

# Fair Tales of Interdisciplinary Learning: Unveiling Students Voices and Competencies Evolution in a Challenge-Based Learning Summer School

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**Abstract**—This innovative practice full paper aims to describe how an interdisciplinary group of engineering students developed sustainability competencies during a two-week Challenge-Based Learning summer school on analysing the impacts and sustainability of digital education and its infrastructure. Our contribution aims to create a “fair” narrative of this experience, taking into account multiple perspectives, and building a transparent and representative reconstruction of the students’ competence development. Our work is qualitative in nature: we gathered pedagogical insights, participants’ emotions, thoughts, and experiences, by relying on a variety of data sources (of which the primary was student diaries), ultimately creating a micro-ethnography of the course. This approach allowed us to identify and track the evolution of the GreenComp competencies over time, create team profiles, and gain insights on the evolution of the students’ thoughts, perspectives, and social dynamics. While further research is needed to refine the approach, reduce researcher burden, and test it in other environments, this paper aims to start the process of creating an analysis method that lets teachers and researchers reconstruct the students’ learnings, experiences, and personal reflections in a rich and transparent way, going beyond the creation of all-too-reductive performance metrics, and contributing to the ongoing discussion on the development of non-technical competencies in engineering education.

**Index Terms**—Ethnography, Sustainability, Interdisciplinary learning, Experiential learning, Competency development, GreenComp

## I. INTRODUCTION

Students’ competency development is central in engineering education [1]. A significant challenge is bridging the gap between the competencies taught in education and those required to address complex real-world problems, especially in areas related to new technologies, sustainability, and society [2], [3].

To develop competencies, a teaching methodology that is widely used today is Challenge-Based Learning (CBL) [4] which requires students to engage in a multidisciplinary setting, requiring substantial collaboration with people from different cultural and knowledge backgrounds. The presence

of these differences may give rise to intricate dynamics that evolve over time, especially when CBL activities have an extended duration.

This paper aims to describe which sustainability competencies students developed and to identify the points of friction that CBL summer schools faces. We do so by proposing a research approach that aims to reconstruct the lived experience of a teaching setting, collecting pedagogical insights, students’ emotions, thoughts, and specific experiences that develop within that context. Our approach tries to reconstruct the development of competencies and attitudes in a personal, fair, and transparent way, while trying to integrate the perspectives of as many participants as possible.

To achieve this, we established three areas of investigation:

- 1) *How can we reconstruct a fair narration of a CBL teaching setting, and what impact did social dynamics and emotions have on the whole experience?*
- 2) *What attitudes did the student develop in our analysed setting, and in particular with respect to digital sustainability?*
- 3) *What pedagogical opportunities did our analysed setting create, and what competencies have been developed the participating students?*

As “fair narration” we took the idea from Latour, [5] which emphasizes the multiplicity of perspectives of each experience within a given context, acknowledging the complexity and partiality of each viewpoint while looking for a balanced representation of the whole.

With this foundation, the paper is structured as follows: we will first present the background of our work in Section II, afterwards we will describe the context of the summer school in Section III and we will outline the methodology used for gathering and analyzing the data in Section IV, we will conclude with the presentation and discussion of the insight gained in Section V.

## II. BACKGROUND

We base our work on the definition and analysis of competencies developed in the ACM/IEEE Computing Curricula 2020 (CC2020) [1]. According to the CC2020, a competency consists of a student's knowledge ("*Know-What*"), their ability to apply that knowledge ("*Know-How*") and their personal disposition influencing their decision-making ("*Know-Why*"). These three elements are combined in a *context*, in which the learned competencies becomes concretely applied.

While CC2020 presents some strong reflections on what technical competencies engineering and computing students need to develop, engineers are increasingly working in environments that also require them to be aware of social issues such as equality and social justice, respecting cultural diversity, fostering shared responsibility, interdisciplinary dialogue, and sustainability [6], [7]. These broad themes go beyond vertical domain knowledge, and indicate an increasing need for socio-cultural skills, which require the cultivation of transboundary competencies [8] and a multidisciplinary approach, that could be institutionalised within educational institutions [6], [9]. The need to develop social competencies in engineers is also consistent with the objectives and opportunities outlined in mainstream policy by the United Nations in Agenda 2030 [10], as well as the requirement for the resilience of contemporary systems indicated by UNESCO [11], which is but the last chapter of a long debate exploring the social responsibilities of scientists and engineers.

