ADVANCING STUDENTS' SUSTAINABILITY COMPETENCES WITH CAPACITY BUILDING COURSE DEVELOPMENT

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ABSTRACT

Universities play a key role as change agents in developing sustainability competences and building capacity through the lifelong learning pathway. Integrating sustainability goals into study programmes, however, presents the challenge of crossing disciplinary boundaries, which can hinder interdisciplinary learning for sustainability. Actively engaging students in sustainability capacity-building through innovative educational practices is a powerful strategy for developing their sustainability competences in alignment with GreenComp and other sustainability competence frameworks.

This paper presents an innovative learning practice approach to enhancing a university's sustainability capacity by involving students from diverse disciplines in the co-design of a micro-credential course on circular bioeconomy road-mapping. Guiding this research is the following question: How can an innovative capacity-building practice for sustainability development in course design support the development of students' sustainability competences? The study is informed by the sustainability concepts of Wiek et al., (2011), Morgan (2006), Brundiers et al., (2021), and Bianchi et al., (2022), which shaped the learning goals in this capacity-building practice.

INTRODUCTION

New challenges have emerged for higher education institutions in curriculum development as they align themselves with the goals of the European Green Deal (European Commission, 2019) and the United Nations Sustainable Development Goals (SDGs). SDGs were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity (United Nations). Higher education institutions are considered key players in developing SDG 4 about quality education, SDG 11 about sustainable cities and communities and SDG 12 about responsible consumption and production. In our paper, we followed a holistic approach (see Morgan, 2006; Wiek et al., 2011) to designing an educational practice that aims to achieve broader capacity building goals of sustainability through developing students' collective sustainability capabilities and competences. According to the European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience (European

Commission, 2020), GreenComp - the European sustainability competence framework (Bianchi et al., 2022) - is seen as one of the main working tools for describing the competences. There are still few empirical studies on how students actually perceive their learning outcomes about green and sustainability competences. Hyytinen et al. (2023) explored the relationship between students' pro-ecological worldviews and their interest in Finland in learning various sustainability competences. Their findings revealed that students found critical thinking and values-based thinking the most engaging.

Our paper emphasises the central role of university students in building sustainability capacities for the university and learning for sustainability competences in the Lifelong Learning (LLL) pathway. We introduce a case study about the micro-credential course development on circular bioeconomy for societal stakeholders. It was co-designed with the students as part of an interdisciplinary problem-solving course called "LIFE" (Learning in Interdisciplinary Focused Environment) – a mandatory component of both bachelor's and master's programmes at Tallinn University (see Ümarik & Jõgi, 2020).

The terms of reference for building the micro-credential course were driven from the report on the methodology development of regional roadmapping in the circular bioeconomy field in Estonia (Pikner et al., 2023). The methodology applies to various organisations, (e.g., county development centres, businesses, local governments and their unions, community initiatives) to map the potential for circular bioeconomy as well as for fixing and developing the roadmap. The methodological components (including three canvasses for business quality features, sectoral value chains and regional support measures), as well as preliminary feedback received from expert interviews and focus groups carried out by the research team, were provided as input for the prototype development of the curriculum. The learning practice at the centre of this paper was focussed on the outreach of these research and development results as regards critical skills to support green transitions aligned to SDG 4, 11, 12 in communities. The micro-credential course was targeted to adult learners and was codesigned by 12 students from different disciplines, along with facilitators.

In presenting the course design, we follow Edelson's (2002) design research aspects. He identified the three aspects that are necessary to explain any design – Domain theory, Design framework, and Design methodology. Domain theories focus on explaining why the design should be as it is, considering the contextual needs and expected outcomes from the theoretical viewpoints. In our case, the Domain theory for sustainability-directed educational practice addresses the need for advancing individual green competences (Bianchi et al., 2022), as well as the need for collective capacity building (Morgan, 2006) for sustainability between the university and its societal partners. For example, system thinking, interpersonal communication, forward looking and adapting, collective performance and normative competences for sustainability (Wiek et al., 2011) are all important.

