Measuring the Impact of Challenge-Based Learning in a Social-Hackathon: Case Study Results from the Eco-Digithon

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Abstract

Equipping students with sustainability competencies and digital collaboration skills is a critical requirement in 21st-century education. Challenge-Based Learning (CBL), grounded in experiential learning theory (Kolb, 1984), offers a promising pedagogical framework to prepare learners for real-world complexity through active engagement and problem-solving (Gallagher & Savage, 2020). The ENNEPlus Erasmus+ project (2024–2027) builds on this foundation by developing and implementing the Eco-Digithon: a digital, challenge-based hackathon model for Vocational Education and Training (VET). Participants are engaged in interdisciplinary teams to co-develop digital solutions addressing community-specific environmental challenges aligned with the United Nations Sustainable Development Goals (SDGs).
In its first edition (2024-2025), the Eco-Digithon involved 31 VET institutions, from them involved students and educators across Austria, Italy, Spain, and Portugal. The initiative included the co-creation of #10 CBL scenarios and a ENNEPlus Methodological Toolkit for implementation in local and transnational learning contexts. The project also fostered collaboration and knowledge exchange through a dedicated Community of Practice Platform - CoP.
To evaluate the impact of this initiative, a mixed-methods case study design was employed (Creswell & Plano Clark, 2018), integrating pre- and post-event surveys, teacher reflections, and student interviews. The ENNEPlus team also developed ten CBL scenarios and a methodological toolkit, used across all sites to ensure instructional consistency. A qualitative content analysis approach (Mayring, 2014) was employed to explore participant experiences, pedagogical processes, and institutional dynamics in depth.
his contribution will present the research design, theoretical framework, and key methodological components of the ENNEPlus case study. I will also represent and discuss selected empirical findings—focusing on how participation in structured challenge-based learning experiences supports the development of sustainability competencies and digital collaboration skills among VET learners. The study is situated within broader European education policy contexts, including the Digital Education Action Plan and the European Green Deal, and contributes to ongoing discourse on inclusion, green transition, and innovation in VET systems.

Keywords: *Challenge-Based Learning, Eco-Digithon, Sustainability Education, Vocational Training, Digital Collaboration, Mixed-Methods Research*

1. Introduction

In the context of accelerating climate change, digital transformation, and rising demands for inclusive, skills-based education, Vocational Education and Training (VET) systems are called upon to play a more transformative role. Beyond preparing learners for specific trades, modern VET must support learners in developing transversal competencies, such as sustainability awareness, digital fluency, problem-solving, and collaboration, that are essential for lifelong learning and responsible citizenship (OECD, 2020; European Commission, 2022).
While policy frameworks such as the European Green Deal and Digital Education Action Plan (2021–2027) emphasize the need for a green and digital transition in education, practical implementation in VET settings remains uneven (Cedefop, 2021). Many curricula are still oriented toward static qualification frameworks rather than learner-centered, challenge-driven models that foster agency and innovation.
Pedagogically, this shift requires moving from teacher-centered transmission models to learner-centered, inquiry-driven approaches that enable students to engage with authentic societal problems.

Challenge-Based Learning (CBL), rooted in experiential learning theory (Kolb, 1984) and aligned with constructivist paradigms, has gained prominence as an approach capable of integrating knowledge acquisition with real-world application, reflection, and collaboration (Apple Inc., 2009; Leijon et al., 2021). It positions learners as co-creators of knowledge, engaging them in cycles of investigation and action around complex, often ill-defined, problems.
In response to these demands, the ENNEPlus Erasmus+ project (2024–2027) introduces a structured model that integrates CBL and social innovation methods—particularly the Social Hackademy framework (Valentini, 2020) into VET across four European countries. At the core of this model is the Eco-Digithon, a transnational, digitally facilitated hackathon where student teams co-develop solutions to locally grounded sustainability challenges aligned with the United Nations Sustainable Development Goals (SDGs).
This paper explores how the Eco-Digithon was implemented in 31 VET schools involving over 226 students and 80 educators and mentors across Austria, Italy, Spain, and Portugal. Using a mixed-methods case study design, we examine its educational impact on learner engagement, digital collaboration, and sustainability competencies. We argue that socially embedded, challenge-based approaches can offer a scalable, inclusive model for VET innovation and contribute meaningfully to Europe's green and digital transformation.

2. Theoretical and Methodological Framework

This study is grounded in two interconnected theoretical pillars: **Experiential Learning Theory (ELT)** and **Challenge-Based Learning (CBL)**. Together, they provide the foundation for the **Eco-Digithon** model developed within the ENNEPlus project and its associated research design.