Building these competencies helps engineering students to develop a critical look about change across the past, present, and future, enabling them to be critical actors in society. Social impact competencies equip students with the skills necessary to analyze structural shifts while focusing on the opportunities — but also the issues — posed by new technologies. They also create a sense of proactive ownership and responsibility in projects, promoting motivation, passion, and enthusiasm in dynamic, multidisciplinary, and high-pressure environments. Effective collaboration within teams is crucial, and these competencies are highly valued by companies. [12]

A specific sub-class of social impacts competencies was proposed by the European Union in GreenComp [13], a framework that identifies 12 competencies connected to sustainability. The identified competencies are grouped into four areas: (i) Embodying sustainability values; (ii) Embracing complexity in sustainability; (iii) Envisioning sustainable futures; and (iv) Acting for sustainability. In GreenComp, the environment and the actions are not two separate entities but are interconnected: the way people experience their surroundings, shapes their knowledge, and helps them construct new concepts and understanding, makes the learning environment an integral part of education [14], [15]. This view echoes the sociological concept of constructivism [16], where our shared reality is seen as a social construction [17], and competencies are shaped by each individual's experiences [18]–[20].

In order to successfully develop these competencies, we posit that teachers should adopt pedagogical methods that

reflect the competencies they intend to develop. We propose Challenge-Based Learning (CBL) [4] as a way to satisfy all the aforementioned ideas: through wicked and real-world challenges, it forces students to adopt a cross-disciplinary approach, which necessitates a multidisciplinary team to innovate and create solutions, while negotiating among multiple stakeholders coming from varying backgrounds [21].

Examples of CBL can be found throughout the educational literature, showcasing its adaptability and versatility in a variety of settings [22]. However, to the best of our knowledge, there are no previous studies that explore the application of CBL to intensive programmes about sustainability for engineering students. We locate our study at the intersection of digital technologies, sustainability, and pedagogy, bringing together participants from different backgrounds in engineering to investigate innovative solutions to urgent global challenges associated with the sustainable transition towards digital education.

## III. PEDAGOGICAL CONTEXT

This study was conducted during a two-week summer school programme on the sustainability of the transition towards digital education. During the programme, students lived together 24 hours a day for 15 days, actively engaging in all aspects of the proposed activities. The experience was part of the Erasmus+ C-FLEX project<sup>1</sup>, a consortium of five universities and an international NGO. The project aims to open a debate on how to manage the transition towards digital education, analysing four dimensions of sustainability:

- **Technological:** What makes digital education infrastructure functional and maintainable over time?
- **Environmental:** What is the ecological footprint of digital education?
- **Social, ethical and legal:** What are the socio-economic, privacy, and inclusion issues in digital education?
- **Pedagogical:** What do teachers and institutions need to deploy successful pedagogical practices for digital education?

### A. The Summer School

The summer school is a core part of the C-FLEX project. Participants were recruited and selected from all partner institutions, and started the experience with an online "*pre-course*" of eight two-hour sessions to establish a common ground and align their expectations. The summer school took place in Italy, hosted by the University of Trento, in July 2023. It involved 16 student-participants, who received a full scholarship for their participation, and several staff members including teachers, researchers, and entrepreneurs from a variety of technical backgrounds and cultures.

The teaching method chosen was Challenge-Based Learning [21], with four external stakeholders contributing challenges to the summer school. In the first week, students analysed the challenge to formulate a clear problem statement and

<sup>1</sup>See the project website at [www.c-flex.eu](http://www.c-flex.eu) (Accessed 2024/08/19)

identify potential opportunities; in the second week, students explored solutions and eventually selected one, which they were requested to present and write a short report on. Fig. 1 gives an overview of the programme’s teaching methodology.

