing a narrative that harmonized the two aforementioned viewpoints.

Following this narrative investigation, a more quantitative analysis was conducted directly on the co-occurrence of codes [4], coupled with an examination of the distribution of codes among groups and individual members. This analysis sought to identify differences between the groups and identify design elements' strengths and limitations.

All of these outcomes allowed for a more in-depth reflection and comprehension, developed in this document in Chapters 5 and 6, of the competencies acquired during the experience, the Challenge Based Learning methodology applied in this context, and the methodology used to analyze the narrative of the experience.

5   Results

In this chapter, an in-depth representation of the results of this research can be found with a particular emphasis on coding activities which focus on teams' dynamics, emotions and approaches to GreenComp values.

5.1   Demographics

This summer school counted 16 participants, 15 of these students consented to participate in the research activities, forming the study's cohort. 14 of the students provided physical diaries for data collection, while one student provided digital pictures. Unfortunately, the digital diary submissions were illegible and fragmentary, in particular pages were plainly cut and some missing entirely. As a consequence, the student's data was deemed unusable and were subsequently discarded from the diary analysis. However, data contributions from the remaining 14 participants who kept physical diaries were incorporated into the research.

The gender distribution among the participants was not evenly balanced. Out of the 15 students in the research cohort, 10 were female, and 5 were male. This distribution is visually represented in Figure 5.1.
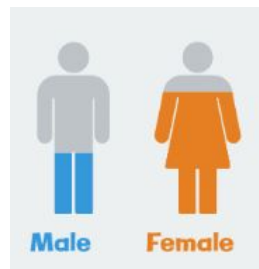
Figure 5.1: Gender distribution

As we can see from Figure 5.2, except for the University of Rennes 1, all consortium students were represented at the summer school. Five members each came from KTH University and TU Delft University, which accounted for the majority of participants. The University of Trento was represented by three attendees, while the University of Technology Eindhoven and Junior Achievement Bulgaria each had one.
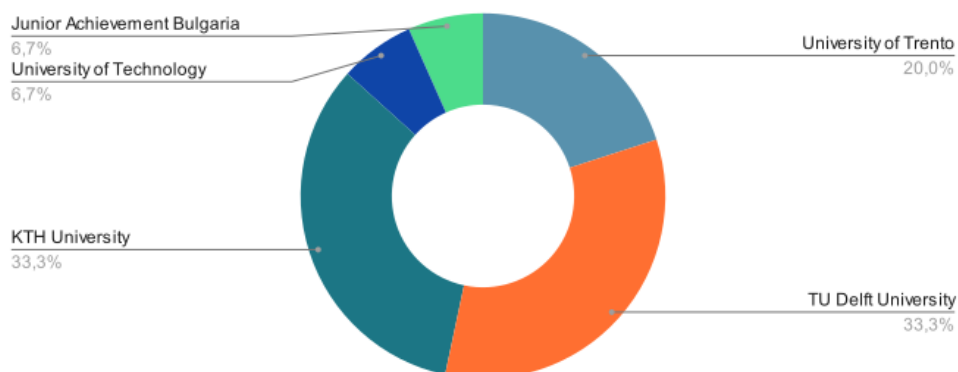
Figure 5.2: Consortium participants

Figure 5.3 provides a comprehensive overview of the participation patterns and distribution of participants in every one of the four groups for the two-week summer school. Notably, one student joined the experience one day after it began, whereas three students left within the first two days of the second week and, interestingly, all three of these early departures came from the same institution. In addition, one more participant departed the summer school for personal reasons on the final day.
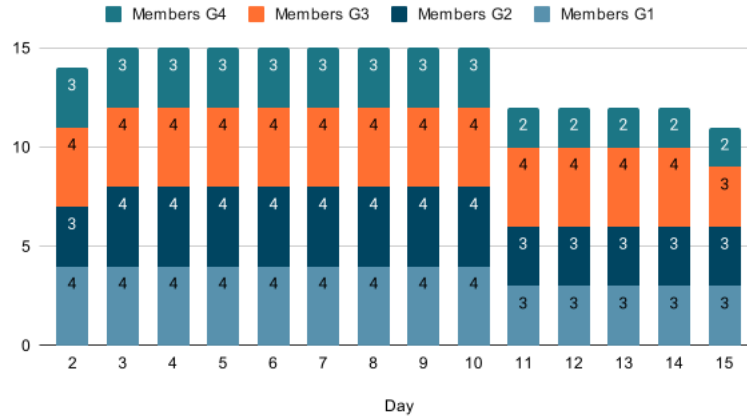
Figure 5.3: Participation patterns by day

5.2 Coding Results

The codes used and described in the methodological chapter, allowed for the identification and to pinpoint the day of events of:

- Usage and contribution on the diaries;

- Activities and workshops;

- Emotions and feelings;

- Reflection topics;

- GreenComp Competences;

- Dynamic interactions between mentors and team members, with the creation of 4 profiles.

5.2.1 Usage and contribution on the diaries

The participants' diaries displayed a wide variety of theme content and documentation styles. The entries in these diaries ranged from in-depth reflections to straightforward task-oriented entries. In addition, the collected information was spread across multiple days and included both real-time and retrospective entries. Some entries included remarks such as

"I realized, I forgot to write here. So, I will quickly sum up last days."

(A participant on 05/07/2023)

Cross-reference with field notes played a significant role in the subdivision of the days: some notes and days were written with the date, but the majority of text lacked a date. Figure 5.4 depicts the reconstruction of the presence of data by the date the data was written using the mixed methodology presented in the previous chapter.

According to Subsection 4.3.4, two distinct categories of writing were identified within the diaries: a journal approach, characterized by extensive reflections, was coded with the label *"Text - Diary"* forty times; a more operational approach, known as the logbook, was classified as *"Text - Notes of the Day"* seventy-four times. It is important to note that while these numbers differ in size, reflections
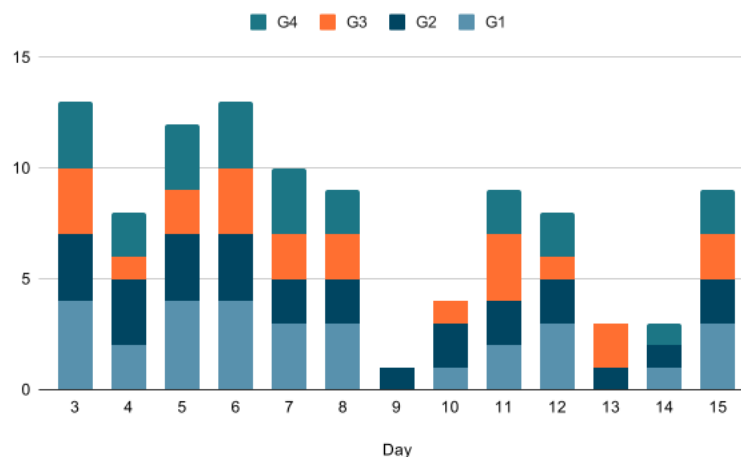
Figure 5.4: Data presence by day

were frequently extensive and treated as a single cohesive block, whereas log entries were frequently interspersed with reflections or other data from the same day and therefore coded multiple times.

To gain a better comprehension of how diaries were utilized and to compare the two categories, the presence of data by day for each student was visualized using a binarization technique in Figure 5.5. This graph reveals three notable increases in reflective content on the 6th, 12th, and 15th day, which correspond to the days when checkpoints had been set up. Intriguingly, when these spikes are omitted, the frequency of reflective entries tends to diminish over time, whereas the operational approach displays greater variability and appears to depend on the needs of summer school activities.
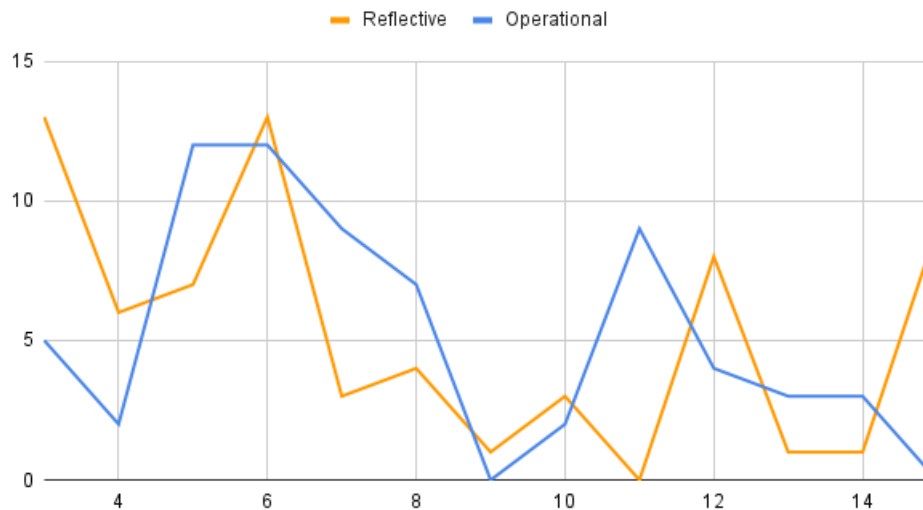
Figure 5.5: Type of data by day

Also, within these two categories, the styles that students employed were very individual, including the material that they contributed to the diary, such as *post-it notes* (coded 47 times), and the incorporation of *art-works, drawings* (coded 81 times), and *mind maps* (coded 24 times). Additionally, in 11 portions of the diaries, the students preferred to write in their native language rather than English, with some requesting that the information not be included in the research and others choosing to do so in order to complete the task more quickly.

The following are examples of these various writing techniques: note that the following annotations are reported in their original form, therefore considering participants' grammar and syntax errors.

Some students preferred lists of elements, ideas, or concepts:

" *Opportunity Space: Having interactions with professors, staff, students, etc. Hybrid Standardization Consortium Introduce Hybrid Education to rankings (Measurement?)* "

<div align="right">(A participant on 08/07/2023)</div>

Others focused on personal and intricate reflections derived from the themes:

" *Yesterday, while taking a gap on the lake, I was thinking about how questions about good & bad only started becoming relevant when life started becoming complex/free enough to control/have power over a wide array of actions, got free will rather than having casual reactions on their enviroment. [...]* "

<div align="right">(A participant on 05/07/2023)</div>

Some students preferred to illustrate and diagram their entries:

" *Final presentation [A mind map with a stakeholder a analysis all interconnected between eachother]*

The content:
→ Research gap on education of online education → one solution will add value to this research domain
→ Research on online education exists multicriteria analysis exists.

Infrastructure: [A draw of the interconnections that builds the application between user, platform and database] "

<div align="right">(A participant on 14/07/2023)</div>

In addition, there was a lack of consistency and distinction between the two aspects of diary utilization, namely note-taking and reflections. Initially, some students attempted to differentiate between these two activities by utilizing one portion of the diary for reflection and the other for recording. As the days progressed, this method was frequently abandoned in favor of a continuous, unstructured stream of entries.

5.2.2 Activities and workshops in diary coding

The I&E Workshops were the most frequently coded activity in the diaries, mainly because students had to write inside the diaries. The checkpoints were the most recorded aspect of these workshops, appearing 50 times in the diaries. The analysis of challenges from various perspectives was coded 24 times, the formulation of problem statements was coded 29 times, and the "5 whys" [2] activity appeared in 17 entries. Further investigation of the journal's contents revealed that other activities were present, like solution analysis was recorded 14 times, opportunities analysis 13 times, and Value Proposition 10 times. In addition, feedback from both teachers and fellow students was mentioned in 12 entries, highlighting its significance in the overall learning process.

5.2.3 Evolution of Emotional dynamics over time

The shifting emotional mood of the participants is an interesting pattern that emerges over the duration of the summer school experience [Figure 5.6]. On the fifth day, the initially prevalent positive outlook endures a significant shift towards a more negative tone. However, after mentors and teachers provided a detailed explanation of the summer school's objectives, participants appeared to realign their emotions.