Second, our Domain theory was translated into the Design framework for sustainability-directed educational practice. The Design framework explains how theoretical assumptions and needs can be realised through concrete course aspects - study phases, learning activities, ways in which roles are distributed within the course, which interactions and engagements are promoted, etc. In our case, the design solution translated the sustainability related competence and capacity building needs into the LIFE course context in Tallinn University. As an interdisciplinary course, the LIFE course has several qualities that make it suitable for mediating sustainability learning, such as a partially open course programme, a focus on interdisciplinarity, student agency and problem-solving (Ümarik et al., 2020). The LIFE course also provided some central elements to be implemented into our case, such as the mid-review and final review and the individual reflective feedback (Ümarik et al., 2020; Pata et al., 2020).

Third, the Design framework for sustainability directed educational practice was outlined as a general design procedure that laid out a sequence of tasks, describing the objectives, processes, resources and participants for each design process step. The co-design approach was central and involved students, facilitators and stakeholders external from the university for jointly developing the micro-credential course in the circular bioeconomy field.

In this paper we take a qualitative approach to evaluate how a capacity building for sustainability approach, if embedded within the course design, would support students' sustainability competences as they attain these learning outcomes. The paper also contributes to better understanding how these course tasks and phases support the university's role in developing new training programmes for adult learners. For the analysis we used qualitative data on students' learning gains, collected from their process reflections in their project portfolios as well as diaries of the facilitators for tracing the process.

In the findings section we describe how the capacity building course model to target sustainability through capacity building practice enabled students to develop sustainability competences. We present the results of the students' reflections and discuss the limitations of the approach.

CONCEPTUAL BACKGROUND

In this section we explain Domain theory that supported the development of the practice.

Our capacity building course development contributed to the sustainability goal of the university in building the micro-credential course on circular bioeconomy road-mapping, and to the students' competence development. It addressed the concepts of both capacity (Morgan, 2006, Wiek et al., 2011) and sustainability competences (Bianchi et al., 2022).

When assuming the role of sustainability actor, universities need to develop their dynamic state, a capacity in which they promote sustainable actions within their academic activities and engagements with stakeholders (e.g., research, courses and knowledge transfer). According to the Quintuple Helix innovation model (Carayannis et al., 2012) the socioecological transition to society requires a cooperative system of knowledge, know-how and innovation between five types of stakeholders and resources (political and legal, education, economic, natural, information and social) for more sustainable development.

Capacity represents a potential state or temporal condition that can be measured in action, both for systems and for individuals (Morgan, 2006). Morgan identifies that dynamic capacity reveals itself through five separate but interdependent collective capabilities: the capability to act; the capability to generate development results; the capability to relate; the capability to adapt and self-renew; the capability to achieve coherence. Several of these capabilities are also addressed in the model of sustainability competences (Wiek et al., 2011). In order to be responsive, the university needs to promote systemically new forms of learning and engagement with stakeholders that keep this capacity active. We provide an insight to such a course model.

We assert that the sustainability competences should be developed in a way that contributes to the overall sustainability capacity that the university encapsulates. In order to support the capacity for sustainable development through courses, universities need to make certain transformations (Pata et al., 2020). There is, for instance, a need for university teachers and external stakeholders to be more prepared for open, interdisciplinary and collaborative approaches to learning and joint problem solving for sustainability goals. Learning opportunities that are open and tailored to societal needs require a different institutional

approach from the university, where norms and regulations are more flexible. This might include, for example, flexibility in learning environments, using contexts and resources for learning external to the university, flexible timing of learning and shorter learning phases such as micro-credential-based learning paths to support capacity building readiness. The changes must also occur with consideration to how academics, students and external stakeholders see their roles and responsibilities in the learning activities that focus on sustainability problem solving. Open and complex problem-solving situations create the need for different competences - those that comprise the sustainability competences framework. Our case study used the LIFE course format in Tallinn University as an opportunity to co-design with the students the micro-credential course for circular bioeconomy for interest groups external to the university. We used the task of codesigning micro-credentials, because micro-credentials are useful approaches for universities to reach SDG 4 (equitable quality education and lifelong learning opportunities for all). Micro-credentials can play a pivotal role in transmitting competences and skills to professionals for contributing to sustainable development (Sauli et al., 2025). Micro-credentials are said to add value to academic programmes (Cartis et al., 2023).