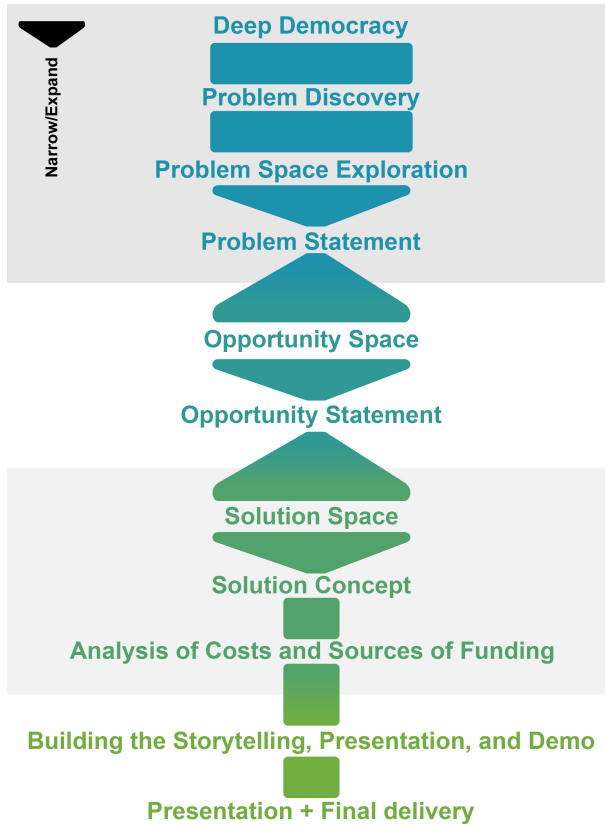


Fig. 1. The phases of the learning path, in particular, can be seen the narrow and the expansion stages

The method was designed with the goal of exposing students to the main points of friction that they experience in digital education through immersive, real-world experiences. These experiences included working in remote areas without internet connectivity, implementing active learning and working in (culturally, disciplinary, age) diverse teams. Everything was done in an environment that was designed to be as safe and inclusive as possible, where the principles of respect and openness towards differing perspectives were fundamental. This environment enabled individuals and groups to freely question the teachers’ ideas and openly debate them, giving students complete freedom to take control of their own process, creating an entrepreneurial-like environment aimed at giving students autonomy and self-direction.

All of this was done with a single objective in mind: 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.

## B. The Challenges

The students were given four challenges to choose from. Each challenge was co-created during an ad-hoc session that involved the C-FLEX project staff and representatives from several institutions taking the role of Challenge Providers (CPs). During the final online meeting, each student indicated their preferences for the challenges and, based on these preferences, the staff formed student teams.

The challenge titles, and relative CPs, were:

- Digital education infrastructures within the context of diverse groups. (Kiron Open Higher Education GmbH)
- Higher education for all: addressing drawbacks and benefits of hybrid learning. (Vrije Universiteit Amsterdam)
- Maastricht University — international & sustainable: can we have it both?
- How to improve the sustainability of the C-FLEX online pre-course? (co-hosted by C-FLEX and U-Hopper Srl.)

In addition to the title, student received a brief document further detailing the challenge, which was also co-created between the project’s staff and the CPs, to clearly define each challenge’s scope and boundaries.

## IV. RESEARCH METHODOLOGY

To identify what happened in the summer school, we selected a qualitative and inductive approach, creating a micro-ethnography with overt participation of a single researcher [18]. The decision to adopt a qualitative approach is due to the relative small number of the participants (which makes dynamics easier to observe) and the wish to gather complex and highly personal emotional data that are context-specific. To comply with the values of transparency at the summer school, the role of the researcher was openly disclosed and explained to the students. During the summer school, the researcher shifted their level of participation to prevent the phenomenon known as “going native”, where ethnographic researchers become participants rather than observers [18]. Depending on the occasion, the researcher decided to adopt the role of an overt full participant, cultivating genuine relationships with the students, or that of a minimally participating or even entirely non-participating observer.