In addition, a visual examination of Figure 5.7 reveals distinct emotional behaviors among the groups, with varying proportions of positive and negative emotions. Notably, Group Two exhibited significant emotional fluctuations, with a predominance of negative emotions on a specific day. Group One also demonstrated emotional changes, whereas Groups 3 and 4 maintained a relatively positive disposition with fewer observable fluctuations.
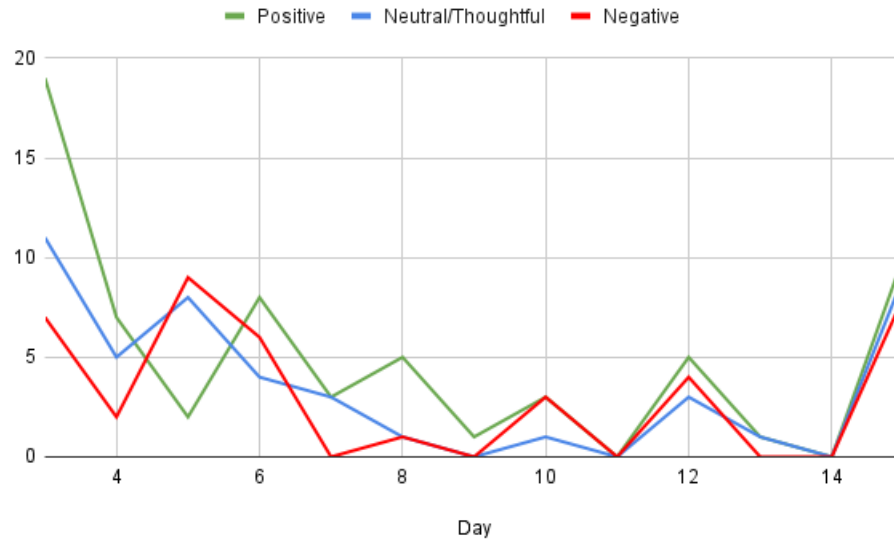
Figure 5.6: Emotional dynamics
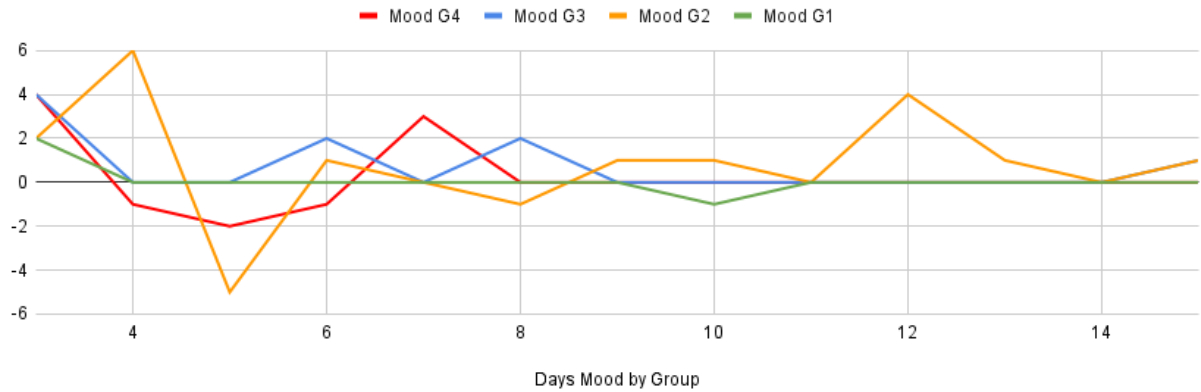
Figure 5.7: Emotional dynamics per Group

5.2.4 Impactful thematic lectures and team dynamics

Several thematic lectures left a lasting mark on the students, as evidenced by repeated references to them in the students' diaries. The *"Deep Democracy"* lecture was notably well-received, as students coded it thirteen times in their entries and, likewise, the *"Unmaking Electronics"* lecture received ten mentions. These lectures played a crucial role in guiding students' reflections on intricate topics such as free will, the substance of relationships, coping with diverse people and cultures, the education system, and sustainability. Team dynamics, which was mentioned a total of 30 times, emerged as a second prominent theme in students' diaries: this theme was particularly prominent in Groups 1 and 2, where teams confronted unique challenges, and was explored from a variety of perspectives by the students. To exemplify, a group acknowledged their differences but collaborated effectively, as one participant explained:

> *" [Name redacted] sees things at a different level of abstraction "*

(A participant)

In contrast, another group encountered recurrent challenges in their project work and interpersonal relationships:

> " My team was very passive, and [Name redacted] did not add anyzing [Name redacted] was hindered by [pronoun his/her/its redacted] English [...] "

(A participant on 15/07/2023)

In another group, thriving relationships and a constructive attitude toward cooperation predominated:

> " Excited to finish as a team "

(A participant on 15/07/2023)

> " There had been a healthy amount of discussing ideas and challenging each other thoughts. Overall my team was great to work with. "

(A participant on 15/07/2023)

The last group, despite confronting difficulties, collaborated proactively to find solutions:

> " One challenge we faced in our group was that our conversation were a bit messy. [Name redacted] however got the idea to have a "talking stick", which made a huge difference. "

(A participant on 05/07/2023)

5.2.5 GreenComp Competences

The day-by-day categorization of GreenComp-related coded competencies found in the student diaries constitutes a significant overarching observation resulting from the summer school experience [Figure 5.8]. Notably, "Embracing complexity in sustainability" emerged as the most explored competency throughout both weeks.
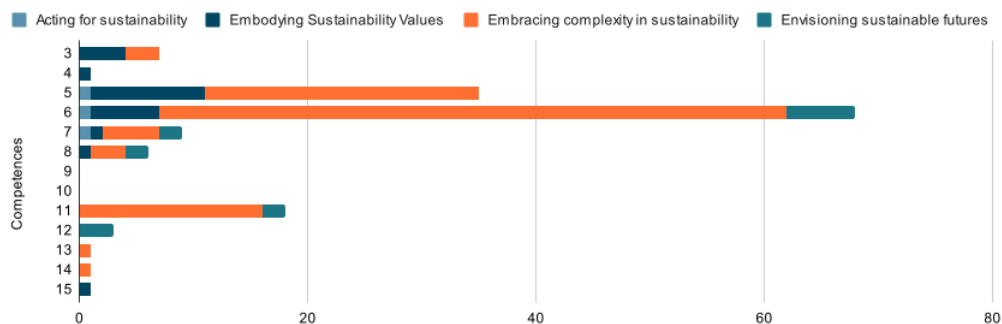
Figure 5.8: GreenComp-related coding

However, as we can see from Figure 5.9, there are differences in the development of competencies between the various categories. The diaries of Group 3 contained a greater variety of texts and reflections associated with various competencies. In contrast, the other groups appeared to have engaged in fewer discussions, focusing primarily on the competencies explicitly addressed during the formal sessions.
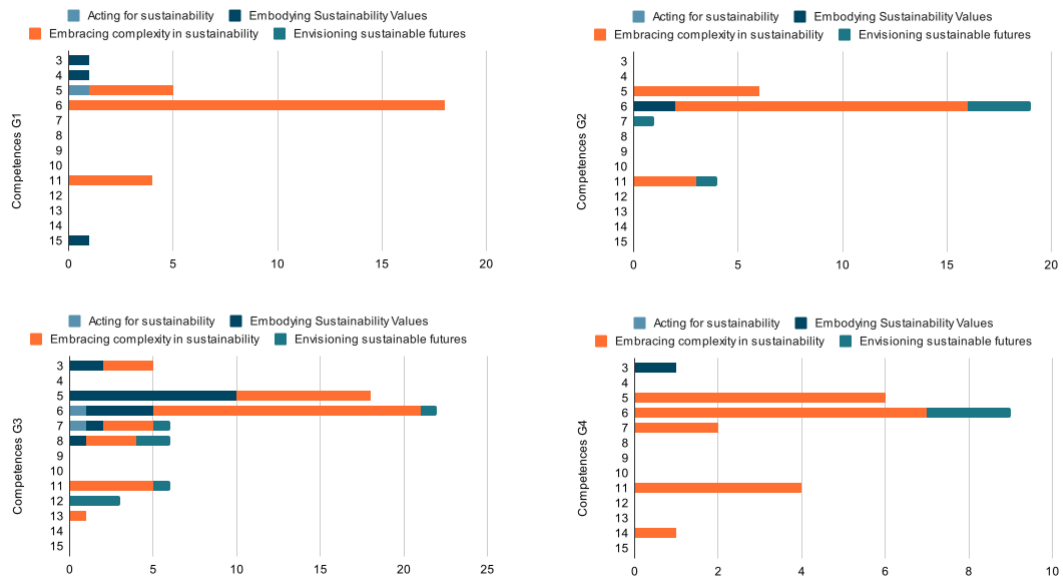
Figure 5.9: GreenComp-related coding per Group

To provide a tangible example of a coded competence under *"Embracing complexity in sustainability"*, consider the following excerpt, derived from a brainstorming activity involving all team members:

" [There are 6 post-its, one for each dimension] Social (Impact)
Variety of background and nationality lead to more perspective, exchanging experience and informative views.
Offcampus solutions can impact social cohesion choices between options can be felt as unfair.

Economical:
Different tuition fees a price incentive for non-EER.
Budget for sustainability is limited
Sustainable choice is more expensive

Pedagogical:
Different Cultures leads to friction in teachers
Sustainability must be gained in material
Mix of backgrounds gives opportunity for new angles

Realm of control
The uni can directly control what happens on campus, not what their people do offcampus or what choices they have or (?) might not be able to ban(?) international students.

Societal:
Manage emmisions happen outside of uni
Sustainability depends on society arpund uni
Uni should be (?) and collaborate with their surroundings to advance greener initiatives
Uni will not represent their bad demographic because of international students

Enviromental:Travelling causes Co2 different sources of emmisions

- *energy*
- *food*
- *travel (commuting)*

"

(A participant on 6/07/2023)

6 Discussions

In relation to this particular experience, the significance of context cannot be stressed enough. Students were fully immersed in a multicultural environment, necessitating interactions with a diverse group and the challenge of developing innovative and plausible solutions in just two weeks of intensive work.

This close proximity to one another allowed for the deep development of social dynamics among the participants. Simultaneously, it highlighted the differences between each individual, which were primarily viewed in two distinct ways:as obstacles to productivity or as sources of creativity.

These two perspectives are representative of two contrasting educational paradigms. The first is the "vertical" approach, in which everyone possesses similar skills and is closely aligned. In contrast, the "horizontal" approach encompasses a multiplicity of competencies spanning numerous disciplines, thereby fostering a diversity of perspectives. While the latter approach enhances the learning experience, it also poses challenges in terms of interaction and consensus-building, making effective communication a crucial factor. This summer school showed the latter approach.

Due to the relatively small number of participants, some may question the scientific significance of this work. However, this skepticism can be openly addressed by considering the nature of the work, the unique combination of components within the methodology, and the quality of the resulting data. These elements not only cast light on the experiences and outcomes of the C-FLEX Consortium, but they also provide a practical demonstration of previously explored strengths and weaknesses.

This research represents a novel method that integrates diverse elements and contexts into a single exploratory project. It is an essential first stage in the development of a Challenge-Based Learning summer school with a specific emphasis on social dynamics and multicultural aspects, putting the individual's development at the center rather than challenges or solutions.

6.1 Two faced Janus

"Science in action: how to follow scientists and engineers through society" [64] has been a fundamental resource for this study research. In particular, it highlighted how narrative and knowledge are intricately linked, with interpretations changing and evolving as a result of the simple variation of words, and thus provided me with a captivating new perspective. I believed that this was also particularly pertinent for qualitative nature of this work.

When analyzing the students' responses, we could choose to view them only superficially, as straightforward manifestations of their thoughts. However, a deeper examination of their language reveals an extensive array of complexities. Their responses contain the potential for curious questions, the expression of emotions, and insights into what most resonated with students during their experience. As one student expressed:

> *" People might only write down their criticism and only focus on the things they want to have differently. I don't think that is representable of the summer school, even through the critical remarks might help. "*

(A participant on 3/07/2023)

This statement emphasizes the complexity of feedback and the need to consider it holistically. It recognizes that, while valuable, criticism does not encompass the totality of the summer school experience. Rather, it functions as a component of a more extensive narrative.

The competences, learning outcomes, and opportunities gained by the students as a result of their participation in the summer school are a second perspective to consider. These experiences can be described with catchy keywords such as sustainability values, complexity, uncertainty, ambiguity, a safe environment, freedom, a success tale, and an emotional journey. These terms encapsulate the

essence of what the summer school offered its participants, presenting a picture of a transformative journey comprised of multiple dimensions of development and exploration.

As a participant points out, neither of these two interpretations can be regarded genuinely fair or exhaustive. Human interaction is inherently dynamic and complex, undergoing constant change and evolution within its unique environmental context. This complexity is not an excuse for dismissing the results of this work as compromised by personal biases; rather, it provides with a valuable opportunity to gain insight into the significant factors at play in this research.

It is essential to recognize that this exploration delves into the intricate nature of human experience and how it is refracted through individual lenses. It is not an attempt to oversimplify the narrative or classify people into broad categories. Instead, it endeavors to navigate the delicate balance between various perspectives, recognizing the inherent subjectivity that pervades qualitative research.

The fusion of methodologies, initially conceived, aims to probe this duality, known also as the two-faced Janus. One perspective is inevitably wrote by the unique perspectives and biases of each student, while the other is shaped by the researcher's perspective, which seeks to construct a narrative that encapsulates one aspect of reality. Again, this version of events does not claim to represent an absolute truth, a universal reality shared by all individuals. Instead, it goes cautiously in an effort to shed light on a portion of this multifaceted reality.

This work is essentially an investigation of the harmonious coexistence of these two perspectives, an attempt to synthesize the different voices and perspectives into one cohesive whole. It recognizes that the truth resides somewhere in the intricate interplay between these perspectives and facilitates a more nuanced understanding of the examined phenomenon's complexity. This narrative, although not conclusive, enhances our understanding of the topic by providing a look into the multidimensional nature of human interaction in complex environments.

Therefore, the following sections of this chapter will be committed to this effort, aiming to provide a complete and fair narrative that examines both sides of the coin. This narrative has been shaped by the invaluable contributions of participant students, teachers, mentors, a vast corpus of literature, and the constructive input of co-relators.

6.2 Domain analysis and pedagogical opportunities

During the summer school program, students had numerous opportunities to challenge their limits and leave their comfort zones, and they frequently felt compelled to do so. The following opportunities and experiences emerged from field notes and reflections documented in the students' journals. It is essential to observe that this perspective is retrospective, looking back at the program's events.

6.2.1 Entrepreneurial contamination

During this phase, students had the opportunity to immerse themselves in a highly dynamic environment filled with a powerful infusion of entrepreneurial spirit from their instructors and mentors, many of whom were themselves experienced entrepreneurs.

