2023

Shaping A Sustainable Future Through Integrating Sustainability, Creativity And Entrepreneurship In Engineering Education At Aalto University

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SHAPING A SUSTAINABLE FUTURE THROUGH INTEGRATING SUSTAINABILITY, CREATIVITY AND ENTREPRENEURSHIP IN ENGINEERING EDUCATION AT AALTO UNIVERSITY.

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Conference Key Areas*: 3. Engineering Skills and Competences, Lifelong Learning for a more sustainable world. 16. Other Topics in Engineering Education.*

Keywords*: sustainability, entrepreneurship, creativity, engineering education, Aalto University*

ABSTRACT

This paper reports the authors' experiences integrating sustainability, creativity, and entrepreneurship in engineering education at Aalto University under the project called the Aalto Co-Educator team. The Aalto Co-Educator team was formed to support the university strategy application into education through three main actions: course development, curriculum development and competence development. The goal of this paper is to share engineering educators' experiences in providing sustainability, creativity and entrepreneurship education to engineering students in a rapidly changing nature of work.

Introduction

Competence requirements for engineering graduates are in transition due to a rapidly changing world and global challenges (e.g. Fomuyam, 2019; Hadgraft, Kolmos, 2020; World Economic Forum, 2020). Aalto University has adopted a strategy that addresses these challenges and aims to shape a sustainable future[2].

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[2] For more information about Aalto University strategy, check www.aalto.fi/en/strategy

The strategy defines three cross-cutting themes: *Solutions for sustainability*, *Radical Creativity* and *Entrepreneurial mindset*, with the goal of impacting all university activities, including research, education and operations. This paper discusses the experiences in integrating these themes into education through a project called the Aalto Co-Educator team[3]. The study sheds light on activities at all levels in the university organization from university top management to schools, programmes, and courses.

University level – Appointing and resourcing a task force

Strategy implementation in an autonomous and self-steering university organisation is not possible using a top-down approach alone. Instead, strategy implementation activities are needed at all levels of the organization. To address the strategy implementation challenges related to education, Aalto University set up the Aalto Co-Educator team project in August 2021. The project team members comprised of teaching development experts with foci in sustainability, entrepreneurship, creativity, collaborative teaching in courses, and experts in programme development. Aalto University works on 2-year study periods. The next period will cover 2024 (autumn) to 2026 (spring). The program-level planning for the 2024-26 study period ends during the 2023 fall term while the detailed course planning continues in 2024. The project is working towards integrating the three cross-cutting themes into the 2024-26 study plan with pilots and development work ongoing in 2021-22.

Aalto University consists of six schools: (1) Arts, Design and Architecture, (2) Business, (3) Chemical Engineering, (4) Electrical Engineering, (5) Engineering, (6) Science. In these schools, education happens in several independent bachelor, master and doctoral programmes. While programmes and courses have significant autonomy and can independently define their intended learning outcomes, the Aalto Co-Educator team's goal is to ensure that the integration of the cross-cutting themes happens in practice and that students receive sufficient education in sustainability, creativity and entrepreneurship.

Aalto Co-Educator team activities

Once established, the team needed to elaborate on the meanings of the three cross-cutting themes in education. The need for translating the strategy language into teaching terms became evident during the piloting stage when the team was working with teachers on courses and with programme directors on programmes. The team

[3] For more information about the Aalto Co-Educator team, check www.aalto.fi/en/co-educators

needed to develop answers to questions such as: What is radical creativity? What do we mean by sustainability? How are these themes relevant to teaching?

Formulating responses to these questions was an iterative process between the team and the teaching faculty. The first iterations of this process analysed the competencies associated with the three themes. This phase was based on literature (e.g. Wiek, Withycombe, Redman, 2011) and practical experiences of the team members in integrating the themes in education.