Within a course that targets sustainability competences, the students themselves are expected to create the dynamic agency. They will discover the concepts, develop an interdisciplinary understanding and shared values, also learn about the different obstacles, what resources are available and missing and learn to implement the tools jointly with stakeholders. These competences are covered within the sustainability competences framework (Wiek et al., 2011; Bianchi et al., 2022).

We also wanted to target SDG 4 (quality education), SDG 11 (sustainable cities and communities) and SDG 12 (responsible consumption and production) goals with this course, for which we chose the circular bioeconomy context (Pikner et al., 2022). We assumed that an interdisciplinary field of circular bioeconomy and the methodology to translate the research approaches to society using the course design approach would trigger the individual sustainability competences of students. It would also allow them to develop collective capabilities and form a capacity while composing the micro-credential course.

METHODS

The methods section first describes the design framework. We then provide an overview of piloting the course and then the formative evaluation approach.

The Design Framework

We agreed on the following aspects beforehand. **Firstly**, the circular bioeconomy report (Pikner et al., 2022) was to be used for building the course because it proposed certain theoretical and practical steps. **Secondly**, we intended to use the co-design approach so that they would meet stakeholder needs. **Thirdly**, as a methodology we set up the sequential design thinking process phases and adapted an approach developed for “Modernising ICT Education for Harvesting Innovation” [1].

The LIFE course format was used as the stance to promote sustainability competences and to build the collective capabilities so that the capacity for sustainability would form throughout the course. The LIFE course structure was not fully predefined in order to keep the process open and student led. The facilitators were prepared to introduce the specific approaches and steps as needed.

[1] Available at http://ictinov-project.eu

We mapped capacity building aspects (five capabilities defined by Morgan (2006), Wiek et al., (2011) and Bianchi et al., (2022) at the course process stages in the Design Framework (see Figure 1). The LIFE project students undertook the following stages:

I. Understanding and discovering incorporated desk research for documentary analysis;
II.-III. Defining a problem and collecting ideas involved field work – persona analysis and accompanying beneficiary pathway roadmaps, student interviews with persona types as potential stakeholders;
IV. Developing a prototype for a micro-credential curriculum involved concept development for a curriculum;
V. Testing pilot materials;
VI. Reporting and reflecting using public pitching and self-reflections.