### A. Data collection

An additional layer of complexity in this research setting lied in designing a methodology that balanced between being simple and time-efficient for the participants, while simultaneously fostering an environment that was engaging, enjoyable, simple, and personalized. The goal was to transform the participants from mere data providers into active participants in the research process, establishing a cooperative and interactive environment in which the participant-researcher relationship transcended the traditional vertical hierarchy, and making the participants leading characters in the research process.

To collect data, we used several sources and methods, linking them together in a logic of triangulation [23]. Our aim was to create a dynamic, real-time record of the unfolding experience as it occurs. Overall, our sources of data include: i)

self-ethnographic diaries that all participants filled during the programme; ii) field notes taken by the researcher-participant; iii) structured activities and discussions that encouraged students to share their experience; iv) artifacts produced by the students themselves. As diaries are our primary data source, we used several strategies to encourage their use, and continuously assessed if we needed an alternate strategy.

In essence, the research was designed to be adaptable and resilient, ensuring that limitations in the approach would not compromise the validity of the findings.

1) *Diary*: On the first day of the programme, staff distributed to all participants an A5-sized paper diary and encouraged students to make it their exclusive note-taking and reflection tool. The diary became both a logbook and a notebook for personal ideas, enabling students to lay bare their own unique narrative. We selected a pen-and-paper format due to its ability to be completely customized and personalized, ease of use, and relative time efficiency [24]. We also sent students open-ended questions via Telegram twice a day to further encourage the use of diaries for reflection.

2) *Checkpoints*: During the programme, we conducted three structured activities that we called “checkpoints”, where we prompted students with questions to engage in discussions about their current ideas and emotions. We structured the exercises in two time frames: first, students reflected individually; then, they exchanged ideas within the team and built a deeper understanding of the project’s progress. Each checkpoint included a standard component, which consisted of reflective questions on their work and an emotional self-evaluation using Plutchik’s wheel [25], and a unique activity that was tailored to the relevant stage of the teams’ projects. The first checkpoint helped students to self-assess their exploration of the problem space; the second assisted them in analyzing their proposed solutions; and the third assisted them in developing a coherent narrative for the solution.

3) *Field Notes*: Field notes served as a supplementary data source, enriching the diaries and providing guidance for their inspection by enabling the researchers to cross-reference the two data sources. This secondary data source let us combine each individual student’s perspective with an outside observer’s perspective. Field notes helped recording “operational” elements such as activities, daily events, general mood, and weather, but they also assisted in documenting participant behavior, interactions, personal reflections, and engagement with other participants.

4) *Student artifacts and questionnaires*: We recorded artifacts created by students (posters, notes, notable conversations, drawings) during the activities, and when possible, we digitised them. We also deployed an online anonymous questionnaire as an extra data source for cross-referencing.

## B. Data analysis

The analysis phase was mainly performed by a single researcher, the same who collected field notes. The aforementioned data sources were encoded and cross-referenced in a single table for each student and group, using coding

techniques from [26], namely: Descriptive Coding, In Vivo Coding, and Emotional Coding.

In order to encode all the data, several iterations were carried out to reorganize codes, group them, and ensure consistency of meaning. The final code taxonomy is the following:

- **Process**: This category collects information about the methods and timing of diary usage. We finished our analysis with the following groups:
  - **Days**: One code per specific day on which participants wrote the diary entry.
  - **Style**: Different styles students used in their diaries such as drawings, maps, texts, and other materials such as post-it notes, blank pages, erased content or diary writing orientation changes.
- **Individual**: All the personal experiences, including diary entries on development and feelings. We ended with the following groups:
  - **Competencies**: GreenComp competencies [13].
  - **Emotions and feelings**: Emotions and feelings, per Plutchik’s wheel [25].
- **Organized experiences and activities**: Diary entries about structured experiences, activities, and lectures.
- **Reflection on topics**: Substantial personal reflections and recurring themes.

After the first researcher conducted the coding using NVivo, the resulting files were shared with the research team, and a second researcher sampled and validated the coding, exchanging ideas and providing adjustments when necessary.

