INTEGRATING SUSTAINABILITY IN AN ELECTRONIC ENGINEERING PROGRAM: INSIGHTS AND EXPERIENCES ON ACADEMIC STAFF INVOLVEMENT

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ABSTRACT

There is a growing urgency to incorporate sustainability in all facets of society to stay within the planetary boundaries. Higher education has a significant role by educating their students - our future work forces – with the knowledge and competences that are crucial for working with sustainability challenges. The development of sustainable technology thereby takes a significant place, pointing out the role of engineering education. This article presents the journey of integrating sustainability in the M.Sc programme Electronic System Design and Innovation at the Norwegian University of Science and Technology. We focus on three aspects of this journey. First, we present the approach used and the process stages for the integration of sustainability, which is a renewed version of a toolbox for integrating ecodesign in engineering studies. Secondly, we present how academic staff is involved throughout the integration process. To be able to succeed with incorporating sustainability into a study programme, it is important to engage and empower academic staff, since they have a central position through their responsibility for a study's central building blocks - the different courses. Lastly, we outline insights and experiences from the perspective of academic staff and the project team involved in the integration process. We conclude with how the approach used and the lessons learned can provide useful strategic and practical insights for other engineering programmes in their process of integrating sustainability and plans for future activities.

1 INTRODUCTION

1.1 Integrating sustainability in higher education curricula

This article presents insights and experiences from academic staff related to the integration process of sustainability in an electronic engineering programme. Through this work, we aim to contribute to the need for incorporating sustainability in all facets of society in order to stay within the planetary boundaries. Higher education has historically played a role in transforming societies, by educating decision-makers, leaders, entrepreneurs, and academics, and by serving the public good [1]. A growing number of universities gets engaged in incorporating and institutionalizing sustainable development (SD) into their education, research and outreach, and campus operations [2], [3]. The role of higher education is to educate and equip their students with the knowledge and competences that make a sustainable transition happen [1]. Growing pressure from industrial entities - asking for graduates with an engineering degree and the relevant skills to be able to handle SD - has become an important driver for higher engineering education to integrate SD in the curriculum [4].

1.2 Involving academic staff

Several researchers emphasize the importance of involving academic staff in the transformation towards education for SD [2]. This is related to the central role they have in curricular development and how to direct it more towards sustainability. However, literature also indicates that there is a strong need for support for educators that empower and involve them in the integration process [4]. In this article, we focus on academic staff involvement during the journey of integrating sustainability in the M.Sc engineering programme Electronics System Design and Innovation (Elsys) at the Norwegian University of Science and Technology (NTNU). We focus on how academic staff got involved and supported throughout the integration process of SD in the curriculum, and on experiences from involving academic staff seen from different perspectives. The results are part of a pilot project within the strategic initiative Technology Education of the Future at the university. The integration of competences for SD in all the university's future engineering and technology studies forms a significant component of this initiative.

2 METHODOLOGY

2.1 Pilot case: study programme Electronics Systems Design and Innovation

In this work we focus on a pilot case, the Elsys study programme that is currently integrating sustainability in its curriculum. The case provides empirical data as a foundation for gathering insights and experiences from academic staff on the integration process of sustainability in the M.Sc programme. The study program Elsys is a 5-year integrated Master's program within electronic engineering, with courses given mainly by the faculty at the Department of Electronic Systems at NTNU. Approximately 120 new students enroll in the program every year. Within the study program, the students can choose specializations within analog, digital and embedded design, signal processing, radio communication, nanoelectronics and photonics, and acoustics. Traditionally, the program has had a limited focus on sustainability. This

may be linked to the past and current focus of the program and its associated academic community on fundamental and enabling technologies, and to a smaller degree on end products, thereby distancing the technology development from end users and society.