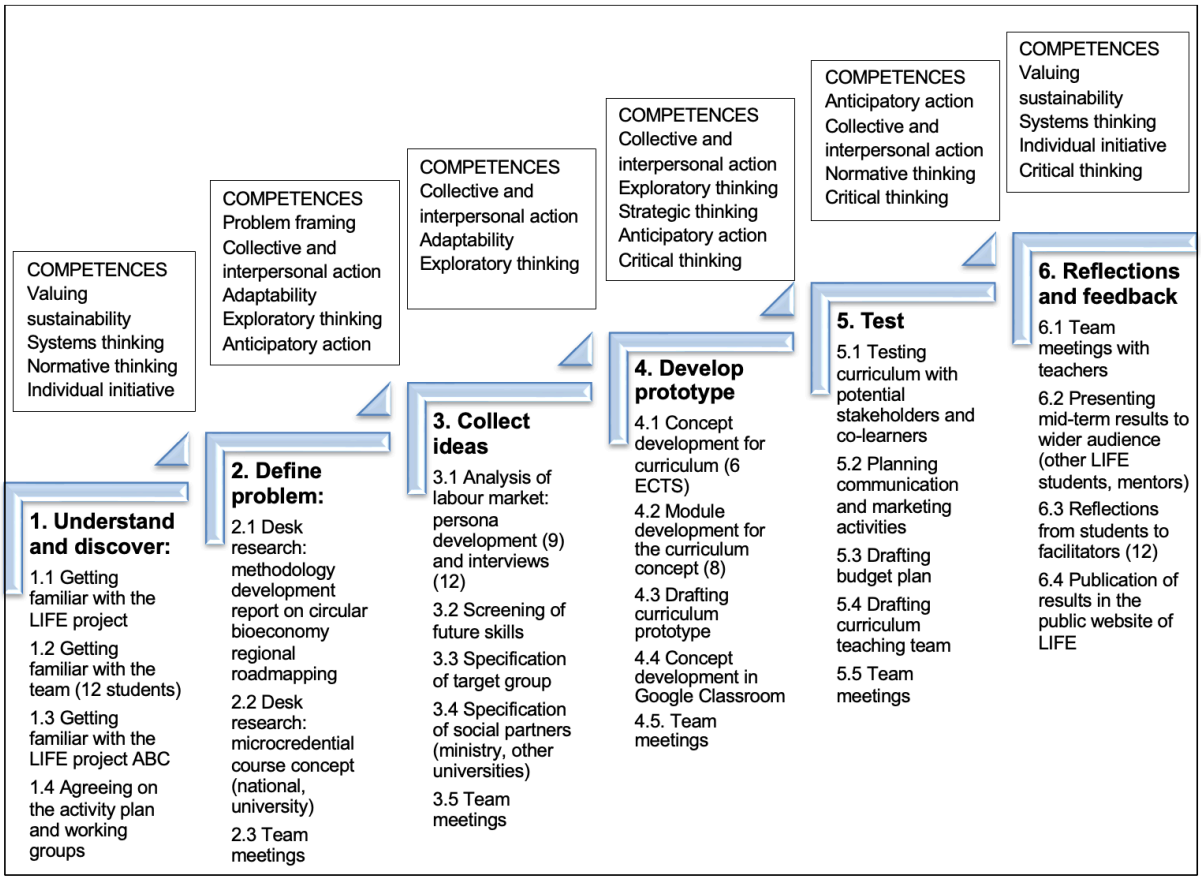

Figure 1*. The stages of competence-building for sustainability competences (Bianchi et al., 2020, Wiek et al., 2011) at the course presenting the learning activities and the learning outcomes.*

The Piloting of the Course

Students in the course came from different university departments. The students voluntarily joined the LIFE project titled “Circular bioeconomy – development of micro-degree programme” in 2023 (*Ringbiomajandus - mikrokraadiprogrammi arendamine*, 2023) using the LIFE matchmaking portal. The selection of the course participants was done according to students’ own motivations and expectations. The design framework added the requirement of working within a heterogeneous group to create a unified understanding of the goals, and to develop their understanding of the field. The group was interdisciplinary and was comprised of twelve students from bachelor and master programmes in psychology,

environmental management, molecular biochemistry and ecology, administration and business, andragogy, sociology, organisational management and contemporary media.

Engagement in the LIFE course took place over a full semester. The first meetings in September were critical for participants to become familiar with each other and their backgrounds, and to agree on an activity plan and to begin the desk research. Two groups of work tasks were proposed by university facilitators (Group 1: market needs analysis, target group and demand in labour market, social partners of university, communication and marketing activities; Group 2; curricula framework, teaching tools and technical solution, budget estimation for implementation, curriculum team). Students decided for themselves which groups to join. The students met regularly every two weeks and organised *ad hoc* meetings. The regular reflections took place in the co-design team. The facilitator's role was to support the team in getting to know each other, discovering the task and agreeing on the action plan, finding right ways to propose the practical solution and presenting results to other teachers and students. The project involved regional and sectoral actors as representatives of potential adult learners and associated partners, and people from different areas of the university including education, nature and communication. They were contacted by the students. In the final stage, students also wrote self-reflections for their own benefit and to supply feedback for university facilitators. The practical outcome of the project was a prototype of the curriculum with eight distinguished modules and learner gains, specified target group and social partners, pilot teaching materials, communication and marketing plan, budget estimation and the team.