This immersive atmosphere was noticeably different from traditional classroom settings, fostering a unique relationship dynamic in which all ideas were encouraged to be explored and all concepts were open to scrutiny and debate. Even statements made by instructors and mentors were subject to review, with group and individual perspectives frequently placed against those of the professors. This environment encouraged direct confrontations and open dialogue, which was made possible in part by the instructors' lack of personal judgment and evaluation of the students' future prospects.

> " The guy [name redacted] was incredibly confusing and really disrupted the process of our group. [Personal comments redacted] "

(A participant on 5/07/2023)

> " Even though they expected us to find 'who', I don't think it is the right way. "

(A participant on 5/07/2023)

This distinctive aspect of the summer school environment also generated a decision-making paradigm mimicking that of certain professional workplaces - one characterized by freedom and independence in

decision-making processes. As a result, students were placed in a situation where they had to organize their work independently and learn through the process, while overcoming obstacles and pursuing potential solutions.

This was a novel and unfamiliar terrain for many students, as they were more familiar to situations in which directives were issued by authority figures and their role was primarily that of executors or, at best, interpreters. This new demand for autonomy and self-direction resulted in initial frustration. It should be noted that the apparent lack of guidance was merely apparent and in reality students were free to seek assistance from readily available and willing mentors and teachers. Thus, the primary obstacle was not their ability, but rather their confidence, recognition of difficulties, and willingness to accept the responsibility of seeking support from others.

Moreover, this difficulty was connected with the inherent competitiveness with which many students approach learning. Some individuals were inclined to assert their ideas and perspectives in a competitive environment without necessarily adapting to the group's dynamics. This dynamic added an additional layer of complexity to the learning experience, requiring students to not only navigate their newly acquired autonomy, but also nurture a cooperative and adaptable spirit within the group setting.

> " [... the] afternoon session [was] a bit stressful, but since there is no forcement to share your thoughts, I was still happy with how it turned out. [...] I enjoy listening to the others share their thoughts and discuss. "

(A participant on 4/07/2023)

> " No one was listening to each other but everyone was trying to push their own ideas. I didn't enjoy it. "

(A participant on 4/07/2023)

This new environment required the students to identify friction points and find a solution, which is especially difficult if they were not trained or assisted in the process.

> " You should be able to interact and comunicate with a wide range of people and it take patience and compromise. "

(A participant on 15/07/2023)

> " Group dynamics are difficult. [...] Open communication and setting boundaries are two key learning that I will take with me. "

(A participant on 15/07/2023)

All of this was done with a single objective in mind: to provide participants with the opportunity to step out of their comfort zone and challenge themselves to development, adjusting their perspectives as necessary and learning to improvise and act as a group, including making compromises.

> " Being uncomfortable is needed to improve, since you are in a situation that challenges your status quo. "

(A participant)

During this time, students were exposed to a combination of interdisciplinary and futuristic concepts, enabling them to confront the complexities of the real world from a variety of perspectives. This experience compelled them to develop a holistic approach for identifying problems and developing solutions. In addition, the I&E Workshops encouraged students to repeatedly broaden and narrow their perspectives. This process required them to cultivate mental flexibility, allowing them to transition between contexts with ease. However, without specific guidance, it occasionally left students feeling perplexed, as participant noted:

" Getting confused is understandable in this working structure. "

<div align="right">(A participant on 15/07/2023)</div>

This was also an occasion to discover and experiment with a new method of working and interacting, one that is becoming known as "slow productivity" [45], and to distinguish between slow work and low productivity.

" I need to slow down when i lose contact with my values. "

<div align="right">(A participant on 10/07/2023)</div>

In conclusion, the effort to resolve environmental challenges and the acquisition of new perspectives to view the problems were made possible by the lessons taught by teachers from vastly different fields: business, ethics, engineering, and linguistics.

6.2.2 Cultural Cross-Contamination

The vast diversity of cultures that the participants contribute to this European experience stands out as a defining characteristic of it. This diversity, while undeniably enriching, posed a unique challenge when it came to establishing relationships. This cultural diversity *added depth and variety to the experience*, but on the other hand, it presented a formidable *obstacle in terms of establishing meaningful relationships.*

The organizers, aware of this challenge, made a concerted effort to create a safe and inclusive environment where all participants could freely express themselves. This environment was intended to be free of judgment, bringing friendliness and openness. Within this framework, **participants engaged in constructive dialogues and actively steered the collective experience's direction**. This cooperative approach occasionally resulted in disruptions, such as the occasional skipping of scheduled activities to resolve critical problems or concerns.

However, **the definition of "safe environment" was somewhat vague, and the rules regulating it were left to the students' discretion and maturity**. This ambiguity prompted participants to reflect in their journals on the very essence of *"safety"* and *"democracy"*. One student coined the title *"Practice what you preach"* to summarize its thoughts.

" Still don't really think all individuals has the same view on our "safe enviroment". "

<div align="right">(A participant on 4/07/2023)</div>

" My problem: if, instead of teaching people to stand up for themselves, there is only focus on the safest baby-ing environment, then the same people will slunt up the second there is a little uncomfort. Safe space, but how about safe people? "

<div align="right">(A participant)</div>

" Is democracy about the majority getting what they want? or everybody having benefits as much as possible? "

<div align="right">(A participant on 12/07/2023)</div>

At the same time communication barriers came to surface, such as not a perfect proficiency in speaking English, the difficulty of expressing complex concepts, difficulty to comprehend others and the interaction between members of different countries.

" [The experience has been] Frustrating, there was a high imbalance of workload and motivation especially from the [Nation redacted] student who got this scholarship who isn't even a country in EU. "

<div align="right">(A participant on 15/07/2023)</div>

An example of these cultural factors is that there was a set of people that spoke also if they were expressing wrong opinions, and others that were more taciturn and reflexive, that before speaking needed to be sure to express something relevant to the discussion. **The severe diversity of communication styles exhibited by the participants was an insightful manifestation of these cultural factors.** Some individuals demonstrated an inclination for expressing their opinions, even when they had doubts about their truth. Others, in contrast, employed a more reflective and reserved approach. Before speaking, they appeared to seek assurance that their contributions would sincerely enrich the ongoing discussions.

" How proficient does a person need to feel on a topic to feel like it is appropriate to talk. [...] They need to be activated/empowered more. "

<div align="right">(A participant)</div>

" Trying to figure out our problem. Sadly our conversations didn't go as smothly as before. I felt that not all voices got heard. "

<div align="right">(A participant on 5/07/2023)</div>

" I believe 'conflicts' are valuable if you are not going to be judged. [...] It is beneficial to broaden your horizon but if others are stubborn on their ideas and not ready/open to hear your voice, there is no point to talk. "

<div align="right">(A participant on 4/07/2023)</div>

Examining the diaries and exploring the recurring theme of a lack of focus coupled with behavioral differences, which are frequently attributed to cultural differences, compels us to question whether these disparities are truly insurmountable. Indeed, *we recognize the cultural differences between nations, but can they be bridged through adaptability and a spirit of mutual understanding?*

Before taking action, it would be wise to obtain the opinions of others, according to a suggestion that emerged from the discussions. This basic yet profound practice, such as requesting permission before photographing someone, exemplifies a possible means of navigating these cultural complexities. These reflections emerged during the exchanges between organizers and students, serving as precious moments for the exchange of values and perspectives.

Despite these obstacles, it is encouraging to note that the majority of students view this experience as a period of significant personal development. They leave with invaluable knowledge on self-management and expanding their knowledge in a dynamic team. Notably, the development of GreenComp skills was not derived primarily from classroom lectures, but rather from collaborative workshops. The questions they posed about their work and the answers they discovered enriched these experiences, demonstrating the efficacy of experiential learning.

6.2.3   Effective and dynamic organizational team

Throughout this entrepreneurial journey, having a team with a vast array of skills in the entrepreneurial field proved to be an invaluable asset. In addition to facilitating seamless operations, this heterogeneous group played a crucial role in boosting student morale during difficult times. Among the extraordinary team members, one stood out for his or her exceptional charisma and capacity to inspire dreams while grounding others in the harsh realities of entrepreneurship. This talent was not unique, but widespread among the organizational team, and was able to breathe vitality into the activity, lifting spirits, enabling a recognition of moments of criticalities. Also the success of creating relationships between the two sides of the table was a moment of success, where with an open and honest dialogue, direct confrontation, and the sharing of experiences, it was possible to turn the tide, transforming what could have been a mere learning experience into a resounding success story.

" Personally the processes here during these 2 weeks in Italy were very strong and emotional. "

<div align="right">(A participant on 14/07/2023)</div>

This sentiment reflected the profound impact that the team had on the journey of each participant. This experience turned out to be a profound **journey of self-discovery and awareness for both students and teachers**. It provided everyone involved with a rare opportunity to confront and acknowledge their limitations. It was an opportunity to learn the invaluable lesson of trust - faith in oneself, trust in the abilities of others, and trust in the group's capacity to overcome the obstacles.

At the same time was a process of discovery and self awareness of personal limitations, both by students and mentors, and an opportunity to learn to trust the skills of others to complement one's own shortcomings with the objective to fast and agile solving of rising problems before they become like that.

In conclusion it was a transformative experience both for students and teachers, marked by emotional ups and downs, with periods of crisis. These experiences were not negative, but rather formative. This journey showed that personal relationships are the foundation of any successful activity, providing the support, motivation, and resiliency necessary to overcome obstacles and achieve success.

6.3 Challenge Based Learning within the summer school

The summer school experience was created and carried out in accordance with the Challenge Based Learning framework, with a focus on the problematization rather than the solution. This implementation of the framework led to perplexity among students who were already familiar with it, and ambiguity among those who were not.

" Different interpretation of CBL made me confused. "

<div align="right">(A participant on 5/07/2023)</div>

" It was a hard method and I think we made it harder than it was. "

<div align="right">(A participant on 5/07/2023)</div>

At the same time, students were not given a full picture of the methodology of learning and the learning goals, and probably was not given also to the pre-course, in fact they did not understand the first days what to do, where to go, and they had not any clear guidance for starting to work.

" I felt very frustrated [...] it takes so much (no needed) energy to trying to figuring out what the challenge is about. "

<div align="right">(A participant on 5/07/2023)</div>

Furthermore, students were not given an in-depth understanding of the learning methodology and objectives, which may have also been lacking in the pre-course preparation. Consequently, during the first few days, students struggled with uncertainty regarding their roles and directions, as they lacked instructions to begin their work. In response to the pervasive confusion among the teams, the coordinators devoted a session to clarifying the learning objectives and their expectations of the students. Subsequent conversations with teams and individual members helped steer the expectations in the proper direction. This transformation is evident in the students' diaries, where they acknowledge its necessity.

" I have been feeling a bit stressed because I don't know the mentors expectations of us but I had a good conversation with a person today that gave me a different perspective: why be stressed, we will figure it out together and they don't expect us to be experts, just do your best. That made me more calm [...] "

<div align="right">(A participant on 6/07/2023)</div>

" I think we needed clear explanation. Understanding 'why' we are doing what we're doing is beneficial to improve our working session. I would like to be able to work without clear guidelines, but unfortunately this is how we got used to work. "

<div align="right">(A participant on 6/07/2023)</div>

A further challenge encountered during this experience was the difficulty students had in a CBL environment in distinguishing and weighting feedback from different stakeholders. Additionally, in particular to the C-FLEX-related challenge, students felt the pressure and expectations of their teachers, despite the fact that it was not their initial preference, which negatively impacted their motivation.

" Confusing feedbacks → I think they were not sure about the challenge. They all had different interpretations and guided us with their personal interest within the topic. "

<div align="right">(A participant on 5/07/2023)</div>

The employed methodology entailed engaging with all challenge providers, involving students in their search for solutions, and employing their own personal relationships with other organizations to gather information. Simultaneously, as students engaged their challenges, they were directly immersed in the process, resulting in a sense of excitement and accomplishment.

" The best thing that happened today was the interview that me and my team made for our project. "

<div align="right">(A participant on 6/07/2023)</div>

" We are realising more the project. We are getting a better understanding of what we want to do and working also more efficiently. "

<div align="right">(A participant on 10/07/2023)</div>

" Nervous, will we make it?/ Exceited! Creative! We have something! "

<div align="right">(A participant on 12/07/2023)</div>

In the end, the obstacles encountered in this experience were not novel, as they corresponded to prevalent problems identified in the literature on CBL. However, what distinguished this experience from others was **its innovative learning format centered on a sustainable theme**. In addition, the summer school setting provided a unique context for CBL. In this context, students and mentors forged relationships that were either impossible or uncommon in other educational settings. These relationships were characterized by a sense of equality, a characteristic of CBL that transcended the conventional dynamic of exploited researcher and expert.

The genuine relationships that extended beyond the scope of work were what made this experience exceptional. Even mentors and professors participated in shared excursions, meals, and collaborative discussions with the students. Essentially, they became more human, transcending their traditional duties of being distant authorities.

Despite the fact that this type of CBL experience and its approach may not be faultless, they represent a crucial first step in bridging the divide between these two entities. It fosters a unified team working towards a more sustainable future, challenges the established educational paradigm, and fosters meaningful connections between individuals, which is uncommon in most other contexts. This strategy facilitates the transfer of horizontal skills and creates a genuinely effective learning environment.