2.2 Toolkit for integrating sustainability in engineering education (ISE toolkit)

The *toolkit for integrating sustainability in engineering education* - shortly ISE toolkit - that is used in this work aims to support the integration process of sustainability in M.Sc programmes and has been applied in the Elsys study program. It is based on the EHE toolkit, a toolbox for integrating ecodesign in engineering studies [4] and has been updated, amongst other by including the UN Sustainable Development Goals (SDGs), and adapted to the context of the university. The new elements and adaptations of the toolkit have been tested throughout several stages of the development process and applied in the pilot case.

2.3 Data gathering and analysis

Students and academic staff have been involved in the integration process of sustainability in the pilot case, thereby applying the toolkit, its approach and elements. In order to gather insights and experiences on academic staff involvement, the project team gathered qualitative data, including a *questionnaire* that provides feedback from academic staff on specific steps of the integration process, *interviews* with academic staff that provide insights on opportunities and barriers for integrating sustainability in the curriculum, and *reflections* that offer insights from the project team on experiences from participants and facilitators during different stages and activities of the integration process. A thematic analysis has been used on the pilot case data to gather insights on how academic staff got involved and supported throughout the integration process of SD in the curriculum in practice, and on the experiences from involving academic staff seen from different perspectives.

3   RESULTS

3.1 Approach for integrating sustainability in M.Sc programmes

In this section we shortly present the ISE toolkit's approach for the integration of sustainability, the main process stages and the toolkit's main elements, before we present how the process took place in practice in the pilot case.

The aim of the ISE toolkit is to facilitate study programme management, academic staff and other stakeholders to integrate sustainability in the curriculum. It does this through *informing*, *motivating*, *inspiring* and *connecting* academic staff and other relevant stakeholders throughout the integration process, thereby supporting *collaborative learning* around SD and how it fits into the curriculum [4]. Moreover, the toolkit *combines a bottom-up with a top-down approach*, whereby initiatives and ideas from academic staff are warmly welcomed and get supported, whilst simultaneously engaging the head of department and other leadership positions in order to provide driving forces in the integration process.

The toolkit provides guidance in getting an overview of SD in the whole curriculum (*programme-driven approach*), as well as it offers the opportunity to look at specific

courses and how sustainability fits in. It does this through dividing the work in different process stages, which can be represented in two main stages of the integration approach: 1) Mapping sustainability in study programme and 2) Opportunities for further integration.
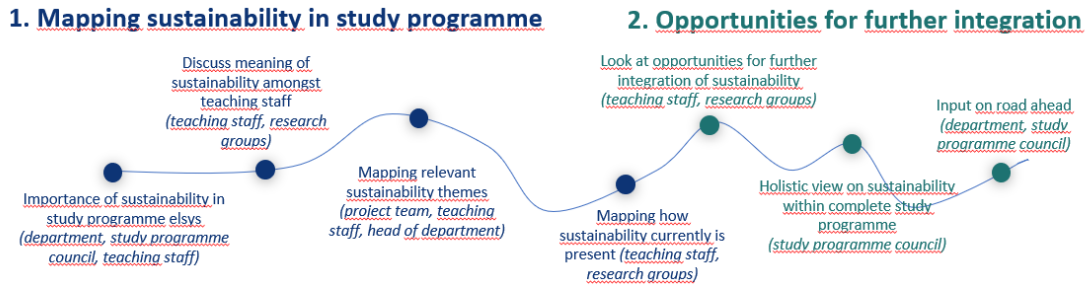