To make sense of the complex volume of data, we constructed a table that provided a day-by-day breakdown of all the diary and field notes material that relates to each individual student, grouped by team. This process facilitated the analysis, as it provided a summary of both the students’ and the observer’s perspectives. The results that we present, therefore, condense two different processes: the one that we as researchers constructed through our analysis; and the one of the students’s self-reporting. The resulting narrative, thus, is an attempt at creating a fair reconciliation between the two.

## V. RESULTS AND DISCUSSION

### A. Participants

The summer school had 16 participants, of which 15 consented to participate in the research activities. 14 participants provided physical diaries, while one provided digital pictures of the diary, which were however unusable.

The group of participants was highly diverse, and included: 10 female and 5 male students; 2 bachelor’s, 12 master’s, and 1 PhD-level participant; students coming from 6 different degrees (all of which, nonetheless, engineering fields); 5 origin universities; speaking collectively a total of 21 languages; and an age range of 21–33, plus one older outlier. One student joined the summer school on the second day; three students left on day 11 (for reasons that we will discuss later), and an additional student left early on the last day. The students were

divided into four groups, as explained in Section III-B, with each group assigned to a different challenge.

### B. Diary usage and contribution

We gathered data during all days of the summer school, mostly from student diaries, which were then cross-referenced to the field notes to identify activities and themes.

In the diaries, participants showed a wide variety of themes and styles, from notes taken during the teaching sessions to deep personal thoughts and personal reasoning, giving the diaries a two-sided connotation: they were at the same time real-time note-taking tools, and instruments for retrospective and deeper thought. 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, though, this method was frequently abandoned in favor of an unstructured stream of entries.

All the text within the diaries was coded with two different codes, totaling 126 codes for “Text - Diary” and 87 codes for “Text - Notes of the Day”.

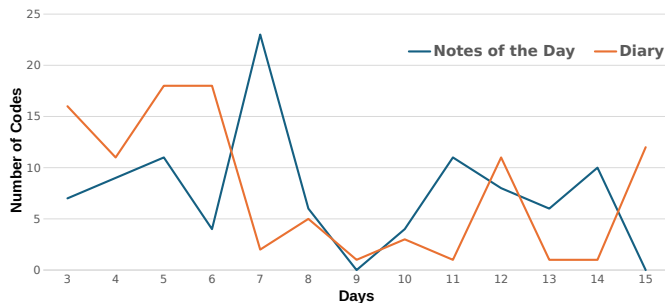


Fig. 2. Type of data by day

As Fig. 2 shows, there are spikes in reflective content on the 6th, 12th, and 15th days, corresponding to the checkpoint activities. Without checkpoints, 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.

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.

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 48 times), and the incorporation of *artwork and drawings* (coded 61 times), and *mind maps* (coded 28 times). Additionally, in 15 areas 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 writing techniques: note that the following annotations are reported in their original form, and thus include the participants’ own mistakes.

Some students preferred lists of ideas or concepts:

“Opportunity Space:

Having interactions with professors, staff, students, etc.

Hybrid Standardization Consortium

Introduce Hybrid Education to rankings (Measurement?)”

Others focused on personal and intricate reflections derived from the programme’s 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 environment. [...]”

Some students preferred drawing-style entries:

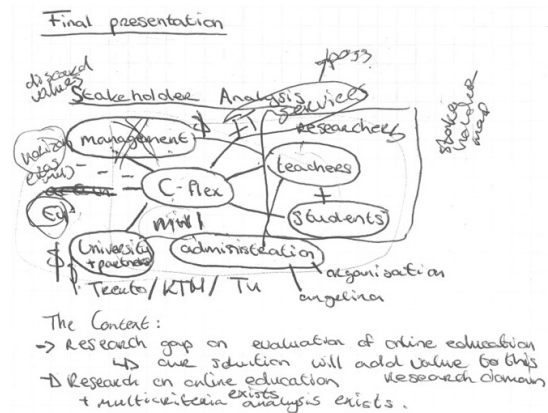


Fig. 3. An example of a drawing-style diary entry.