2.1 Experiential Learning as a Foundation

At the heart of this pedagogical model is Kolb's (1984) Experiential Learning Theory, which conceptualizes learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation. This theory aligns closely with vocational education's practical ethos but offers a more reflective and learner-driven alternative to traditional instructional models. It emphasizes that knowledge is constructed through transformation of experience, making it particularly suited for addressing complex, interdisciplinary challenges.
In the ENNEPlus project, experiential learning is operationalized through structured encounters with real-world problems, collaborative team processes, and critical reflection stages embedded within the Eco-Digithon process.

2.2 Challenge-Based Learning (CBL)

Challenge-Based Learning has emerged as a flexible, inquiry-based methodology capable of aligning classroom instruction with real-world complexity (Apple Inc., 2009; Leijon et al., 2021). CBL engages learners in three iterative phases — [**Engage**, **Investigate** and **Act]** — where students identify big ideas, narrow them into actionable challenges, research relevant context, and design, implement, and evaluate solutions.
This approach is supported by empirical research demonstrating that CBL fosters both disciplinary and transversal competencies, especially when industry or real-world partners are engaged in the challenge design phase (Membrillo-Hernández et al., 2019).
CBL goes beyond project-based learning by rooting its inquiry in authentic, community-defined problems and involving learners in co-creating the learning path. It fosters student agency, interdisciplinary thinking, and transversal skills, all of which are essential to address the green and digital transitions emphasized by EU policy (European Commission, 2022).

2.3 Social Hackademy Methodology

The implementation of CBL within ENNEPlus draws heavily from the Social Hackademy framework developed by co-author Altheo Valentini (2020). The Social Hackademy introduces a structured sequence of capacity-building, collaborative innovation, and public-facing challenge solving, primarily through social hackathons. It is oriented toward civic empowerment and the digital inclusion of marginalized youth.

Adapted for the VET context, the Eco-Digithon preserves these essential characteristics while embedding them into structured CBL scenarios. It maintains the emphasis on community-based challenges, team mentoring, and public dissemination of student outcomes, reinforcing the social relevance and visibility of vocational learning.

2.4 Competence Frameworks and EU Policy Alignment

The Eco-Digithon methodology is also informed by key European competence frameworks:

- **GreenComp** – for sustainability competencies (Bianchi et al., 2022)
- **DigComp** – for digital citizenship and collaboration (Vuorikari et al., 2022)
- **EntreComp** – for entrepreneurship and initiative (McCallum et al., 2018)
- **LifeComp** – for personal, social, and learning-to-learn competencies

By integrating these frameworks, the ENNEPlus model ensures alignment with current EU recommendations and VET modernization goals. It also supports **transnational comparability**, facilitating data collection and impact evaluation across contexts.

3. Project Design – ENNEPlus and the Eco-Digithon

The **ENNEPlus project** is a Erasmus+ initiative focused on fostering ecological and digital innovation in **Vocational Education and Training (VET)** through a transnational, challenge-based learning model. The project connects 31 VET institutions from **Austria, Italy, Spain, and Portugal**, along with NGOs, universities, municipalities, and private-sector actors. It aims to equip VET learners with the sustainability, digital, and entrepreneurial competencies required by the green and digital transitions outlined in EU strategic frameworks.

3.1 Objectives and Systemic Approach

ENNEPlus pursues four core objectives:

1. **Embed CBL methodologies** in VET curricula and teacher training
2. **Build collaborative networks** through transnational communities of practice
3. **Support grassroots digital innovation** aligned with the UN Sustainable Development Goals (SDGs)
4. **Facilitate institutional change** in pedagogical culture, assessment, and curriculum integration

These objectives are pursued through the creation of a **Challenge-Based Learning (CBL) Toolkit**, implementation of **Eco-Digithon events**, and development of a **Community of Practice (CoP) Portal** for resource sharing and cross-country mentoring.

3.2 Eco-Digithon: A Transnational CBL Laboratory

The **Eco-Digithon** is the pedagogical centerpiece of ENNEPlus. It is a digital, challenge-based hackathon that allows student teams to investigate community-specific sustainability problems and co-develop actionable, technology-enhanced solutions.
In its first phase (2025), the model was implemented across the partner countries with the active participation of:

- **226 VET students**, organized into interdisciplinary teams
- **80 VET teachers**, acting as facilitators and co-learners, as well as **International project mentors and thematic experts**, supporting methodology, innovation, and evaluation

Teams worked on one of ten thematic **CBL scenarios**, co-developed by the consortium, covering key sustainability domains. Each challenge was directly aligned with the UN Sustainable Development Goals (especially SDG 4, 11, and 13), and also mapped to European competence frameworks (GreenComp, DigComp, EntreComp, LifeComp).