The Formative Evaluation of the Course

The formative evaluation of the course was done using the 12 students' final reflections and the diaries of the two facilitators. The analytical method was deductive content analysis (Bingham & Wytkowski, 2022). We categorised the reflections according to the sustainability competences we selected from different related frameworks (Bianchi et al., 2022, Wiek et al., 2011; Brundiers et al., 2021). We expected these competences to be developed as learning outcomes (see Figure 1).

Valuing sustainability enables learners to reflect sustainability as a core personal and societal value and requires respective commitment to contributing to sustainability. **Systems thinking** is the ability to understand and analyse complex sustainability problems and their evolution. It enables learners to **gain** insight into how ecological, economic and social systems co-evolve. **Adaptability** involves the capacity to respond flexibly to new situations and adjust to them considering disruptions in socioeconomic or socioecological systems. **Problem framing** competence is the ability to critically define sustainability problems (from simple to wicked) considering the context, diverse stakeholder perspectives and ethical implications. **Critical thinking** includes skills needed for evaluating and understanding information regarding sustainability problems. It involves questioning assumptions, evaluating evidence and reflecting on values and real actions. **Exploratory thinking** is the capacity to engage with uncertainty and complexity through creative and experimental performance and includes an ability to assess alternatives towards sustainability. **Normative thinking** competence refers to the ability to articulate and negotiate sustainability values, principles and goals. It involves the capacity to envision desirable futures. **Anticipatory competence** entails the ability to understand and design future scenarios, implement foresight and act proactively considering sustainability risks and opportunities. **Individual initiative** involves the capacity to act autonomously and proactively in sustainability contexts, often requiring entrepreneurial thinking, motivation and responsibility. **Collective action** competence is the ability to collaborate effectively in teams who share goals and engage in participatory processes for co-creating sustainable solutions. **Interpersonal communication** means the ability to engage in meaningful and respectful dialogue considering cultural, regional or other stakeholder contexts.

The diary reflections were used to specify the activities and observations at the course phases. The categorisation within the students' reflection texts and the facilitators' diary was done by two researchers and the interrater reliability was discussed. We illustrate some evidence of certain competence areas, as these were perceived by students in the course phases.

MAIN FINDINGS

In the findings section, we present the results of the formative evaluation of the course. The research question guiding this study is: how can an innovative capacity-building practice for sustainability development in course design support the development of students' sustainability competences?

Students progressed through six distinct phases (see Figure 1) in collaboration with university facilitators, also engaging external stakeholders through interviews conducted during fieldwork. Competences were developed through the acquisition of new knowledge, practical application and continuous learning-by-doing throughout the co-design process.

Below, we present the examples of how students expressed different sustainability competences in relation to the course activities.

Valuing sustainability

Students approved their support on sustainability values through acquiring new knowledge and practices. More specifically, they increased their knowledge about the circular bioeconomy field and its role for the regional and national value added in further economic development towards sustainability aims defined in strategies (Estonia 2035, Estonian Research, Development, Innovation and Entrepreneurship Strategy 2021-2035). Most students were not previously aware of the circular bioeconomy or of lifelong learning fields. They highlighted the high impact role of the bioeconomy sector to gradually replace fossils with bio-based commodities. Quote from student reflections: "*I joined the LIFE project of the circular bioeconomy micro-credential programme because I believe that promoting green thinking is essential for the future. The programme allowed me to gain an in-depth understanding of the concept of circular bioeconomy, helping me to gain new insights into the field in different contexts."*