6.4 Research Methodology analysis

The analysis of diaries yielded all of the aforementioned findings and explanations. As specified in Subsection 4.3.4, the validity of the diaries' methodology has already been widely debated and accepted as a valid method. Thanks to its use at every stage, it was possible to comprehend not only the students' emotions and thoughts, but also the notes they deemed significant or on which

they received feedback. It was also possible to distinguish between students who enjoyed writing or were predisposed to it, who wrote lengthy and detailed sections, and those who made an effort to write something, using the journal more like a notebook. In spite of this disparity, there was sufficient information to reconstruct the summer school, and everyone contributed, even if it was only a single word or an opinion for constructing the whole picture.

Intriguingly, the combination of methodologies yielded a great diversity of data, all of which were combined in the previous sections. However, **additional data emerged from moments of sharing between organizers and students**: they include precious moments of sharing values and opinions, made possible by the group method, as opposed to the diary methodology, in which everyone thinks independently. Thus, there are a variety of perspectives within this mixture: the one where the individual student is the protagonist and gives their personal perspective in the diary; the team view, where members had the opportunity to express themselves through group work; and finally, the group view, where a general direction could be decided collectively. This was an intriguing discovery, especially considering the technological rather than humanitarian backgrounds of the participants. They all together helped to obtain a broader perspective as opposed to the use of a single questionnaire where, if individually considered, much data would not be gathered during the experience, but only at the end or in a particular moment with a retrospective view, preventing the ability to analyze and plan action for another experience.

The development of team profiles was made possible as a result of this methodology.

6.4.1 Team Profiles

The four teams behaved in different ways during the experience, developing different types of relationships. These considerations were visible in the way they worked during the summer school, how they wrote their diaries and what they wrote. From this data, four profiles were created.

Common. GreenComp competencies in the area *"Embracing complexity in sustainability"* were developed by all groups, and positive emotions and thoughtfulness were widespread among all participants. Positive and negative emotions could be graphed together as we can see from Figure 6.1, with the negatives subtracted from the positives, and the general mood could be graphed by day to reveal an interesting result.
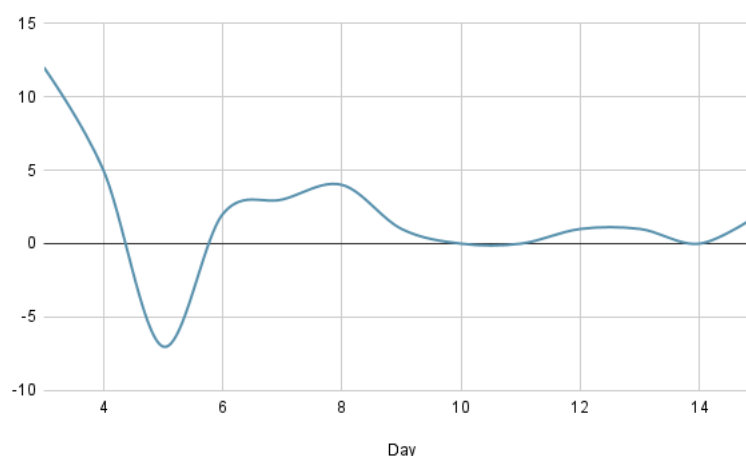
Figure 6.1: General emotional dynamics

This graph appears to be quite similar to the **Gartner Hype Cycle** [1] (Figure 6.2), and students appears to be going through this cycle within the experience: a high peak of inflated initial expectations on the program and on the journey, a disillusionment of expectations and a moment of perdition and lack of clarity, a slope of enlightenment and alignment with the formative goals and expectations, a plateau of productivity where everyone is aligned.

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[1]Hype Cycle. `https://it.wikipedia.org/wiki/Hype_cycle`
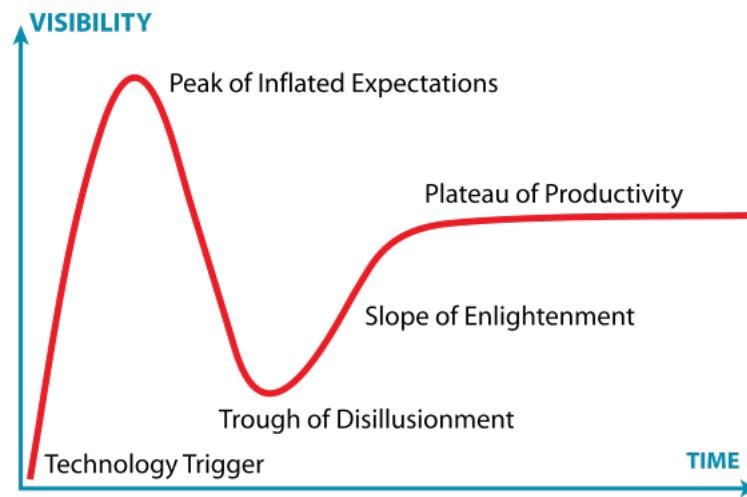
Figure 6.2: Gartner Hype Cycle from [22]

This concept does not aspire to be a discovery or a conclusive outcome; that is why it resides within the realm of discussion rather than being categorized as a result. It merely serves as an intuitive notion for potential future analysis, primarily due to the insufficient data gathered to warrant scientific significance.

Furthermore, it is noteworthy that all students have diligently engaged in a minimum of two required activities, as evidenced by their completion of checkpoints and responses to questions. Additionally, nearly every student has demonstrated their commitment by taking thorough notes during lectures and their respective challenges.

Group 1. Diaries and completed assignments submitted by the students provide evidence of a diverse range of perspectives and skill-sets within the team. This observation is further supported by the results of the final questionnaire, where students reported that the workload was distributed evenly across the team and that there was a positive imbalance in terms of the various skills possessed by each team member.

" I really enjoyed working with my team. I got very inspirational thoughts and interesting point of views. "

(A participant on 15/07/2023)

" The work load is balanced equally among the remaining three team members. "

(A participant on 15/07/2023)

The team members unanimously endorse the final solution, displaying a high level of engagement and activity in their diaries during the search for an optimal resolution. This demonstrates a cohesive alignment among most team members, although it is worth noting that two individuals had notable disagreements that significantly impacted the project's direction. While the team collectively agrees on the solution's immediate usefulness, they acknowledge its limitations in the long-term. This reservation is rooted in the unpredictability of future factors and the realization that substantial additional work still required for further refinement.

" The solution seems very rushed and needs to be worked on but overall it can be very useful. "

(A participant on 15/07/2023)

> " I believe [our work] it is useful but not very long-lasting. [...] this work is lasting till you get your optimum education environment. "

The loss of a team member had a profound impact on the group, resulting in heightened stress levels. This was evident in the responses provided in the final questionnaire, where the students openly discussed the significant challenges they encountered.

> " The problem statement being changed a lot [was a big challenge for us]. [...] [Name of team member redacted] leaving the group. "

Ultimately, the utilization of their diaries was a blend of reflections and notes contributed by all team members. What they took away from this experience includes valuable insights on interpersonal interactions, frequently cited within the diaries, as well as personal reflections gathered throughout their journey.

> " Many things. Intellectually but more imply growth as a person. "

> " I liked more and more the ambiguity. "

Group 2. This group faced significant obstacles from the outset, as evidenced not only by their reflections on team members in their diaries but also by the nature of their completed tasks. Their projects were typically less complex than those of their peers, consistently falling behind schedule and necessitating additional effort to remain on track. A comparison of their work and journal entries reveals a lack of agreement in their ideas.

It is evident that a dominant member of the group with strong leadership skills, a strong commitment to sustainability, and a knack for practical action led the team.

> " Working a s a team gives me stress (as usual). There've been imbalance in my team I think. This is caused by the situation that someone was busy with other works, someone wants to get initiative, someone wants to take average/middle line of each member's opinion. "

Nonetheless, this strategy placed the group in a precarious position on two fronts. First, it was difficult to evaluate and incorporate the issues, solutions, and collaborative leadership efforts of other team members while taking into account the contributions of each individual. Secondly, a problem with the group dynamic arose, as noted explicitly in the diaries of a few team members: some individuals felt overwhelmed or neglected within the team.

> " The team work today was not the best. One person in particular decides everything and does not allow anyone else to talk. "

Similar to Group 1, the loss of a team member had a significant impact on the group's morale and cohesion. In their final questionnaires, they indicated their ability to collaborate effectively and reach a resolution. In contrast, they maintained an optimistic outlook regarding the practicability and long-term viability of their idea, believing it to be sound and realizable.

> " [One of the biggest problem we faced was] [Name of the team member] leaving. "

In the end, they agreed that the overall experience was overwhelmingly positive and impressive, recognizing the need for improvement but affirming that it already represented a significant accomplishment.

Group 3. Compared to the other groups, this particular group fostered a strikingly unique dynamic. Their exceptional synergy and rapport were evident not only in their diaries but also in their group projects. In contrast to the majority, their diaries contained more personal reflections on various concepts, the essence of their summer school experience, and the dynamics within their own team. Remarkably, on average, their diaries had a less negative tone, and one of their members was an expert at maintaining personal diaries.

Despite having diverse backgrounds, skill sets, and age ranges, this group demonstrated a remarkable ability to collaborate and interact harmoniously. This is evidenced by their intricate, well-crafted, and meticulously researched projects. Notably, no team members left this group.

> " I will keep this time here always in my mind. "

<div align="right">(A participant on 14/07/2023)</div>

> " [I feel] Happy, I love the team. "

<div align="right">(A participant on 12/07/2023)</div>

> " The most useful thing from the summer school are the people I met here. I can see myself maintaining some of these connections into the future. "

<div align="right">(A participant on 15/07/2023)</div>

Group 4. Regarding ideas and approach to problem-solving, this specific team exhibited a striking degree of congruence. This cohesion helps to explain the relatively low level of activity in the problem formulation phase of the challenges, as evidenced by the outcomes of their respective projects.

Throughout their experience, they encountered a distinct lack of motivation and faced the difficulty of navigating somewhat confusing mentorships, especially due to their close connection to a consortium-related issue. In terms of team chemistry, they found themselves more closely aligned with Groups 1 and 2 on an emotional level. They simultaneously dealt with a regional conflict and an uneven workload distribution within the team.

> " 2 people, especially, were not motivated for working on the project. Tier low energy also has affected our motivation. Also due to background and experience differences, there has been a significant imbalance within the team. [...] Working on a project which wasn't our top preference, lack of motivation and confusing feedbacks were challenges that my team had faced. "

<div align="right">(A participant on 15/07/2023)</div>

They successfully implemented strategies to ensure that every team member's voice was heard and to maximize their collaborative efforts, despite facing numerous challenges within the team. In addition, a team member who initially assumed a leadership position sensed the discontent among team members and promptly stepped back, a move that was appreciated by the remainder of the team.

> " I do believe that our team work is going fine (I have heard from other groups that the "team work" is horrific :-("

<div align="right">(A participant on 15/07/2023)</div>

> " I have noticed that me taking a step back in taking the lead has helped more and also any jump in when we lost a bit of track. "

<div align="right">(A participant on 8/07/2023)</div>

They carry with them the lessons they have learned about group dynamics, emphasizing the significance of proactive communication and problem resolution to prevent problems from escalating.

6.5   Discussion finalization

The focus of this discussion was the construction of an experiential narrative, with diaries serving as the central elements. The qualitative analysis of these records allowed for the acquisition of highly individualized insights that would have been difficult to obtain otherwise. These occurrences have provided numerous opportunities to address the two identified gaps in the existing literature: Innovation and Entrepreneurship, and Sustainability for tech students. The strong integration of entrepreneurial perspectives, as encouraged by the teachers, and the interactive and dynamic nature of this experience provided opportunities for stepping outside of one's comfort zone, delving into complex team dynamics, tackling intricate challenges in the realm of sustainability, and mastering the art of balancing various effects. In addition, participants were required to cultivate flexibility in their sustainability-related ideas and interpersonal relationships. This process facilitated the cultivation of a critical perspective on their actions and motivations.

Simultaneously, the distinct personal dispositions of team members became apparent and significantly influenced the experience's overall perception. Specifically, the collective identity of the group emerged as an amalgam of the individual personalities that composed it. Notably, the attitudes of all participants fostered a sense of friendship that transcended ordinary interpersonal relationships, as a result of the extended duration of interaction and the richness resulting from participants' diverse experiential contexts.

7 Conclusions

In this study, a qualitative approach was used to analyze complex social dynamics within a Challenge-Based Learning active learning environment and it was possible to build a fair narration. Various methodologies were employed to investigate these dynamics among technological students, with a primary focus on utilizing diaries as a main instrument. This method enabled the examination of complex relationships among stakeholders, their evolving perceptions, and significant points of friction, such as cultural differences creating a picture of attitudes of each individual. The study also investigated the evolution of emotions and the internal and external factors that influenced these changes.

Furthermore, this research casted a light on **learning opportunities**, highlighting a collective growth voyage that transcends individualistic perspectives. The diversity of the participants' experiences, backgrounds, and needs highlighted the complexity of the learning process. In addition, the study shed light on the **acquired competencies and knowledge** of the students.

The application of **CC2020** notions within Education for Sustainable Development, particularly in the development of Green Competencies, has evidenced its position of importance in a global landscape that is constantly evolving and increasingly concerned with environmental issues. In particular, industry, education, and daily life will all play a crucial role in the development of competences and professionals capable of addressing **environmental challenges**.

Simultaneously, the significance of future scenario complexity is growing in these sectors. In technical disciplines dominated by quantitative approaches, qualitative methodologies offer an intriguing avenue for investigation. These methods emphasize the analysis of individuals as integral components of research. **Diaries** stand out among these approaches due to their capacity to facilitate communication and allow for parallel analysis of both collective and individual aspects, thereby facilitating insightful comparisons.