One intermediate stage of the evolution is visualized in Figure 1 below. This version presented one Intended Learning Outcome (ILO) for each of the cross-cutting themes (violet circles): Understanding and addressing sustainability-related challenges, driving viable solutions to open-ended challenges (entrepreneurial mindset), and being able for creative teamwork (radical creativity). These high-level themes have then been broken down further into more detailed topics - e.g., systems thinking, futures thinking (Wiek, Withycombe, Redman, 2011), experimenting and decision making. The interesting observation here was that the breakdown of each of the 3 top-level themes resulted in the same or very similar topic breakdown, supporting the notion that the three cross-cutting themes can and should be managed together for inclusion in education.

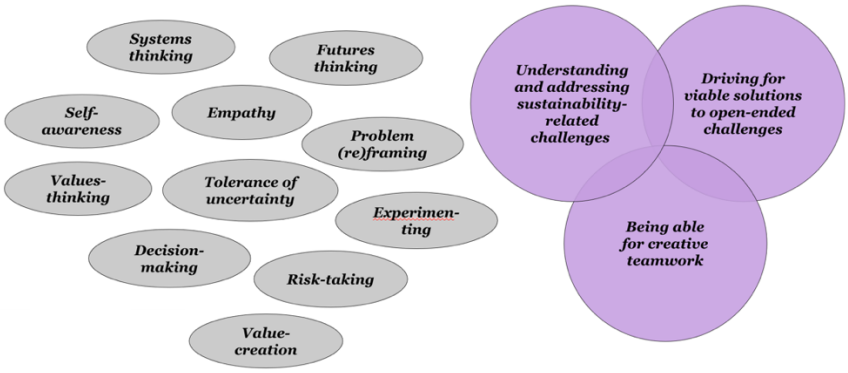

Figure 1. Competencies under the cross-cutting themes

After understanding the main topics derived from the cross-cutting themes, the goal of the Aalto Co-Educator team was to establish intended learning outcomes (ILOs) for programmes and then for courses. In this process, the team noticed how these three topics presented clear overlaps in terms of learning goals and how counterproductive it would be to consider them separately. For example, ‘ability to identify challenges, ideate, experiment, and implement feasible, user-centric interventions’ resonate both with the entrepreneurial mindset and radical creativity. By building broader ILOs that encompass the three cross-cutting themes, the team managed to develop a “language” that facilitated the process of applying and integrating these topics into programmes and courses. This result is shown in Table 1 (next page).

Understanding and addressing sustainability-related challenges Knowledge of sustainability-related challenges and their systemic nature. Ability to contribute with one's field-specific expertise to shaping a sustainable future.	**Driving for viable solutions to complex challenges** Ability to identify challenges, ideate, experiment and implement feasible, user-centric interventions. Capability, courage and perseverance for acting in an environment of risks and uncertainty.	**Nurturing creativity in teams and individually** Ability to provide alternative framings and seek novel perspectives. Ability to participate in and facilitate creative processes and to collaborate across disciplines.

Table 1: Cross-cutting themes integrated into three ILOs.

Parallel with establishing how the cross-cutting themes are translated into ILOs, the Aalto Co-Educator team started to build connections with different levels in such a complex and distributed organization. Table 2 lists the types of activities that the project team engages in at different levels of the university.

University level	**Activity**	
University	Strategy for tackling future challenges, including the identification of the three cross-cutting themes. *Setting up the Aalto Co-Educator team to drive strategy implementation into education.*	
School	Instigating and (re)defining the necessary educational programs: BSc, MSc, PhD. *Active dialogue with school education leadership.*	
Programme	Defining programme learning outcomes and curriculum. *Active dialogue, ideation and concrete ILOs definition in cooperation with program management and teaching team.*	Competence development support for teaching staff in different roles. *Pedagogical course for course and program staff, support for teamwork.*
Course	For selected course, (re)define course content to include relevant topics supporting the three cross-cutting themes. C*ourse co-design and co-teaching together with course staff.*	
Teacher	Supporting teachers in practical teaching activities. *Teaching method development.*	

Table 2: Aalto Co-Educator team activities in the university.