Systems thinking

Systems thinking was developed with deepening knowledge and know-how about the interdependencies between fields such as circular bioeconomy, regional development and university lifelong learning, followed by specifying potential target groups and their potential interest in professional learning. Communication with stakeholders through interviews showed skill gaps in the circular bioeconomy field to tackle challenging sustainability questions. Based on 12 persona analyses and nine interviews with stakeholders (business, ministry, local municipalities representatives), students defined the major target group: the future micro-credential course was primarily addressed to public sector potential learners (50%), followed by private sector (40%) and non-profit sector and others (10%). This is illustrated by the following quote from student reflections: "*I work in local government and it is important to me that there is a common understanding at the local level of what circular bioeconomy means and how it can be developed step-by-step"; "During the process, I learnt that there is an important link between the waste streams from the blue economy and other bioeconomy sectors in order to raise the profile of the sector."*

Adaptability

Students met several challenges to understand the wider spectrum around the topic on circular bioeconomy (circular economy, sustainability goals), as well as going deeper on building up the new micro-credential programme on a specific topic (why and how). As per student reflections: *"I will end the LIFE project with positive feelings, because the job is done and everyone worked hard for it. Despite the fact that we were all different people, from different professions and completely different backgrounds, and that none of us was involved in any way in the circular economy, I think we achieved a good result"; "The most challenging part of the whole programme was the collection of the interviews in a temporal context, where I had to take into account my own work and private life and the time schedule of the informants".*

Problem framing

Though the core of the problem was provided by facilitators, it was still necessary to explore it and delve deeper. This meant becoming familiar with the prior report on the circular bioeconomy road-mapping methodology and also other documented materials (i.e., strategic documents of Estonia, future skills report of the Estonian Qualifications Agency and the adult learning framework). The following is taken from a student reflection: "*The creation of the framework for the micro- credential programme provided an excellent opportunity to take a deeper look into this topic. It gave me the opportunity not only to deepen my knowledge of circular bioeconomy, but also to actively participate in the process of creating the curriculum, which was a new and exciting experience for me."*

Critical thinking

The learning process helped students discover facts and figures about the circular bioeconomy field, international practice outside of the circular bioeconomy methodology report (Pikner *et al.,* 2023), labour market gaps towards sustainable development as well as opportunities for learning through the micro-credential programme of the university. Establishing the goal and structural framework for the curriculum was said to be a challenging task among students, also due to the fact they came from different institutes and areas. Another quote from student reflections echoes that: *"I realised how important it is for all parties involved to be aware of and understand the concept of circular economy. This is important because if you don't understand the concept then change cannot happen."*

Exploratory thinking

The students expressed their support in exploring the circular bioeconomy field from scratch as well as finding new perspectives of sustainability and working together on the idea development. They met several challenges in different phases, including fixing the major aim of the forthcoming curriculum, discovering the persona types and planning the field work. They made as-needed changes in plans (learning-by-doing). One student remarked: "*I joined the LIFE project because I wanted to get experience in making a micro-credential curriculum. Moreover, circular bioeconomy is a topic that everyone should be familiar with. The most important thing for me is to see and participate in all the stages of setting up a programme"; "I had the opportunity to work with people from different backgrounds, which broadened my perspective on the need for collaboration, its different forms and gave me new ideas on how different disciplines can be brought together for sustainability."*

Normative thinking

Normative thinking was a bonus to understand the depth of the challenging sustainability problem and to find ways for solutions through micro-credential co-design. Quotes from student reflections reflect that: *"There is still quite a lot of resistance in society to the 'green transitions' because more sustainable and responsible behaviour requires breaking old habits, but on the other hand, there is too little knowledge about how to achieve this more sustainable way of life".*