Fig. 1. The process stages of the integration of sustainability

Lastly, the toolkit brings together different pedagogical elements that are crucial in education, thereby combining knowledge on relevant *learning content* related to SD, *competences* for SD and student-active *teaching methods*. These elements are presented in the form of learning theme cards, competence cards, work sheets and guidelines for the integration process.
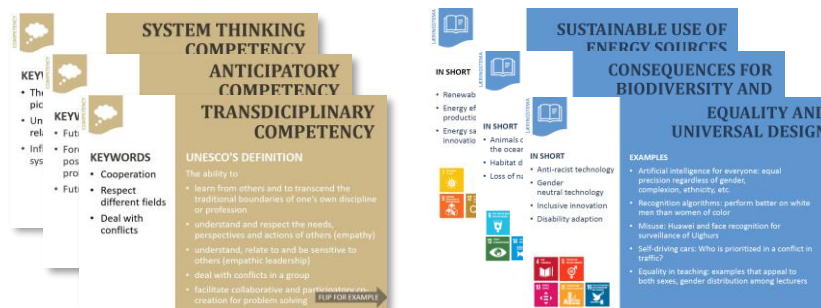

Fig. 2. Examples of the competence cards and the learning theme cards

3.2 Academic staff involvement in the integration process at Elsys

In this section, we present how academic staff at Elsys is involved throughout the integration process so far. To be able to succeed with incorporating sustainability into a curriculum, it is important to engage and empower academic staff, since they have a central position through their responsibility for a study's central building blocks: the courses that make up the curriculum. Creating an environment that values SD is thereby essential to create lasting changes and sustained educational improvements [5]. The academic staff have been, and will be, involved as active participants in completed and future workshops, training seminars and other activities. Fig. 3 presents a timeline of the activities in the pilot case.

Fig. 3. Timeline of activities involving academic staff

Thus far, one webinar and two workshops have been held in the period between the spring semester of 2021 and 2022. In the webinar, the staff were introduced to SD in higher education and asked to reflect upon the role of SD in electronic engineering. In the first workshop, the staff were asked to map the current status of integration of SD in the programme and identify opportunities for further integration. The second workshop focused on looking forward by making plans for integrating SD in specific courses, course groups and the whole study programme.

In preparation for both workshops, a smaller group of the staff has been invited to test versions of the workshops, allowing the project team to observe the staff, getting feedback and enabling improvements to be made. For example, the learning content and competence cards along with the webinar introducing education for SD came as a result from the first test workshop, where we realized that the staff's knowledge of SD was insufficient to complete the work sheets.

Lastly, between the first and second workshop, the staff were invited to sign up their courses as pilot courses for integration of SD, entailing that they were willing to make smaller changes to their courses to facilitate integration of SD and serving as exemplars for the rest of the staff by sharing their plans at the second workshop. In addition, any staff willing to start integrating SD into their courses have been promised support and extra resources in order to enact these changes.

3.3 Insights and experiences from the pilot case

In this section, we share insights and experiences on the integration process from the perspective of the academic staff and the project team. We frame the results in terms of how the toolkit's approach supports the integration of sustainability in the curriculum.

Inform: Based on the interviews with staff and reflections from the project team, the lack of knowledge on SD in education is found to be an obstacle, which gets supported in literature [6]. This came forward especially when staff tried to connect fundamental technology courses with its application in and impact on society and environment. This opened up for reflections from the staff on the role of their study program to society and is illustrated in the following quote: *"... there exists nearly no product today that doesn't have electronics in it, so it's a really important field for everything happening in society […]. So-called enabling technology".* In the pilot case, information has been shared with the staff on SD in higher education and electronics in general, the student perspective on the importance of SD, SD learning content relevant for electronic engineering and competences for SD. Information has been given through the webinar, workshop presentations and material, and in staff meetings not organized by this project. The importance of discussing and working actively with the shared information was mentioned by staff in the questionnaires to be indispensable in order to get a shared understanding, as well as to challenge and inspire each other.