Figure 2 below represents how the Aalto Co-Educator team conceptualises its work: teachers develop their skills in competence development, which are transmitted to students in programmes and courses. The implementation of the strategy into education aims at better preparing students for shaping a sustainable future. In practice, integrating sustainability, creativity and entrepreneurship in education, and therefore promoting student learning in these topics, is the focus of the Aalto Co-Educator team in three different types of actions. (1) Programme Development, where the team collaborates with programme directors to define the program ILOs and curriculum (2) Course Development, where the Aalto Co-Educator team works closely with teachers to ensure that the programme-level ILOs are implemented in the planned courses and (3) Competence Development, where we support pedagogical training experts and develop one course for the formal pedagogical training track for university teachers. We will describe each of these three types of activities over the next paragraphs while also pointing out examples.

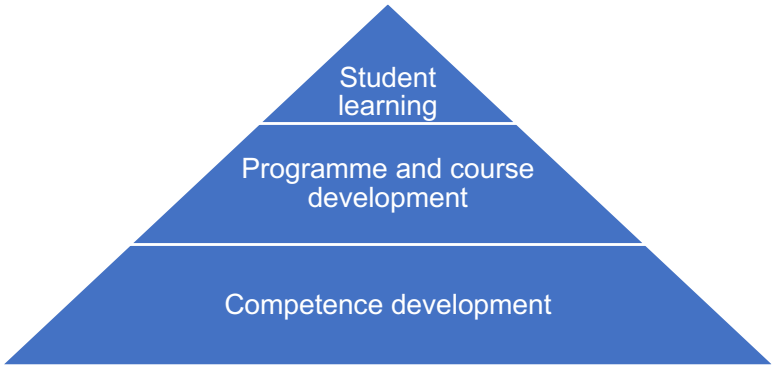

Figure 2: Aalto Co-Educator team works towards student learning

Programme development

At the programme level, one commonly applied solution for introducing a new topic is to introduce a new course. However, the Aalto Co-Educator team aims to integrate sustainability, creativity and sustainability as meaningful and fitting elements in the curriculum courses. We hypothesise that as a separate course, the themes will remain separate while as part of the core courses, the themes merge into the field-specific expertise.

While in course development, the Aalto Co-Educator team works with individual teachers on their courses. In programme development, the team takes a holistic view of the programme: its objectives, learning goals and courses. Similar to what was described in course development, the goal is to identify meaningful connections between the programme objectives with sustainability, creativity and entrepreneurship.

In practice, the Aalto Co-Educator team engages in discussions with programme managers and the teaching team to collaboratively identify how the connections between sustainability, creativity and entrepreneurship can happen. Examples of tools used by the Aalto Co-Educator team in programme development are, for example, curriculum mapping and workshops with the teaching team. Below is one short example of refining ILOs with the support of the Aalto Co-Educator team.

Case example: Programme dialogues in an engineering school

One of the four engineering schools at Aalto University decided to have dialogues with all the programme directors at the school. To date, the dialogues with the directors have continued as a) a reflection dialogue with a programme director, b) facilitation of a workshop with the directors of the majors in a programme, c) sustainability integration in a central high-reach course.

Course development

The actual implementation of the university strategy, and its three cross-cutting themes, into education happens in courses. The strategy does not mandate that every course implements some or all cross-cutting themes. Instead, program development should identify a (small) set of relevant courses that will be used to deliver the program-level ILOs.

The Aalto Co-Educator team works together with the course teaching team to identify meaningful connections between the course content and practices with sustainability, creativity and entrepreneurship. In practice, this means that the Aalto Co-Educator team meets with the teacher(s) in charge of a course for a discussion on what the course learning objectives are and how sustainability, creativity and entrepreneurship can be integrated. An important note is that the teacher(s) in charge have a key role in establishing the connections, while the Aalto Co-Educator team takes the role of facilitating the discussion.

After the discussion with the teaching team, the activities for integrating sustainability, creativity and entrepreneurship in the course are planned. One option is that one of the members of the Aalto Co-Educator team member teaches one (or more) sessions in the course (co-teaching). Another option is that the Aalto Co-Educator Team identifies an expert in the university (or outside) to teach the course. A third option is that the Aalto Co-Educator team only joins the planning of the activities (co-development), where the teaching team takes responsibility for teaching elements of sustainability, creativity, and entrepreneurship in the course. Below, we briefly present one example of a course supported by the Aalto Co-Educator team.