Anticipatory action
The majority of students joined the LIFE project due to personal and professional motivation on the field matter. At the same time, their open-mindedness towards a wider perspective on sustainability appeared gradually during the learning process. Quote from student reflections: *"I decided to join the project because I saw it as an opportunity to contribute towards a sustainable future. My aim was to use my knowledge and skills to help set up a micro-degree programme that would promote the principles of circular bioeconomy at university."; "I found this project particularly interesting because, through my work in local government, I understand that people need more support and guidance in changing their behaviour. At the same time, local governments often lack the necessary knowledge to effectively guide them."*

Individual initiative
Students felt a change in their personal attitudes and potential efforts to make improvements in their individual steps towards sustainability. They also understood that a single role in the system is critical to achieve bigger changes. Quote from student reflections: ""*I joined the project because I am interested in green transitions and I was also interested in how the development of the micro-degree was going. My expectations were to gain knowledge on how to start researching something from scratch on the one hand, and on the other hand to understand the work involved in preparing a micro-degree, as I have participated myself at the micro-degree course before at Tallinn University. I end the LIFE project with positive feelings, because the work is done and everyone put effort into it"; "My personal expectations were related to the opportunity to learn the content of circular bioeconomy and to apply it in a practical project. The biggest obstacle was time, but thanks to good teamwork we were able to complete a project that could be implemented by Tallinn University in the future."*

Collective action and interpersonal communication
One of the greatest values of interdisciplinary tasks lies in the opportunity to build new connections and gain experience in teamwork. Students were placed in new situations at every stage of the learning process, culminating in a successful co-design process — though not without its own limitations and challenges. Quote from student reflections: "*Despite the fact that we were all different people, from different professions and with completely different backgrounds, and at the same time none of us were in any way related to the circular bioeconomy, I think we got a good result"; "The project taught me a lot about team dynamics, and I think the biggest challenge was how all the smaller activities contribute to the end result"; "It was interesting to see and experience the creation of something with so many different people from different backgrounds".*

DISCUSSION AND CONCLUSION

Overall, our study demonstrated how universities can achieve their sustainability goals by targeting individual students' sustainability competences within a broader capacity-building conceptual framework. Interdisciplinary approaches to learning experiments present challenges for university lifelong learning; however, they also increase the likelihood of meaningful changes toward sustainability. Universities must provide open and flexible support for novel approaches to learning and capacity building.

Our study provided evidence that joint learning efforts - guided by university teachers and involving motivated students from various fields - can lead to student leadership in educational experiments. During the LIFE project, students gained ten types of competences through personal and group assessments: valuing sustainability, systems thinking, critical thinking, problem framing, adaptability, exploratory thinking, normative thinking, anticipatory action, collective action, interpersonal communication and individual initiative. It is important

to emphasise that while students recognise green skills as defined in competence frameworks, they do not deliberately assess their own sustainability competences in accordance with the design framework. This learning aspect should be made explicit to students when defining project tasks. Additionally, integrating both teaching and research within the same initiative could yield twofold benefits. Universities strongly favour research-based teaching, which supports this approach.

Our co-design process with various stakeholders inside and outside the university was constrained to a one-semester time frame, which must be taken into account in developing the design framework of sustainability. Not all GreenComp competences were detected within the given time frame. We mainly demonstrated in this paper how different learning outcomes were received by students. Our data collection in the formative evaluation did not involve interviewing other codesign stakeholders. This limited us in terms of fully demonstrating the collective capabilities and the holistic capacity development potential that this learning practice approach has for sustainability learning. Further research is needed in these areas to help determine that these holistic level learning outcomes emerge during the learning process blending universities and the external situations.

While the role of university facilitators was critical in keeping the learning process going throughout the study phases, a bottom-up approach to assigning the student team leaders and promoting students' self-agency was essential to achieve the sustainability competences during the process. Students reported that their individual initiative and collective learning and interpersonal communication improved during the course.

To conclude, we found that the codesigning approach to the micro-credential course on circular bioeconomy together with the students and external stakeholders provided a complex problem-solving framework for the LIFE course that was suitable for developing sustainability related learning outcomes. Our subsequent research will focus on higher education practices for sustainable development across universities and communities.

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