Among the activities, I&E Workshops were the most frequently coded, mainly because students had to use their diaries. The checkpoints were the longest recorded aspect of these workshops, appearing 41 times in the diaries. The analysis of challenges from various perspectives was coded 48 times, and the formulation of problem statements was coded 25 times. Further investigation of the journal’s contents revealed that other activities were present, like solution analysis was recorded 24 times, opportunities analysis 16 times, and value proposition 6 times.

Coding allowed to see a shift in emotional mood among participants [Fig. 4]. 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.

Even if the data we have is insufficient to provide a formal fit, we like to see a similarity between the mood fluctuations and the so-called Gartner Hype Cycle<sup>2</sup>. Students appear to be going through a similar journey through the summer school: a

<sup>2</sup>For an overview, see for example Wikipedia at [https://en.wikipedia.org/wiki/Gartner\\_hype\\_cycle](https://en.wikipedia.org/wiki/Gartner_hype_cycle) (Accessed 2024/05/17)

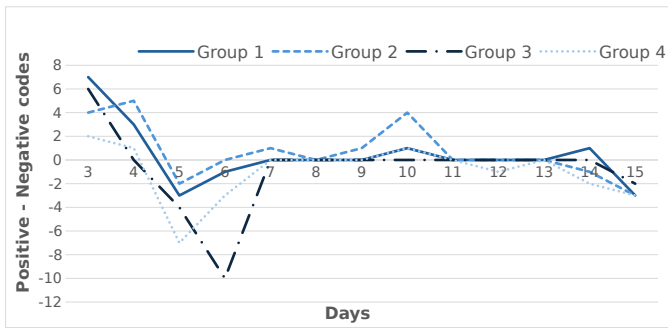


Fig. 4. Emotional dynamics per Group

high peak of inflated initial expectations, a disillusionment of expectations, a moment of perdition and lack of clarity, and an eventual plateau once students align their expectation and experience. In the last few days, the negative bump mostly refers to tiredness at the end of the experience.

### C. 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 13 times in their entries and, likewise, the "Unmaking Electronics" lecture received 15 mentions. These lectures played a crucial role in guiding students' reflections on topics such as free will, the substance of relationships, coping with diverse people and cultures, the education system, and sustainability. Team dynamics (coded 32 times) and relationships (coded 20 times) emerged as a main theme in students' diaries: this was particularly prominent in Groups 1 and 2, where teams confronted unique challenges like a team member leaving the programme midway, and was explored from a variety of perspectives.

To exemplify, a group acknowledged their differences but collaborated effectively, as one participant explained:

*"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?"*

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

Another group encountered recurrent challenges in their project work and interpersonal relationships:

*"My team was very passive, and [Name redacted] did not add anything. [Name redacted] was hindered by [their] English [...]"*

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

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

And 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. [One team member] however got the idea to have a "talking stick", which made a huge difference."*

Communication barriers came to surface, such as not having perfect proficiency in speaking English, the difficulty of expressing complex concepts, the difficulty of comprehending others, and the interaction between members of different countries, sometimes with remarks that would be considered unacceptable in professional contexts.

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

An example of these cultural factors is that there was a set of people who spoke even if they were expressing wrong opinions, while others were more taciturn and reflexive, seeking assurance that their contributions would sincerely enrich the ongoing discussions before speaking.

*"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."*

*"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."*

Beyond team dynamics, however, we have observed that teams with a vast array of skills, especially in the entrepreneurial field, fared better. In addition to facilitating seamless operations, having internal diversity played a crucial role in boosting student morale during difficult times.

### D. GreenComp competencies

A core aim of the summer school has been the development of competencies connected to sustainability in digital education. As we mentioned in Section IV-B, we analysed the competencies students were developing by coding our analysed artifacts using the GreenComp framework. To provide a tangible example of coded competence under "Embracing complexity in sustainability", consider Fig. 5 as an excerpt, derived from a brainstorming activity involving all team members.

This coding, we argue, gives a proxy for what competencies the students were developing. We summarise our codes connected to GreenComp in Fig. 6, where "Embracing complexity in sustainability" emerged as the most explored competency throughout both weeks.

However, as we can see in Fig. 7, there are differences in the development of competencies between the various categories and groups. 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.