However, it is essential to recognise that the applicable methodology cannot be considered exempt from flaws. This iteration of the design exhibits a number of limitations, many of which have been extensively discussed in the existing literature. The absence of well-defined and continuous moments for diary entries throughout the learning experience is a major concern. As the experience unfolds, there has been a noticeable decrease in diary use. To address this issue, strategies such as using gamification to motivate and engage students or incorporating journaling as an integral workshop activity may be implemented.

In addition, providing students with increasingly vague and generalised questions as well as guidance on what to include in their entries has the potential to improve diary-keeping. Alternatively, the original idea of designating students micro-activities at more frequent intervals could provide a solution, allowing for a more **continuous and nuanced record** of their experiences over time.

It is crucial to acknowledge the substantial time and effort that data analysis requires for researchers. Experience and perseverance are necessary to achieve consistent coding and minimise personal bias. Exploring **collaborative approaches**, in which students actively take part in streamlining the process, may prove crucial where they could assume a more proactive role by contributing to data and proposing initial analyses. They may also identify key terms, pertinent reflections, and defining instances from their own experiences, and this transition transforms the participant's role from solely contributing with personal data to actively processing and interpreting the data.

Concurrently, for future projects within the chosen methodology, incorporating the perspectives of all participants in the research might provide fresh perspectives. This inclusive approach enables a more exhaustive understanding, not only from the researcher's or student's perspective, but also from the perspectives of the numerous parties involved. It provides the opportunity to capture a multifaceted snapshot of reality, allowing for a comprehensive examination of the relationships between all participants, without exclusion.

Obviously, such an approach may impose extra duties on professors and mentors; however, utilising their expertise in this field could result in a compromise that does not overburden anyone involved. The collaborative effort that results could significantly enhance the research process and outcomes.

In addition, a potential direction for future research is enhancing the CBL experience by implementing a strategy that combines teamwork and personal development. This strategy seeks to enable each student to feel comfortable and free to engage in their own learning journey, allowing them to directly influence their path and outcomes. The objective is therefore to develop a CBL methodology that provides a variety of opportunities, making it accessible to everyone, including professors, not limited to those with extensive knowledge in the discipline.

The ultimate goal of this endeavour *does not imply the construction of a "black box" or an inaccessible learning monolith.* Instead, it represents an exploration of a novel approach to cultivating competences and relationships. It represents a means of fostering cross-disciplinary connections, not only between subjects of study but also between diverse groups of people from various backgrounds and countries. This journey is about continuous development, the pursuit of opportunities, and the discovery of individual attitudes - a concerted effort to make learning more accessible, inclusive, and influential for all participants.

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Appendix A   Infographic

The following pages showcase a project developed as part of the I&E Studies course. The aim is to create a representation of Challenge-Based Learning (CBL) that is plain and visually appealing and at the same time provide straightforward and understandable definitions of key terms and phases associated with CBL, along with applicable examples and tools. All of the content in this section is sourced from the Apple Challenge-Based Learning document [25] and the CBL Guide [77].

Summary

CHALLENGE BASED LEARNING
INNOVATION AND ENTREPRENEURSHIP STUDIES IN ICT

UNIVERSITÀ DI TRENTO

eit Digital

Challenge based learning

Tommaso Carraro

1

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Cheat sheet

Challenge

The challenge is a **general concept** and is the work required to discover a solution, an innovative idea, or a process.

Def. Challenge Based Learning

It is an **experiential** process carried out with individuals of **various roles** in order to uncover **fresh viewpoints** and, as a consequence, **new connections** that result in new inventions and **unexpected results**.

ENGAGE
Through essential questioning the learners move from a big idea to a concrete and actionable challenge.
1. Big Idea
2. Essential Question
3. Challenge

INVESTIGATE
All learners plan and participate in a journey that builds the foundation for solutions and addresses curriculum requirements.
1. Guiding Questions
2. Guiding Activities/Resources
3. Analysis

ACT
Evidence based solutions are developed, implemented with an authentic audience and the results evaluated.
1. Solution
2. Implementation
3. Evaluation

CHALLENGE based learning

DOCUMENT • REFLECT • SHARE

A bit more in depth

What is a Challenge?
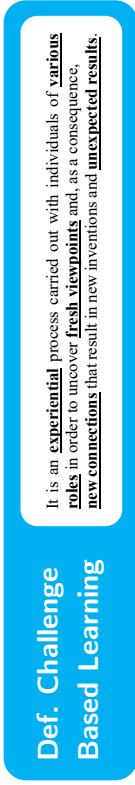
Def. Challenge

noun
A new or difficult task that tests somebody's ability and skill

A challenge is the work required to **discover a solution**, an innovative idea, or a process to **address a elaborate** or **complex problem** that has never been solved or that has to be optimized in an entirely new way.
The challenge is a **general concept** that may be applied to any sector, e.g. climate change, technology, history, projects.

In a university study course, it is used in the "Challenge Based Learning" technique outlined on the following pages.

What is Challenge Based Learning?

Def. Challenge Based Learning

It is an **experiential** process carried out with individuals of **various roles** in order to uncover **fresh viewpoints** and, as a consequence, **new connections** that result in new inventions and **unexpected results**.

Challenge Based Learning is an experience which is built on experiential learning and progressive ideas.

In this process, **teachers don't know the answer** to the problem in advance, and have no clue on how to proceed, therefore work together with students (in a **collaborative process**) to help them learning about compelling issues, proposing solutions to real problems, and taking action.

This **practical** and **nebulous approach** helps students in **reflecting** on what they know, attempting to imagining the impact of their actions, decisions, focusing on how they have chosen one solution over another, as well as identifying errors in reasoning and struggling in problems, re-focusing, and learning making mistakes.
This process is essential in order to explore **themes starting from numerous perspectives** and through the lens of several disciplines and considering the fact that everyone has a unique background and experience, new elements and connections between the subject areas explored might emerge.

Some further reading on the Foundations of Challenge Based Learning can be found at page 8-10 here: https://www.challengebasedlearning.org/wp-content/uploads/2019/02/CBL_Guide2016.pdf

Challenge vs Project Based Learning?

A considerable amount of similarities can be found between Challenge Based Learning and Project Based Learning, but the primary distinction is on **how the concept and process emerge.**

Project Based Learning	Challenge Based Learning
Typically, during a **Project**, the teacher **assigns something** "to do" that has already been scoped and identifies an idea that has to be explored.	In a **Challenge**, students and instructors **work together** to identify, plan, and implement solutions.

The distinction is almost unclear; in fact, for particularly complicated situations, a Challenge might be part of a Project as same as the other way.

We can therefore see that the fundamental distinction between the two is the process' roles and the responsibility of the process: in challenges, the experience is shared.

Roles

As previously stated, the primary distinction between Challenge Based Learning and other teaching and learning approaches is indeed the **roles of students, instructors, and other participants.** Everyone will gain **real-world knowledge** while tackling real-world challenges and developing solutions to challenging problems.
Teachers are not simply **"information specialists"**, but also **collaborators** whose responsibility it is to empower students by providing advice on where to discover knowledge and how to model beneficial habits of thinking and learning.

Therefore, a teacher DOES NOT HAVE A SOLUTION FOR THE CHALLENGE and DOES NOT TEACH IN THE CONVENTIONAL WAY, but it is more like a companion with significant knowledge who can assist locating the needed information but does not have the answer in their pocket.

At this point, one would probably wonder why a teacher is needed in the first place.
Working with genuine Challenges will certainly be **messy**, and it will be easy to **get lost** and fall in a Project rather than trying to solve a Challenge.
Here, the teacher will assist on **refocusing** the general attention on what is essential by offering **techniques** and **methods** to assess the work. As a consequence, a strong emphasis will be set on **finding alternative perspectives** which are shared throughout the class.

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Types of challenges

Nano Challenges
- Short in length
- Focus on a particular area or skill
- Tight boundaries
- Teacher directed
- Phases included: Investigation and Act, but not the Engage
- Used as a foundation for larger challenges or to address specific ideas

Mini Challenges
- Increased duration (2-4 weeks)
- Work through the entire framework
- "Show me what you can do" perspective
- Increased level of choice and responsibility

Standard Challenges
- Longer (>1 month)
- Learners have a lot of freedom of movement
- Ther's an extensive investigation across multiple disciplines
- Full ownership of the process by the learners
- Framework used from start to finish, also on evaluation of the solution

Capstone Challenges
- Are standard Challenges for Learners as a final academic and intellectual experience
- Ex. thesis for graduation

Strategic Challenges
- For planning at the institutional level
- To identify the mission and the challenges of the organization and help in developing a strategic plan

Phases

Engage, Investigate, and Act are the three interconnected phases of the Framework.
There are tasks for each step that prepare the student for the following phase and assist in investigating the work and, if necessary, reverting to a previous phase.
It is a constant process, and therefore the most significant approach will be to document each phase, reflection, and conclusion so that they may be shared in an organized manner.

CHALLENGE based learning

ENGAGE
Through essential questioning the learners move from a big idea to a concrete and actionable challenge.
1. Big Idea
2. Essential Question
3. Challenge

ACT
Evidence based solutions are developed, implemented with an authentic audience and the results evaluated.
1. Solution
2. Implementation
3. Evaluation

INVESTIGATE
All learners plan and participate in a journey that builds the foundation for solutions and addresses curriculum requirements.
1. Guiding Questions
2. Guiding Activities/Resources
3. Analysis

DOCUMENT • REFLECT • SHARE • DOCUMENT • REFLECT • SHARE • DOCUMENT • REFLECT • SHARE • DOCUMENT • REFLECT • SHARE • DOCUMENT • REFLECT • SHARE • DOCUMENT

ENGAGE

Engage Through a process of Essential Questioning, the Learners move from an abstract Big Idea to a concrete and actionable Challenge.

BIG IDEA

Big ideas are **broad concepts** that may be explored in a variety of ways and have some significance for you or a segment of society. It should be important on a **worldwide scale** for it to be an entertaining notion to work with, thus it is necessary to develop **multidisciplinary subject** expertise and a deep comprehension.

Examples: Sustainability of natural resources such as water, food, energy, and air; Climate change and its effect on the planet; Public health threats such as pandemics; Economy downturns, recovery, and growth; Conflict and human nature; Personal, group, or cultural identity.

ESSENTIAL QUESTION

The big idea, by definition, allows for the creation of various questions that should represent the interests of the students or community. Their primary goal is to find **what is essential to know** about the big concept and to **refine and contextualize** it.
These questions should be researchable and should help in directing efforts, giving a framework for the task, and learning about the subject of the challenge.

Examples: The following are some big ideas with one related essential question.

Sustainability	Conflict	Economy	Public Health	Identity	Climate change	Health and wellness
• What is the impact of my water consumption on my community?	• How do views on race, ethnicity, and nationality contribute to conflicts?	• How does graduating from high school or college affect the economy?	• How does my personal access to healthcare affect global disease pandemics?	• What groups do I belong to and what roles do I play?	• What is the impact of my use of fossil fuels on my planet?	• How do my personal food choices affect the health and wellness of my community?

Sustainability	Democracy	Resilience	Health	Creativity	Relationships	Community
• What is the impact of my water consumption on my community?	• How do we foster participation in democracy?	• How do communities recover from disasters?	• What is a healthy lifestyle?	• What is creativity and why is it important?	• How can we improve relationships between groups in our school?	• How do we build supportive communities?

INVESTIGATE

During this phase, all of the steps assist the learners in planning and participating in all of the actions for laying the groundwork for the challenge's solution.

GUIDING QUESTIONS

They are created by students and reflect the information that students **will need to respond in order to design a solution to a challenge.**
These should define what needs to be understood to develop a feasible solution.
As knowledge is obtained and concepts are examined, questions will be answered, reframed, and formulated new.

Example: If the big idea is water, guiding questions might include:
How we use water? How much water do we use? How is water wasted? How much water is wasted?
How can water be conserved? Where does water come from?

TIP To structure the learning experience, categorize and prioritize the questions.

TOOLS

Research plan and Timeline

Create a document to arrange the entire project.
It should be **helpful enough to see** where the research effort to address the guiding questions is heading.
If done correctly, the end result should be a well-prepared plan that shows where the learning effort is going while looking for a solution and if the time spent to an activity is appropriate.

Plan some **checkpoints** to go through the timeline on a regular basis. The following are some useful questions:
• What part of the process are you working on this week?
• What new knowledge or skills have you acquired this week?
• What has been your biggest success this week?
• What has been your biggest challenge this week?
• How is your group doing as a team?
• What are your top priorities for next week?

Implementation and evaluation plans

Make a plan that includes a detailed explanation of the solution, how it was determined, where it will be implemented, who will be involved, and how success will be measured.
If time permits, the strategy might incorporate a beta testing phase with numerous review cycles.
To do this, it is critical to **maintain track** of everything that occurs during the project, as well as every decision made by the team.

A **call to action** (challenge) can be developed from each essential question, and at this point, thinking about a possible solution to the problem can begin.
The challenge must be properly chosen and have a genuine and significant meaning: if it is **too wide or unclear**, you will become confused in attempting to discover a solution and will need assistance in focusing on your goal. It must also not be **excessively restricted**; we are not searching for a single answer, but rather **numerous perspectives to determine which is ideal.**

CHALLENGE

Examples: The following are some examples of the entire flow of the engaging phase.