Case-example: Hands-on project course in electronics.

The *Sähköpaja* (Electrical Workshop in English) course is an innovative project course, which is mandatory for the majority of the students at the School of Electrical Engineering. The student teams ideate, develop and build an electrical device during the course. The topics integrated into the course are a prototyping session, exercise and reflection to support the visualizing and testing of an idea as topics of entrepreneurial mindset and radical creativity themes. Sustainability topics presented were environmental impacts associated with the life cycles of electrical and electronic products and the eco-design tools applicable. The student teams reflected upon the themes in a separate session.

Competence development[4]

Building competencies in sustainability, creativity, and entrepreneurship for the teaching staff at Aalto University is a goal shared by the Aalto Co-Educator team and pedagogical specialists across the university. The Aalto Co-Educator team provides support for teachers on these topics and how they can be integrated into their courses and programmes. In addition to that, the Aalto Co-Educator team collaborates with pedagogical specialists from different schools in co-design and co-execution of school-level teaching development activities.

One example developed by the Aalto Co-Educator team is the development and execution of the course Sustainability in Teaching, as part of the pedagogical training for teaching staff at Aalto University. The 3 ECTS course runs twice a year and offers up to 20 teaching staff members the opportunity to identify and apply different approaches to integrate sustainability into teaching. Some of the topics covered in the course are the relevance of sustainability for participants' specific fields, identifying key areas of sustainability relevance, sustainability in higher education, key competencies of sustainability education and how to cope with student anxiety regarding the sustainability crisis. The course has received positive feedback from teachers over the last few years.

Lessons from integrating sustainability, creativity and entrepreneurship into courses and programmes

Implementing a university strategy in education does not come without challenges. However, the experiences of the Aalto Co-Educator team reported in this article can serve as guidance for other engineering educators who aim to integrate

[4] For more information about competence development in the Aalto Co-Educator team, see Schönach, Jaakkola, Karvinen (2023).

sustainability, creativity and entrepreneurship into their educational programmes. Below, we summarize our key takeaways for fellow educators.

- *The translation from strategy into education is not straightforward*. Collaboration with programme staff and teaching faculty was essential. Together, we translated the strategy terms into the language and terms used in the teaching development in the form of ILOs, content topics and teaching methods.

- *Staff support is an ongoing need.* Even after the Aalto Co-Educator team managed to translate the strategy terms into ILOs, teaching staff could not simply implement them. Instead, it required further resources and capabilities from the Aalto Co-Educator team on how to meaningfully integrate the cross-cutting themes into education.

- *The three levels of support - course, curriculum and competence development - offered by the Aalto Co-Educator team proved to be useful for tailoring the support for different staff needs*. For example, teachers in charge of courses and programme directors have different needs (and reach) in terms of the integration of new topics into their teaching. We discuss these three different levels in the next items.

- *Curriculum development proved to be essential to get the mandate and priorities from the schools' teaching leadership*. The dialogue with the programme directors called for thorough background work on the programme goals and courses. Having an overall picture of the programme content and the strategy terms in the form of ILOs facilitated the discovery of meaningful connections between the themes and programmes.

- *Course development is the place where the integration of sustainability, creativity and entrepreneurship happens in practice*. In other words, students meet these topics in practice within the actual coursework. Thus, course integration needs to be directed at the courses with a high reach of students and/or mandatory courses, due to being a resource-intensive activity.

- *Competence development, in the form of a pedagogical course, has proven to function as a platform for competence development*. More specifically, it strengthens the teachers' confidence in teaching sustainability topics and builds connections within the teacher community.

In conclusion, as the Aalto Co-Educator team activities will end at the end of 2024, we acknowledge that the journey of educating engineers on sustainability, creativity, and entrepreneurship cannot be restricted to a single project. It requires continuous support from universities and should be viewed as an ongoing, iterative process. Therefore, we encourage academic institutions to consider the long-term horizon of their support systems, beyond the conclusion of specific projects or teams.

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