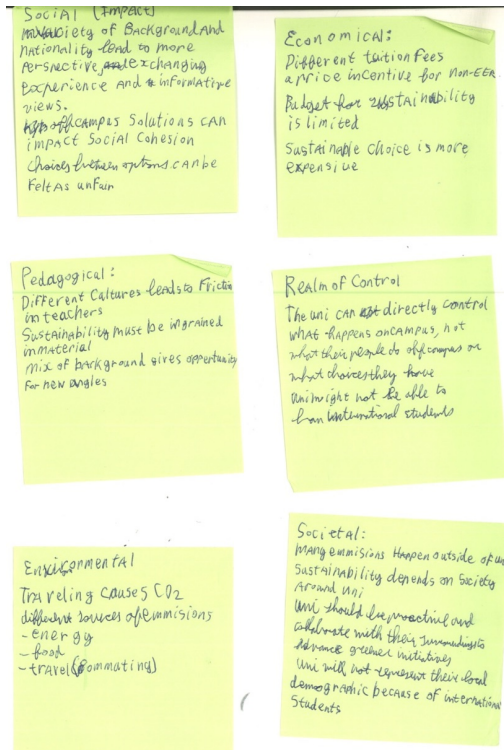


Fig. 5. An example of a brainstorming activity

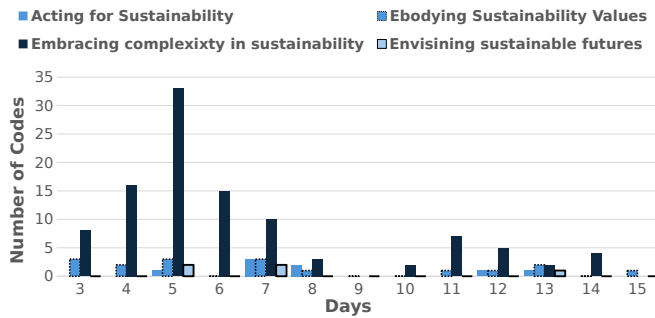


Fig. 6. GreenComp-related coding

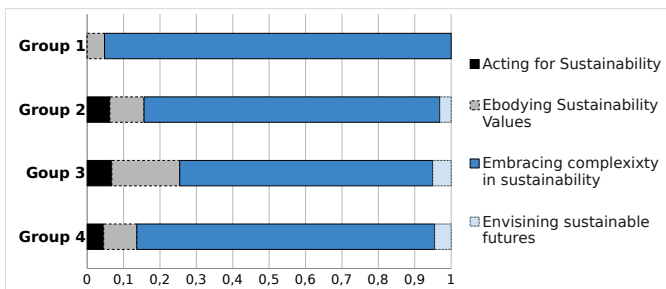


Fig. 7. GreenComp-related coding per Group

Our analysis reveals that all teams developed the core competence of the summer school, "Embracing complexity in sustainability," while also highlighting the diversity within and among groups.

## E. Challenge Based Learning in the summer school

The specific implementation of CBL within the programme strongly focused problematization over solution finding, with the first week being fully dedicated to exploring the problem, and only a part of the second week being dedicated to solutions. This choice led to perplexity among students familiar with CBL, and ambiguity among those who were not.

*"Different interpretation of CBL made me confused."*

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

At the same time, students felt they were not given a full picture of the methodology of learning and the learning goals, creating confusion and misunderstanding.

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

In response, the coordinators devoted a session to clarify the learning objectives and expectations. Subsequent conversations with teams and individuals helped steer the expectations in the proper direction. This transformation is evident in the students' diaries, where they acknowledge its necessity.

*"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."*

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."*

## F. Team Profiles

When analyzing the students' responses, there is an extensive array of complexities where knowledge and narrative are intricately linked together [5], containing curious questions, emotions and insights of their personal experience.

*"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."*

The participants' close proximity for two weeks facilitated the profound development of social dynamics and emphasized the distinctions between each individual, necessitating a holistic analysis of their work. We have found that the four teams behaved in different ways, developing different types of relationships and enabling the creation of four profiles:

a) *Group 1:* Their diaries and the final questionnaire insights reveal a diverse range of perspectives and an imbalance of skill-sets within the team, where workload was distributed evenly among all the members.