Motivate: Based on the data from the questionnaires and interviews, the staff indicate that there is agreement on the importance of integrating SD in the curriculum. The following quote from a staff member exemplifies this: *"sustainability is important for all, it is good that we also started talking about it".* However, when it comes to working with specific courses, several educators reacted that SD does not fit into their course,

and pointed out other courses where it would fit better. Through exemplifying in the workshops and with pilot courses, we aimed at overcoming this hurdle. The mapping of and reflection on how SD already is present in the curriculum and different courses was mentioned by staff in the questionnaire to be a motivator for taking further steps. Simultaneously, further activity needed to be initiated by the project team and management, thereby pointing out the need for a change agent to lead the integration process forward. Next to that, we experienced that support from management, thereby emphasizing the importance of integrating SD in the curriculum, was important to motivate academic staff. It turned out to be difficult to stimulate them to join workshops related to SD, on top of other teaching and research activities. We encountered that we managed to motivate a part of the staff to actively get involved in the integration process of SD, whilst a group of the academic staff has not been triggered to join (yet).

Inspire: For changes to occur as a consequence of the information and motivation efforts, the staff needs to be inspired to take action, thereby facilitating a bottom-up approach driven by staff in addition to the top-down driven by management. Through the discussions at the first workshop and associated test workshop, statements were made that indicated one hindrance being a limited view by staff on how integrating SD in a course or a programme practically can be done. Simultaneously, while the staff can understand the context and importance of SD in education, they can lack inspiration and the awareness to take action. The following quote from one of the interviews illustrates this: *"... I think that the biggest challenge may be being conscious and thinking of it, and actually doing things for it as well. Because I don't think it's very difficult to implement more of it in my course".* The pilot courses and examples from other programmes aim to illustrate practical integrations of SD in education. These show that the choice of teaching methods is important for the activisation of students and SD competence development, and lower the barrier for action. We also aim to create awareness on the need for a programme-driven approach, in order to succeed in creating a holistic integration of SD, where courses build onto each other in order to meet the curriculum's intented learning outcomes. Through working collaboratively in workshops we intent for the staff to inspire and support their colleagues.

Connect: The main workshops have the goal of providing arenas for discussions and reflections on SD and the own teaching, and creating a shared understanding among the staff, thereby framing the structures of courses, curriculum and their own role as educators with a responsibility towards students and society. Based on the questionnaires and reflections, both the teaching staff and the project team experienced that these activities support collaborative learning on SD for the attendees. The test workshops offered us insights into how the workshop activies shaped these reflections, allowing us to make meaningful changes before inviting all academic staff.

However, in order for connections to be formed, as well as informing, motivating and inspiring the staff, participation in the process is important. A challenge we have seen is a lack of attendance at the workshops, with significantly less than half of invited staff joining some of the workshops, which reduces the effect of the ISE toolkit on the integration process. The underlying reason for an academic staff member to choose

not to attend, can stem from a multitude of reasons. From the interviews and our own reflections from observing the staff, we have indications that a large group of the staff does not prioritize to integrate SD in their courses due to fear for the extra workload, a conviction that SD should be in a separate course rather than in their course, and/or a lack of believe that their field is relevant to SD. Understanding how to overcome these barriers is one of the most important goals moving forward.

4   CONCLUSION

Based on the pilot case, we believe the approach used and the lessons learned can provide useful strategic and practical insights for other engineering programmes in their process of integrating sustainability through involving academic staff. However, one should keep in mind that the ISE toolkit provides guidance for the start of this process, whilst the entire integration process runs over a longer period of time. Next to that, assigning someone for the role of a change agent to lead the process is crucial, together with support from management. All in all, it is the academic staff that makes a transition happen, whereby much effort goes to motivating and inspiring them.

Further steps related to the integration of SD in the curriculum of the Elsys study programme entail the further development and teaching of the pilot courses in 2022, taking up competences for SD in the intended learning outcomes of at least three course in the coming year, including SD in the intended learning outcomes of the study programme, and designing structures that allow courses to build on one another to reach these intended learning outcomes. The long-term goal is to have SD integrated in the complete study programme by 2025. Further development of the toolkit entails incorporating the lessons learned from the pilot case. Next to that, we aim to pilot the toolkit in another study programme before making it publicly available.

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