3.3 Digital Collaboration and the CoP Portal

To support scale and continuity, ENNEPlus established a **Community of Practice (CoP)** portal. It functioned as a:

- Central repository for toolkit resources
- Hub for peer mentoring and educator collaboration

- Platform for disseminating student projects
- Forum for sharing reflection practices and pedagogical adaptations

The CoP not only enabled transnational engagement but also supported localized customization and feedback loops across institutions, reinforcing institutional learning and innovation transfer.

3.4 The #10 Challenge-Based Learning Scenarios (CBLS)

To ensure consistency, scalability, and pedagogical richness across all participating VET institutions, ENNEPlus developed **ten thematic Challenge-Based Learning Scenarios (CBLS)** inspired by feedback from focus groups, technical expertise, and aligned with UN SDGs and European competence frameworks. Each scenario provides a structured, real-world case that participating teams adapt to their local contexts during the Eco-Digithon.

The ten CBLS themes are:

1. **Sustainable Transport** – reducing emissions and promoting clean mobility solutions
2. **Green Construction** – integrating energy efficiency, passive design, and low-carbon materials
3. **Renewable Energy** – designing community-scale PV or wind systems and battery storage
4. **Environmental Awareness** – developing digital tools or campaigns for sustainability education
5. **Short Food Supply Chain (SFSC)** – creating local distribution models and circular economy solutions
6. **Biodiversity Protection at Power Plants** – reconciling energy infrastructure with ecological preservation
7. **Circular Economy** – designing upcycling, recycling, and resource efficiency solutions
8. **Water Scarcity** – addressing water management and sustainable consumption
9. **Water & Human Health** – focusing on sanitation, potable access, and waterborne risks
10. **Improving Water Quality** – monitoring, filtering technologies, and clean-water advocacy

Each scenario includes a **challenge description**, contextual background, suggested stakeholder roles, guiding questions, digital tools suggestions, competences that students are going to develop while working on CBLS and reflection prompts. VET teams select and customize one scenario, tailoring it based on local conditions, community needs, and resources.

This mid-level scenario design ensures:

- Pedagogical coherence across diverse institutional settings
- Local adaptability for relevance in Austria, Italy, Spain, and Portugal
- Teaching teams can scaffold learning while allowing student-driven creativity
- Impact of the involved teams from schools learners, teachers, role models, community, companies and international partners

These scenarios were delivered through the ENNEPlus CoP Portal, which housed collaborative spaces tied to each CBLS theme. VET teams could interact with other teams and mentors, share resources, and adapt materials to their local context

Fig. 1. Target Groups Eco-Digithon

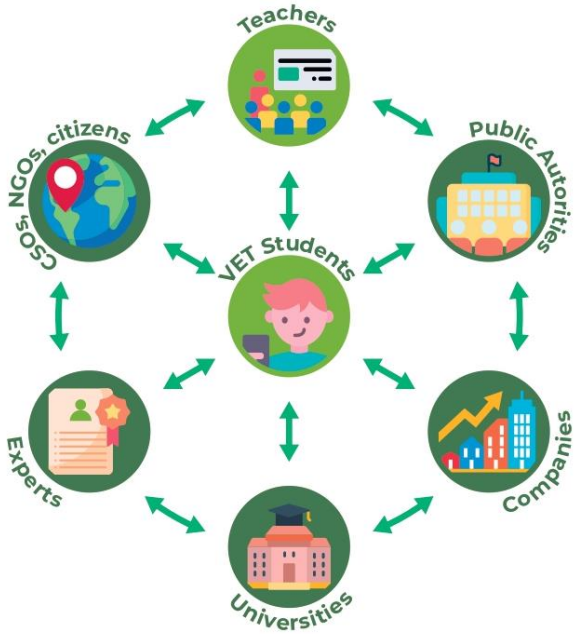

Fig. 2. Phases of Eco-Digithon

4. Research Methodology

This study applies a mixed-methods case study design to investigate the pedagogical and developmental impact of the Eco-Digithon model implemented in four European countries. The research aims to evaluate how Challenge-Based Learning (CBL), embedded within a socially grounded and digitally facilitated hackathon framework, fosters the acquisition of transversal competencies among VET learners—particularly in sustainability, collaboration, innovation readiness, and digital problem-solving.

4.1 Methodological Approach

Drawing on Creswell and Plano Clark's (2018) typology, a mixed-methods approach was selected to capture both measurable trends and contextualized insights. The case study method enabled the investigation of the Eco-Digithon as a bounded yet contextually adaptable system (Yin, 2018), with consistent design logic and localized implementation across Austria, Italy, Spain, and Portugal.