Big idea	Essential Question	Challenge
Community	How do we build supportive communities?	Build a supportive community!
Relationships	How can we improve relationships between groups in our school?	Improve relationships in our school!
Creativity	What is creativity and why is it important?	Use creativity to improve someone's life!
Health	What is a healthy lifestyle?	Be healthy!
Resilience	How do communities recover from disasters?	Help a community recover from a disaster
Democracy	How do we foster participation in democracy?	Involve Citizens in Democracy

TIP The sort of word employed determines the scope of a challenge.

Create positive relationships
• This Challenge allows us the most flexibility in terms of learning and solutions.

Create positive relations in school
• This limits the scope of the solution by location.

Use math to create positive relationships
• This limits the scope of the learning by subject area

Create positive relationships by developing an online community for discussion and problem solving
• This is too narrow as it includes a solution inside the Challenge

TOOLS

Brainstorming
Value judgements, whether favorable ("excellent concept!") or poor ("that would never work!"), are not allowed, and everyone's opinion is heard. It's the ideal tool for **quickly recording thoughts.**

Technology
Make use of everything that can assist you. Creating a **shared online location** is a fantastic idea. Request materials such as videos, webpages, or other formats.

Working Groups
You are responsible for everything. **Divide the group into roles and tasks,** such as researchers, scientists, writers, interviewers, information producers, and publishers.

Time management
At each phase, manage the time by defining reasonable goals and expectations. Don't spend too much time on one stage, otherwise you won't have enough for the next. Schedule **regular checkpoints** with **milestones.**

Research skills
Identify keywords and utilize them to look for relevant material throughout your study, as well as understand the various sorts of available resources. Ask about where you may get information regarding your project.

Teamwork
Distribute the tasks across the team members. Make the most of your many skillsets while also communicating with the team.

Schedule expectations
You already know how much time you will have to complete all of the tasks, so **create a timeline.** Be aware of the time constraints and the tasks that must be completed. Maintain it across all phases and provide a distinct beginning and finish point.

ACT

Solutions are developed, implemented, tested, and assessed during this phase. The testing step should take place in a real-world situation with a genuine audience.

SOLUTIONS

A solution should be chosen from the findings of the previous phases in this step. The decision should be done through **prototyping** and **experimentation**, as well as thorough **research**, **documentation**, and development of an **implementation plan**. The solution should also be presented in a publishable multimedia format. The following properties should be present:

Thoughtful

Actionable

Clearly articulated

Concrete

TIP

Remember that the solution must be implementable by the research team, therefore it should not be fantastical or take years to develop.

TOOLS

Brainstorm, select and plan

Consider **several options** before choosing on one. This is necessary for Challenge Based Learning.

The Solution

The solution should also examine how to get people to accept the innovation. The exact steps that need be performed should also be developed here.
It is essential to be creative while developing and implementing a solution in the paper.

GUIDING ACTIVITIES

Are **teacher-organized** lectures, simulations, laboratories, and games that should aid in answering the guiding questions and give a framework for generating an innovative, insightful, and realistic solution.

Examples: The following is an example of steps to go through.

Matrix
Make a three-column matrix with the guiding questions in the first column and the activities/resources in the second column that will help you answer that question.
When the activities are finished, the results are entered into the third column.

Acquired knowledge
List all that is known about the topic in a document, then do online/offline research to find topic-related issues and knowledge gaps.

Discovery
Using local periodicals, public offices, interviews and polls, discover drawbacks, needs, and aspects related to the topic's community.

Experts
Interview experts from all across the world to expand the scope.

Personal Experience
Establish a personal connection to the issue by measuring how much of it affects your life and keeping track of the statistics over time or asking family members about their experiences.

GUIDING RESOURCES

This is a collection of **materials** provided by the teacher to aid in the development of a solution.

Podcasts, websites, movies, databases, and meetings with experts are some examples.

TIP

Use each team member's network to do research outside of the local community.

IMPLEMENTATION

The solution is applied in a real-world context in this stage, and the results should be measured.

EVALUATION

Multiple implementation stage outcomes should be examined to reflect on what worked and what didn't and to identify how to go forward in fixing the problem. The methodologies utilized should also be properly defined by the team members, clearly explaining what the team is looking for and how they are determining whether or not the challenge is addressed. All of this should be **clearly argued in a document** shared by the team members so that the team may compare the results throughout the process.

Documentation

Throughout the process, several papers should be produced, and they should reflect the team's effort.

Some examples of deliverables that aid in demonstrating the team's efforts and learning are:

Survey of Big Ideas	Challenge Proposal
Guiding Questions	Learning Plans and Timeline
Research Reports	Solution Proposals/Design Briefs
Implementation and Evaluation Plans	Evaluation Results
Final Presentations	Journals

Appendix B Challenges

In the following pages, the four challenges presented to the students can be found. These challenges seamlessly integrate the comprehensive information provided to them, along with the thoughts and requirements of the respective companies/organizations for developing viable solutions.

C-FLEX
FUTURES FOR
EU'S DIGITAL
EDUCATION

Summer School Challenge

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 (optional):
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.*

C-FLEX

FUTURES FOR EU'S DIGITAL EDUCATION

Summer School Challenge

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 man 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 (optional):

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/ICT4S55073.2022.0027
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

C-FLEX
FUTURES FOR
EU'S DIGITAL
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Summer School Challenge

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-,Descri ption%20of%20Scope%203%20Emissions,scope%201%20and%202%20boundary).

Understanding our greenhouse gas emissions

Scope 2: Indirect	Scope 3: Indirect	Scope 1: Direct	Scope 3: Indirect

Upstream →		Our operations →	Downstream →
- Line loss - LNG use of electricity - Facilities' use of electricity	- Purchased goods and services - Business travel (small) - Employee commuting (small) - Sold electric – use by customers - Waste management (small)	- Leaks and venting emissions from gas network - LNG venting and fuel - SF$_6$ leaks from electric equipment - Fleet fuel use	- Sold gas – use by customers

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 of the 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 (optional):

- https://www.ed.ac.uk/sustainability/topics/travel/sustainable-travel-policy-2021
- https://intra.kth.se/polopoly_fs/1.749950.1600689803!/Guidelines%20for%20meetings%20oc h%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-operation s/sustainable-travel/sustainable-travel.html?cb

C-FLEX

FUTURES FOR
EU'S DIGITAL
EDUCATION

Summer School Challenge

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

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

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.

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?
(e.g.: a reflection report, a policy survey, an MVP, …)
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 (optional):
Websites, articles, books, or any material that could get the students inspired about your challenge.

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

Appendix C   Research consent

C- FLEX

C-Flex Summer School

Informed consent for research activity

By signing this form, you consent to the collection of data that can personally identify you.
In particular, at the end of the summer school, we will collect your logbooks-journals and your summer school deliverables, and you will allow the researcher to take field notes (notes on what happens during the summer school) which may describe situations that involve you.
This data will be used to reflect on the implementation of the summer school, assess students' satisfaction, and will in any case be used exclusively for research and internal reflection purposes.
If any part of this data is made public, it will be in **anonymous or aggregated form** and will not include any information that may identify you.

The only people who will be able to see data in non-anonymous form are:

- ○ Tommaso Carraro (Master thesis student, University of Trento)
- ○ Jessica Lucchetta (PhD student, University of Trento)
- ○ Lorenzo Angeli (Assistant professor, University of Trento)
- ○ Martijn Klabbers (Education Innovator, University of Eindhoven)
- ○ German Varas (Education Analyst, University of Rennes)

Even within the Erasmus+ C-FLEX consortium, partners not listed above will only be able to access data in anonymous form.

All the collected information will be treated in compliance with the European regulation on the protection of personal data (GDPR, EU Regulation 2016/679).

If you do not want your data to be collected, you can deny your consent below.
If so, we will gather no data that will involve you, and you will be excluded from our analysis.
You will always be free to participate in all the summer school activities, including keeping your own diary, even if you refuse to give your consent.

At the end of the summer school, we will collect the journals, which we will ship back to you around November. If you would like to receive a copy of your journal immediately, we remain available to make scans even on the day of the end of the summer school.

You can change your mind (to give or withdraw your consent) at any time, and the research team remains available for any doubts or questions at: **tommaso.carraro@studenti.unitn.it cc lorenzo.angeli@unitn.it**

_____

Name and Surname: _____

☐ I **agree**
☐ I **deny**

my consent to take part in the study.

Day: ____/____/____   Signature: _____

Appendix D   Readme

Readme .md

Tommaso Carraro: Hi there! I'm Tommaso, a master's student in ICT Innovation.
I'm evaluating the experiences that you are going to do during this Summer School.
> **Option 1**: Interesting, tell me more! (continue)
  Option 2: Sorry, I'm not interested in. (read the "Deny Consent")

SUMMER SCHOOL IMPACT RECONSTRUCTION

We're looking for an innovative approach to **reconstruct** the summer school experience and determine its **efficacy and impact** on you.

We're not just interested in measuring the outcomes of our learning objectives; we're also interested in capturing insights into your intellectual journey as it evolves during each activity on a **continuous basis**.

Our hope is that, by the end of this experience, you will have gained a deeper understand of your own **capacity for growth**, enthusiasm for innovation and aptitude for **critical thinking**.

YOUR EXPERIENCE YOUR VOICE

Our goal is to provide a **safe space** for you to express yourself, pose challenging questions, and develop critical thinking skills through self-discovery.

To accomplish this, we will improve your experience based on your **actual experiences**, thought and explorations, rather than assumptions. For this reason, we will *carefully read your journals*, taking into account every insight and consideration you express since each input is highly valued.

So, we need **your voice and your genuine opinions**, not just what "we want to hear".

> Start writing to PLAY <

Your main task is to **enjoy the experience**.
Focus on **writing for yourself**, about your feelings, ideas, and experiences and anything else you find interesting and worthwhile to preserve.

It is **our responsibility to interpret** what you have written **and to rebuild the story**, while *it is your job to live it*.

We **do not expect consistency** from your work, but we are interested in learning how your ideas **change over time**, how you come up with better ideas, and how you perceive things differently from us.

This is the real treasure for us: **your growth is ongoing, and we want to hear your authentic voice.**

The final goal of this work is to build a **better experience** in the next Summer School, and to ensure that you are an **active protagonist** in making it happen.

We ask to keep a logbook/journal/personal diary with you at all times and **annotate everything that comes to mind** in whatever form you want: drawings, graphs, small phrases, lecture notes, or entry pages.

It's entirely up to you, as are the timings: there will be no set times, so you can do whatever you want whenever you want!

Feel free to write in the way you think, without masking or making your thoughts more pleasant.

In summary:

No template constraints
No thematics constraints
No time constraints
Not evaluated
                Take notes on the fly
        Enhance your **personal exploration**
                Tell **what** and **how you want**

At the end of the summer school, **we will collect the journals**, which **we will ship back to you** around November.
If you would like to receive a copy of your journal immediately, we remain available to make scans even on the day of the end of the summer school.

FIREWALLS

You   Tommaso   Lorenzo & Jessica   Research Partners

The data collected **will not be subjected to any kind of evaluation by the summer school professors**, and will be analyzed only after the summer school is completed and you have received your grades. It will be my (Tommaso) responsibility for removing or anonymizing any sensitive information, including information about professors.

TOOL BOX   We have put together a list of useful software and tools that you may find helpful during your Summer School. Take a look!