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

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

Despite notable disagreements between two individuals within the team, they all ultimately endorsed the final solution they had chosen. However, they acknowledged the limitations of this solution in the long-term, demonstrating a cohesive alignment. The team experienced the departure of a team member, resulting in an increase in stress levels. In the end, the use of their diaries involved a combination of reflections and notes provided by all members of the team.

b) *Group 2:* The group encountered substantial challenges from the beginning, as demonstrated not only by their self-reflections but also by the nature of their completed tasks, consistently lagging behind the planned timeline and requiring extra effort to stay on course. An analysis of their work and journal entries indicates a lack of agreement on their ideas. This situation may arise due to a significant power imbalance within the team, where it is apparent that a dominant member possesses strong leadership abilities, a strong dedication to sustainability, and a talent for taking practical action, which led them to assume the leadership role. However, as a result, certain individuals felt overwhelmed or neglected.

*"Working as 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."*

*"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 contrast, they maintained an optimistic outlook regarding the practicability and long-term viability of their idea, believing it to be sound and realizable. 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.

c) *Group 3:* Compared to the other groups, they had exceptional synergy, which 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. 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."*

*"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."*

d) *Group 4:* The group had great cohesion and alignment with objectives and ideas, and could be an explanation for the relatively low level of activity in the problem formulation phase of the challenges. Through the experience, they encountered a strong lack of motivation and faced the difficulty of navigating confusing mentorships, especially due to their close connection to a consortium-related challenge. They also experienced a regional conflict and an uneven workload distribution within the team but successfully implemented strategies to ensure that every team member's voice was heard and to maximize their collaborative efforts. In addition, a team member who had initially assumed a leadership role noticed the discontent among the group and promptly stepped back, a move that the other team members appreciated.

*"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."*

*"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."*

Overall, the incorporation of personal diaries provided deep and detailed understandings of the participants' experiences, emphasizing the importance of a comprehensive and context-specific analysis.

## VI. CONCLUSIONS

In this paper, we used a qualitative approach to analyze a Challenge-Based Learning summer school, and we attempted to build a fair narration and identify social dynamics, emotions, attitudes, and competencies developed by students. In particular, the mix of methodological tools allowed us to move from a sole ontological view towards an epistemological understanding of the experience.

While the limited number of participants may raise questions about the generalisability of this work, this concern can be addressed by emphasizing the qualitative nature of our approach. Our approach aimed to combine the personal and unique perspectives of each student with the researcher's aggregate findings while preserving the complexity and dynamic nature of human interaction without oversimplification.

Throughout the study, we encountered several challenges. Keeping the students engaged with their diaries was demanding, and the analysis phase proved to be highly time-consuming and susceptible to researcher bias. To address these

issues in future iterations, we are considering the creation of collaborative approaches where students actively participate in the analysis process. By allowing students to contribute to data interpretation, propose initial analyses, and identify key terms and reflections, we can shift their role from mere data providers to engaged interpreters.

Faculty perspectives are also not included in this work, though we recognise that their perspective could be insightful. However, this approach may place additional demands on professors and mentors, which need to be carefully managed.

Future iterations of the summer school will consider these limitations commonly identified in the research on diaries [18], [24]. Specifically, the emphasis will be on mitigating study bias, reducing the workload for researchers, addressing participants' lack of commitment, and guaranteeing consistent involvement throughout the program.

In conclusion, we hope that readers of this work will recognise how the qualitative nature of this work is not a limitation, but a sought-after feature. Too often are educational settings flattened in their complexity because of the request — or desire — to fit them into metrics, creating a sterile “tale”. The converse, the creation of an all-too-perfect and unfalsifiable “fairy tale” is equally undersirable. We hope that this study exemplifies a possible alternative that is able to construct a teaching and learning “fair tale”.

#### ACKNOWLEDGMENT

This work has been funded with support from the European Commission (Erasmus+ C-FLEX project, grant number 2021-1-IT02-KA220-HED-000032115). This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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