4.2 Data Collection Instruments

The study employed three interlinked instruments to collect quantitative and qualitative data:

1. Student Surveys
   Pre- and post-Eco-Digithon surveys were administered to assess changes in learners' self-perceived competencies. Key dimensions included:
   - Digital collaboration and communication
   - Sustainability awareness and systems thinking
   - Problem-solving confidence and adaptability
   - Readiness for innovation and creative risk-taking
   - Sense of social responsibility and community engagement

These indicators align with EU frameworks such as GreenComp (Bianchi et al., 2022), EntreComp (McCallum et al., 2018), and LifeComp (Hoskins & Crick, 2010), offering a holistic picture of learner development within CBL environments.

2. Focus Group Discussions (FGDs)
   Conducted with VET teachers, project mentors, and local stakeholders in all four participating countries. These discussions explored:
   - Perceived student growth and team dynamics
   - Institutional readiness and teacher capacity
   - Stakeholder involvement and local adaptation
   - Challenges in digital delivery and mentorship
3. Reflection Journals and Semi-Structured Interviews
   Teacher reflections and follow-up interviews offered insight into:
   - The pedagogical integration of CBL scenarios
   - Mentoring strategies and facilitation styles
   - Observations of learner engagement, autonomy, and peer learning

Student interviews served to triangulate survey results and uncover qualitative aspects of their learning experience, including emotional engagement, self-efficacy, and perceived societal relevance of their project work.

4.3 Participants and Implementation Context

The study draws on data from:

- 226 VET students, organized into interdisciplinary teams

- 80 VET teachers, acting as facilitators and pedagogical co-designers, as well as incl. international project mentors, stakeholders, and local innovative actors.

These participants were affiliated with 31 VET institutions across Austria, Italy, Spain, and Portugal. Due to national and institutional variability in platform access and timetables, data collection varied slightly by site. Nonetheless, survey returns, and qualitative data were sufficient for meaningful triangulation and cross-case reflection.

4.4 Data Analysis Procedures

Quantitative data from student surveys were analyzed using descriptive statistics and compared across countries and challenge themes. This analysis helped identify general trends in student-reported growth, particularly in the domains of collaboration, problem-solving, innovation confidence, and sustainability awareness.
Qualitative data were examined using Mayring's (2014) qualitative content analysis, which facilitated systematic theme development. Codes were generated both deductively (based on the research questions and framework indicators) and inductively (emerging from the data). Themes included:

- Learner motivation and engagement trajectories
- Reflections on social relevance and community connection
- Teacher adaptation and institutional culture shifts
- Mentoring dynamics and peer feedback structures

The combined dataset allowed for an integrated view of how the Eco-Digithon fosters not only cognitive but also affective and civic dimensions of learning—key outcomes in future-oriented VET systems.

5. Analysis of Findings

The Eco-Digithon model demonstrates clear potential to foster learner engagement, digital collaboration, innovation readiness, and social responsibility development among VET students.

5.1 Learner Engagement and Motivation

Survey data from all four countries revealed that over 80% of participants felt the Eco-Digithon met or exceeded expectations. Students expressed appreciation for authentic problem-solving, team collaboration, and mentorship interactions. Focus group findings corroborated this positive learning climate, noting an increase in learner initiative and agency. Teachers reported higher levels of organization and responsibility among teams with preparatory training. Time constraints and uneven technical pre-skills emerged as common challenges, suggesting a need for more scaffolded support.

5.2 Digital Collaboration and Problem-Solving

Participants reported marked improvement in digital coordination and problem-solving, particularly via collaborative platforms and iterative prototyping. Teams frequently engaged in digital brainstorming, versioning tools, and synchronous planning. Reflection journals highlighted how open-ended problem framing encouraged critical thinking and peer learning. These themes align with broader findings in educational hackathons reported in the literature, which emphasize rapid idea exchange, cross-disciplinary dialogue, and reflective iteration (Flus & Hurst, 2022; Oyetade et al., 2024).

5.3 Innovation Readiness and Social Responsibility

Throughout the Eco-Digithon, students reported growth in their readiness to innovate, demonstrating greater comfort with creative risk-taking. Equally important, many described feelings socially connected to local environmental problems and civic engagement. Teachers emphasized that embedding challenges in community contexts reinforced the sense of purpose. Echoing findings from other hackathon studies, such experiential formats foster self-determination, motivation, and civic reflection (Araújo et al., 2025).