Appendix E   Presentation
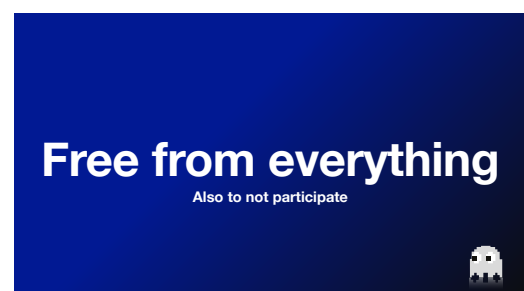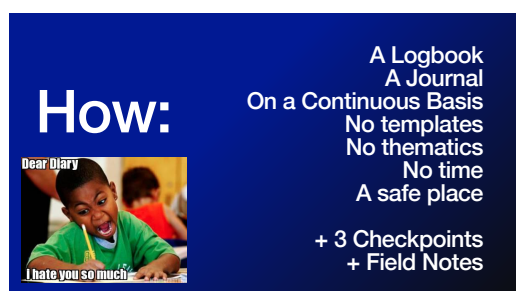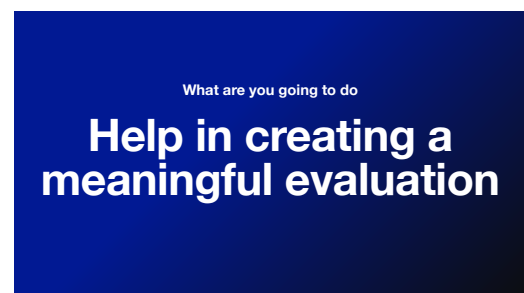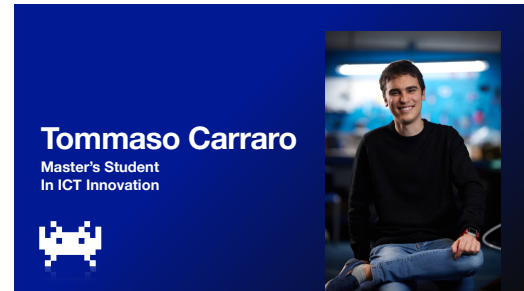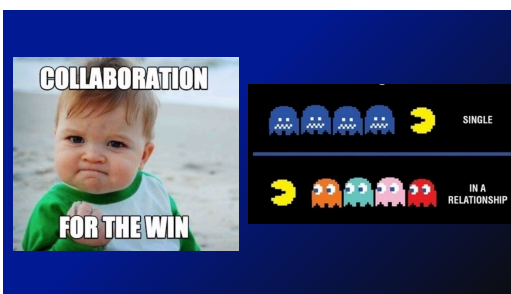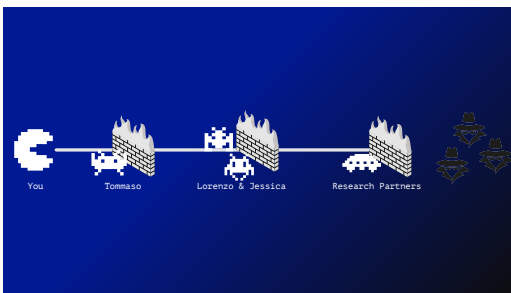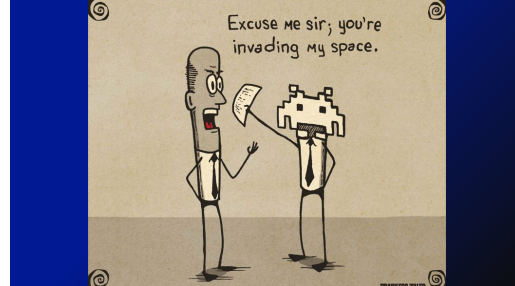
Appendix F Checkpoints

THE TIMELINE

(a) Checkpoint 1 -2. A variation of [8]

THE PRIORITIES

(b) Checkpoint 1 - 1. A variation of [9]

(a) Checkpoint 1

(b) Checkpoint 2-1. A variation of [5]

(a) Checkpoint 2-2. From [20]

(b) Checkpoint 2-3. A variation of [3]

THE RISKS

This activity is designed to help you generate a range of potential solutions to a problem you are facing.

To begin, you should work alone with a piece of grid paper and write down your problem statement. Then, for each block on the paper, write down a potential solution. Don't hold back - your ideas should be practical, crazy, or anything in between. The more innovative they are, the better.

Once you have listed all your ideas, it's time to apply the WOOP framework. For each idea, write down the Wish (what you hope to achieve), Outcome (what success looks like), Obstacle (what challenges you might face), and Plan (what concrete steps you will take to make it happen).

Once everyone has completed this task, come together and share your ideas and WOOPs. While you are sharing, place each idea in a risk map. This map should highlight the ideas and their assumptions, as well as any potential problems that could arise. With this activity, you'll be able to generate a wide range of solutions and identify the most promising ones to pursue.

HOW ARE YOU
Emotion: Assign a percentage to represent the intensity

Successful 100% | Neutral 50% | Blissful 0%
Happy 75%
Angry 25%
Desperate 0%

HOW ARE YOU
Activity: Assign a percentage to represent the intensity level of your emotion

0% Depressed | 50% Neutral | 75% Bored | 100% Full of energy | Surprised

CHECKPOINT GOALS
Create a keyword map for the following questions and connect them to build your priorities (like a mind map) and your journey.

How do you feel about your abilities for this challenge? What abilities and knowledge do you require to advance? What are the ones that your team lacks for the various solutions?

CONTENT + PROCESS: [&] 2 categorite

SSSSS! Could you share with us the most recent interesting thing you've learned? Additionally, is there something you've been intending to learn or try, but haven't had the opportunity to do so yet?

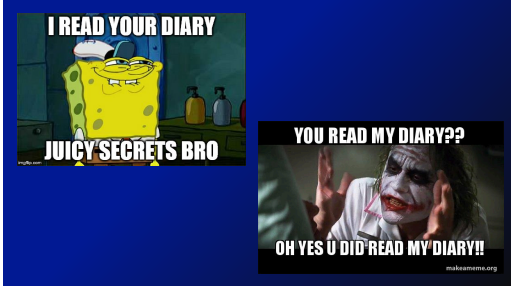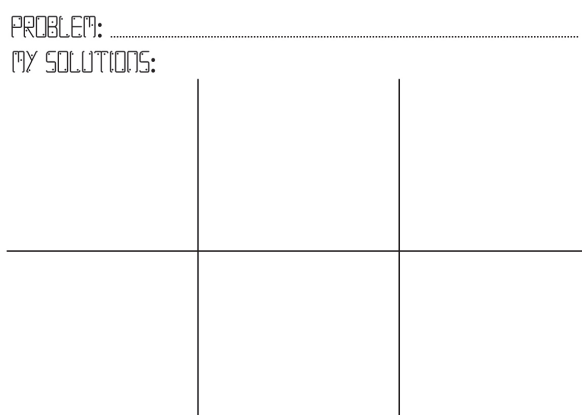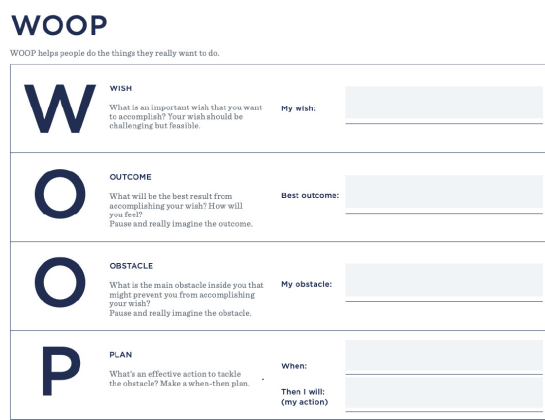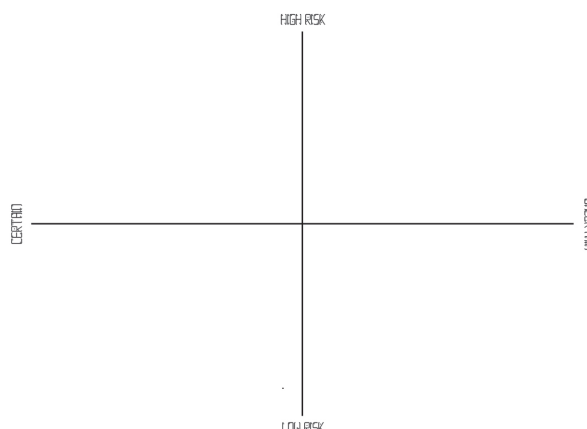(a) Checkpoint 2

CHECKPOINT GOALS
Create a keyword map for the following questions and connect them to build your priorities (like a mind map) and your journey.

THE STORY

In this activity, you will create a story and identify the necessary steps to bring it to life. Follow the instructions below to complete the activity.

Begin by identifying a character, a setting, and a plot for your story. Write each element on a separate Post-It note. Feel free to draw representations of these elements if you prefer.

Next, determine the key scenes that depict the plot unfolding from beginning to end. Consider your storyboard as a comic strip. Combine quick sketches with speech and thought bubbles, action bursts, captions, and narration to illustrate your scenes.

Share the story you've created with your team. Before presenting, remind everyone that the focus is on communicating the idea in detail, not on judging drawing skills.

By the end of this activity, you should have a well-developed story, an action plan to achieve it, and a list of main challenges along with proposed solutions.

As a group, select the best parts of each story and reassemble the timeline, similar to the process from the first checkpoint.

Be realistic when identifying the actions needed for each step. Write down any assumptions you make. These assumptions and questions. Consider the following: can you talk to someone directly to get an answer? Is it possible to validate your assumption through direct observation? Can you build a prototype to test a hypothesis?

Brainstorm various ways to validate or invalidate these assumptions. Organize your assumptions and corresponding problems in rows, and list potential solutions in columns.

HOW ARE YOU
Assign a percentage to represent the intensity level of your emotions (0% very negative - 100% very positive) and your level of activity (0% passive - 100% very active)

EMOTION ......%   ACTIVITY ......%

Incoming asteroid! What's the biggest challenge your team is currently facing? What's something your team does to stay motivated and productive?

Watch out! Can you list a conflict your team has faced, and how did you work through it?

Mission accomplished! What's a valuable piece of feedback you've received from a teacher, and how have you applied it to your work?

(b) Checkpoint 3. A variation of [17]

Appendix G Survival-Toolset

Interesting Things to Explore

| Category	In Summary	Licence	Url	Description (Taken from websites/Wikipedia/SEO Descriptions)
Communication		Open Source	https://delta.chat	Delta Chat is a messaging app that works over email
Design		Free	https://informationisbeautiful.net/	Distilling the world's data, information & knowledge into beautiful infographics & visualizations
Design		Free	https://brandmark.io/logo-rank/	Check your logo design with deep learning
Design		Free	https://mockups-design.com/	Create your mockups
Writing		To investigate	https://namelix.com/	Free AI-powered naming tool
Tools		Free with requirements	https://education.github.com/pack	GitHub Student Developer Pack
Design		Free	https://aicolors.co/	AI Color Palette Generator - Browse, Edit, Visualize and Generate Unique Palettes
Design		Attribution Required	https://previewed.app/	Create beautiful mockups for your app, in just a few clicks.
Search Engines		Open Source	https://www.zotero.org/	A reference management software to manage bibliographic data and related research materials.
Communication		Essential tools Free	https://pitch.com/	Presentation software for fast-moving teams
Communication		Free with requirements	https://www.apple.com/keynote/	A presentation software made by apple
Search Engines		Free	https://elicit.org/	Elicit uses machine learning to help you with your research: find papers, extract key claims, summarize, brainstorm ideas, and more.
Design		Essential tools Free	https://www.remove.bg/	Delete the background from your photos automatically in 5 seconds and with a single click. Don't waste hours working on every single pixel. Upload your photo and discover the magic.
Design		Essential tools Free	https://coolors.co/	The super fast color palettes generator!
Communication		Essential tools Free	https://www.DeepL.com/translator	A neural machine translation service
Communication		Licence Required	https://giphy.com/	GIPHY is the platform that animates your world. Find the GIFs, Clips, and Stickers that make your conversations more positive, more expressive, and more you.
Search Engines		Essential tools Free	https://answerthepublic.com/	Search listening tool for market, customer & content research - AnswerThePublic
Design		Essential tools Free	https://www.canva.com/	A graphic design platform that is used to create social media graphics and presentations.
Design		Free	https://realtimecolors.com	Visualize your color palettes on a real website.
Communication		Essential tools Free	https://prezi.com/	It is a video and visual communications software.
Communication		Essential tools Free	https://www.popplet.com	A mind-map Software.
Communication		Open Source	https://pictogrammers.com/	Open-source iconography for designers and developers
Design		Free	https://codepen.io	An online community for testing and showcasing user-created HTML, CSS and JavaScript code snippets.
Communication		Free	https://www.webfx.com/tools/emoji-cheat-sheet/	Emoji codes used by GitHub, Basecamp, Slack and other services. Searchable. With emoji meanings.
Music		Attribution Required	https://filmmusic.io/	Download High-Quality Tracks
Design		Free	https://app.haikei.app/	A web-based design tool to generate unique SVG design assets for websites, social media, blog posts, desktop and mobile wallpapers, posters, and more! Our generators let you discover, customize, randomize, and export generative SVG design assets ready to use with your favorite design tools.
Design		Free	https://storyset.com/	Customize, animate and download illustration for free
Design		Open Source	https://undraw.co	Open source illustrations for any idea
Enviroment		To investigate	https://earth.nullschool.net	See current wind, weather, ocean, and pollution conditions, as forecast by supercomputers, on an interactive animated map. Updated every three hours.
Communication		Essential tools Free	https://miro.com/	Is a digital collaboration platform designed to facilitate remote and distributed team communication and project management.
Writing		Essential tools Free	https://poe.com/	Poe lets you ask questions, get instant answers, and have back-and-forth conversations with AI.
Writing		Essential tools Free	https://quillbot.com/	Paraphrasing Tool - QuillBot AI
Newsletter		Free	https://tldr.tech	TLDR is the free daily newsletter with links and TLDRs of the most interesting stories in startups, tech, and programming!
Newsletter		Open Source	https://hackaday.com	Is a hardware hacking website that also hosts a community database of open-source hardware designs.
Music		Free with requirements	https://www.youtube.com/audiolibrary	Youtube Music Library
Video		Free with requirements	https://www.blackmagicdesign.com/t/products/davinciresolve	DaVinci Resolve is a color grading, color correction, visual effects, and audio post-production video editing application
Design		Open Source	https://inkscape.org/	Vector graphics editor
Design		Open Source	https://www.gimp.org/	Is a raster graphics editor used for image manipulation (retouching) and image editing
Enviroment		Free	https://earth.google.com/	Google Earth is software that generates virtual images of the Earth using satellite images
Tools		Essential tools Free	https://todoist.com/	Todoist is the to-do and task management app
Music		Open Source	https://www.audacityteam.org	Multi-track audio editor and recorder
Communication		Open Source	https://github.com/domenicosolazzo/awesome-okr#readme	OKR are the best practice of setting and communicating company, team and employee objectives
Enviroment		Open Source	https://github.com/nglgzz/awesome-clean-tech#readme	The goal of this list is to gather a list of awesome companies fighting climate change, as well as collecting research about the issues and solutions connected to it.
Tools		Open Source	https://github.com/wardley-maps-community/awesome-wardley-maps#readme	Wardley Mapping is a technique that helps you examine your environment, identify upcoming changes and properly choose your actions. By examining what is needed, what components will be in use, what are their dependencies and characteristics, you can build a visual representation of your world, play what-if games, and pick your direction and best actions to support it.
Tools		Open Source	https://github.com/kdeldycke/awesome-engineering-team-management#readme	A curated list for software developers to transition to an engineering management role.
Tools		Open Source	https://github.com/sindresorhus/awesome#readme	Hundreds of tools and curated lists
Communication		Essential tools Free	https://quizizz.com/	Create interactive quizzes
Collaboration		Essential tools Free	https://padlet.com	Create beautiful boards to group, organize and present anything you want.
Collaboration		Free	https://edu.google.com/intl/ALL_it/jamboard/	Interactive whiteboard
Design		Open Source	https://timeline.knightlab.com	Easy-to-make, beautiful timelines.
Design		Free with requirements	https://www.figma.com	Figma is a collaborative web application for interface design.