Tabel 1. Summary Tabel Of Results: Country Comparisons Insights

Focus Area	Portugal / Spain Findings	Austria Insights	Italy Insights
Student Engagement	High satisfaction, peer collaboration	High discipline, technical focus	Civic motivation, expressive design
Digital Collaboration	Positive use of tools, confidence reported	Emphasis on reliability and precision	Creative digital communication prioritized
Innovation & Responsibility	Innovation readiness, social value perceived	Strong problem framing, feasibility orientation	Social challenge framing and cross-sector awareness

6. Discussion and Reflections

The findings from the Eco-Digithon implementation reinforce the value of Challenge-Based Learning (CBL) and socially grounded pedagogies in promoting learner-centered, future-oriented education within VET systems. They also offer insights into the conditions under which such innovations succeed, the challenges they face, and the broader implications for educational transformation across Europe.

6.1 CBL as a Driver of Deep Learning in VET

This study demonstrates that CBL, when scaffolded through structured scenarios, authentic challenges, and guided mentoring, leads to high levels of student engagement and sustained motivation. These results align with existing literature emphasizing CBL's capacity to foster active, reflective, and collaborative learning environments (Kolb, 1984; Gallagher & Savage, 2020).
Learners in the Eco-Digithon not only developed technical and transversal skills but also began to see themselves as **change agents**—able to address societal issues through co-designed, community-responsive innovations. This aligns with emerging research on the transformative potential of hackathons in education, which frame these events as accelerators of learner agency, creativity, and social capital (Flus & Hurst, 2022; Araujo et al., 2025).

6.2 Innovation Readiness and Civic Orientation

A distinctive contribution of the Eco-Digithon model lies in its dual emphasis on **innovation readiness** and **social responsibility**. Learners were not only asked to produce creative solutions but to engage critically with the ethical, ecological, and systemic dimensions of local problems. In this way, the model operationalizes principles embedded in both GreenComp and EntreComp, which advocate for competence development that bridges entrepreneurial initiative with civic purpose (Bianchi et al., 2022; McCallum et al., 2018).
Student feedback and teacher observations suggest that even in time-limited, high-pressure environments, learners internalized the relevance of their work. This is particularly important in VET contexts where motivation and school-to-society connections are often difficult to establish (Cedefop, 2021).

6.3 Mentorship and Professional Learning

Teacher and mentor involvement emerged as a key enabler of quality CBL experiences. The reflective practices documented in journals and focus groups show that educators engaged in the Eco-Digithon were themselves participants in transformative professional learning. By co-facilitating student projects, adapting scenarios, and navigating cross-disciplinary content, they expanded their instructional repertoires and deepened their engagement with digital and ecological pedagogy.
However, some educators reported feeling underprepared or constrained by institutional structures. This reflects broader systemic challenges in embedding CBL in formal curricula and underscores the need for targeted professional development and curriculum integration pathways.

6.4 System-Level Implications

The transnational scope of the ENNEPlus project highlights both the potential and complexity of implementing CBL-based hackathon models at scale. While learner outcomes were broadly positive, variations in institutional readiness, mentor capacity, and digital infrastructure significantly shaped the quality of implementation.
This reinforces the importance of building scalable support ecosystems—including Communities of Practice (CoPs), adaptable toolkits, and policy alignment—to ensure equitable access to innovation-oriented learning. The CoP developed within ENNEPlus served as a valuable digital hub for peer exchange, scenario sharing, and mentoring coordination, but its uptake varied by country and digital fluency.

7. Conclusion and Outlook

The findings presented in this paper affirm the value of integrating Challenge-Based Learning (CBL) and socially embedded methodologies such as the Eco-Digithon into Vocational Education and Training (VET) systems. By engaging students in collaborative, real-world problem-solving aligned with the Sustainable Development Goals, the ENNEPlus project demonstrated that learners can develop not only digital and sustainability competencies, but also a deeper sense of innovation readiness, civic engagement, and self-directed learning.
At a pedagogical level, the Eco-Digithon model reveals that well-structured challenges, interdisciplinary mentoring, and scenario-based learning can activate higher-order skills in VET contexts traditionally viewed as skills-transfer focused. At a systemic level, the project underscores the need for investment in teacher training, institutional flexibility, and scalable support frameworks such as Communities of Practice (CoPs) to ensure the long-term integration of innovation-focused learning.
The work presented here contributes to a growing field of research advocating for learner-centered, socially connected, and digitally mediated pedagogies in vocational education. As Europe advances its green and digital transitions, such models will be essential in ensuring that all learners, not just those in academic tracks, are equipped to shape sustainable futures.

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