Appendix H   Cards
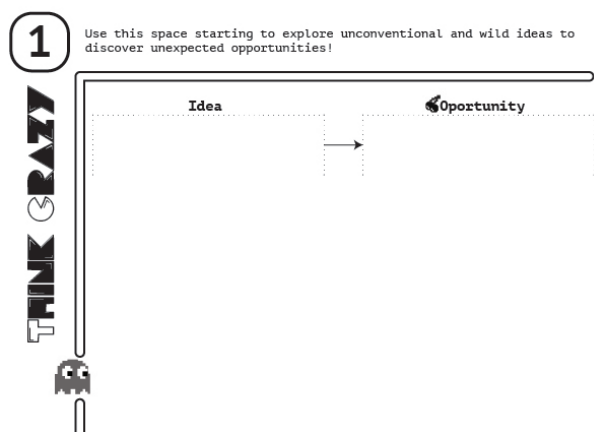
(a) Card 1.1
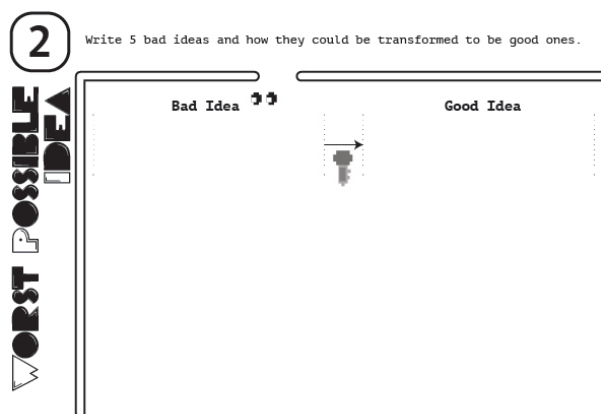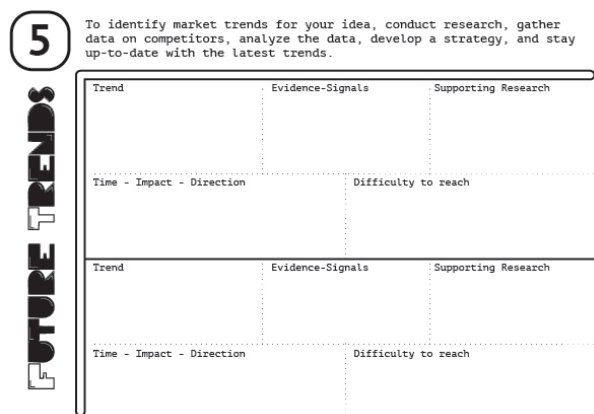

(b) Card 1.2 - From [6]
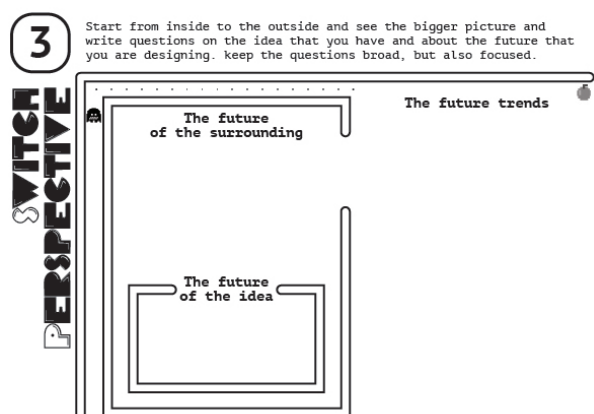
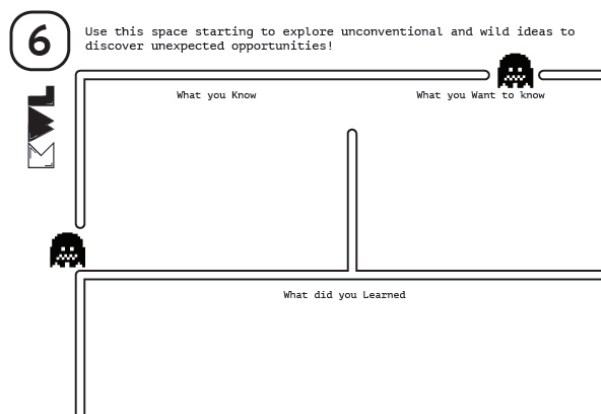
(a) Card 1.3 - From [10]
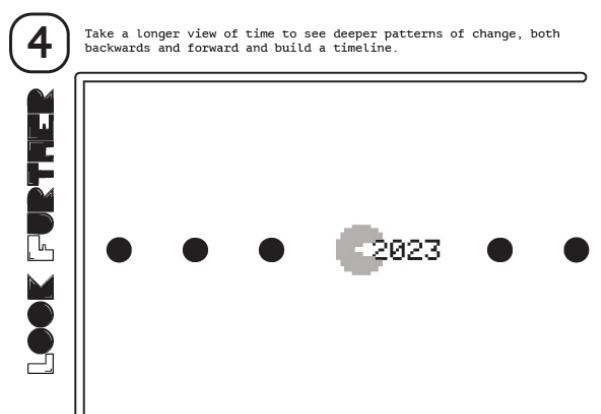
(b) Card 1.4 - From [10]

(a) Card 1.5 - From [15]

(b) Card 1.6

Some questions to help you think about what you're doing.

CRITICAL THINKING

What is happening now and why?
Who benefits and who loses?

How does the existing situation compare to the past?
Are there patterns in the changes?

What is causing the changes?
Could be specific community perceptions, beliefs,
value or attitudes or could be other ripple effects
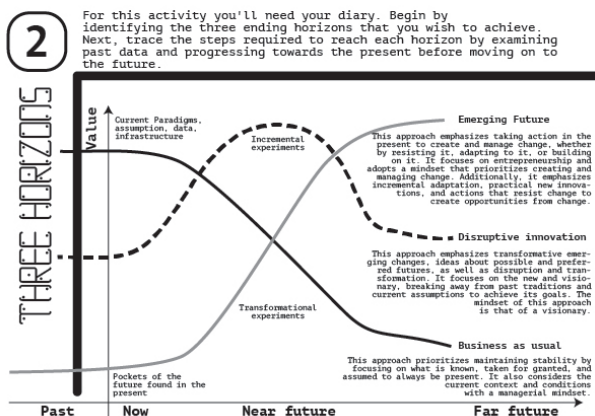like demographics changes or enviromental ones to have
caused the change?

How did your understanding of the context of your
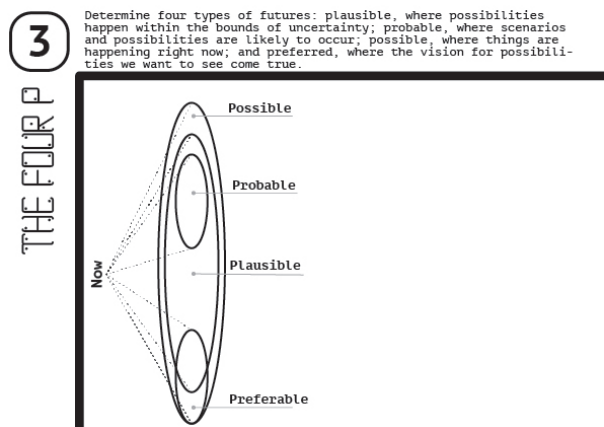organization changed through these period of time?

(a) Card 1.7 - From [27]

1

Identify the implications of choosing a trend or change.
Select a relevant trend or change from your challenge and list its
implications from various perspectives such as market, business, social,
tech, and law. Note down additional implications in the white space of
your diary and go beyond the third level of implications if necessary.

IMPACT WHEEL

2 Level Implication   2 Level Implication   1 Level Implication   2 Level Implication

1 Level Implication

Trend or Change

2 Level Implication

2 Level Implication

1 Level Implication   3 Level Implication

1 Level Implication

2 Level Implication   2 Level Implication

(b) Card 2.1 - From [15]

2

For this activity you'll need your diary. Begin by
identifying the three ending horizons that you wish to achieve.
Next, trace the steps required to reach each horizon by examining
past data and progressing towards the present before moving on to
the future.

THREE HORIZONS

Value

Current Paradigms,
assumption, data,
infrastructure

Incremental experiments

Emerging Future

This approach emphasizes taking action in the
present to create and manage change, whether
by resisting it, adapting to it, or building
on it. It focuses on entrepreneurship and
adopts a mindset that prioritizes creating and
managing change. Additionally, it emphasizes
incremental adaptation, practical new innova-
tions, and actions that resist change to
create opportunities from change.

Disruptive innovation

This approach emphasizes transformative emer-
ging changes, ideas about possible and prefer-
red futures, as well as disruption and tran-
sfomation. It focuses on the new and visio-
nary, breaking away from past traditions and
current assumptions to achieve its goals. The
mindset of this approach
is that of a visionary.

Transformational experiments

Business as usual

This approach prioritizes maintaining stability by
focusing on what is known, taken for granted, and
assumed to always be present. It also considers the
current context and conditions
with a managerial mindset.

Pockets of the
future found in the
present

Past   Now   Near future   Far future

(a) Card 2.2 - From [60]

3

Determine four types of futures: plausible, where possibilities
happen within the bounds of uncertainty; probable, where scenarios
and possibilities are likely to occur; possible, where things are
happening right now; and preferred, where the vision for possibili-
ties we want to see come true.

THE FOUR P

Now

Possible

Probable

Plausible

Preferable

(b) Card 2.3 - From [1] and [16]

4

Connect more dots to see a richer view of change. here you can put
the driver of change and reasonings that you have done and after
that think how to find connections between them.

SEE CONNECTIONS

Driver of change

The big shift
What does this furutre shift look like?
What is happening?

From:

To:

(a) Card 2.4 - From [10]

Some questions to help you think about what you're doing.
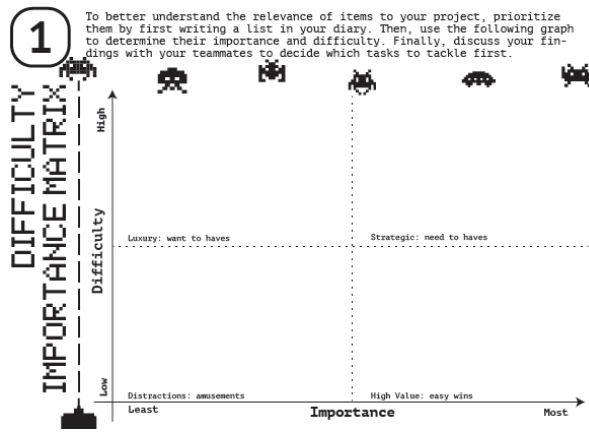
CRITICAL THINKING

Focus: what are you doing?

Identify: what are the key elements?

Reframe: start from scratch based on the key
elements.

Exchange: connect the reframed idea to a
broader topic.

(b) Card 2.5 - From [26]

1 To better understand the relevance of items to your project, prioritize them by first writing a list in your diary. Then, use the following graph to determine their importance and difficulty. Finally, discuss your findings with your teammates to decide which tasks to tackle first.

DIFFICULTY IMPORTANCE MATRIX

High

Difficulty

Luxury: want to haves   Strategic: need to haves

Low

Distractions: amusements   High Value: easy wins

Least   **Importance**   Most

(a) Checkpoint 3.1 - From [7]

2 Assess what you know about a particular topic before and after you have engaged with it. Fill in the columns below with what you know about the topic, what you want to know and what you've learned

SCENARIO BUILDER

Drivers/Trends/Events   **Challenges and Opportunities**

Scenario Narrative
Describe your scenario as a
story, a description of a world,
a day in life, a news report...

(b) Checkpoint 3.2 - From [15]

3 To complete this activity, use both sheets, including Poems 2. Observe users targeted by your product/idea, and identify correlations and contrasts. Record your observations in detail here and take the time to perform a thorough analysis.

POEMS - 1

Detailed Description

People
List main groups of people

Objects
List objects that are used by the
people and that populate the
environment

Enviroment
Describe the surroundings.
What are the main features?

(a) Card 3.3A - From [13]

3 Once you have completed the user observation and documeted your findings, it's important that you share your observations with your team. You can discuss your findings together and review them to gain a deeper understanding of the user's needs and behaviors.

POEMS - 2

Messages
What are the messages or conversations being
communicated and how?

Services
List services being offered. List services avai-
lable to the people

**Comments about
user experience**

General thoughts & comments

(b) Card 3.3B - From [13]