Synergies between multi-level strategies to better prepare our students for a highly uncertain future

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***Abstract*— As engineering faculties strive to educate students equipped to navigate accelerating polycrises, a persistent challenge is embedding sustainability coherently across curricula at the Faculty of Engineering (LTH) at Lund University. This paper articulates and discusses a contextual, multi-level model that leverages synergies between three complementary strategies: (1) grassroots course development that scaffolds sustainability progression; (2) middle-out program- and LU level efforts to build capacity and confidence in teachers to teach for sustainability, and (3) top-down measures like compulsory training. Examples are provided and opportunities and challenges are discussed. An important aspect is the need for a purposeful coordination between management and "teachers on the floor" to effectively prepare our students for continuous adaptation of the competencies, knowledge and skills needed in an uncertain future.**

***Index Terms*— sustainability, education, strategies**

I. Introduction

HOW do we prepare our students for a highly uncertain future? This question is especially critical and relevant given that our society is currently confronted with multiple interconnected global challenges including climate change, health pandemics, war/conflict and economic instability. Is it fair to expect our students, as our future leaders and decision makers, to bear the weight of dealing with this polycrisis when we cannot fully understand or provide a clear answer to the wicked problems they impose?

In this paper, we address this challenge by focusing on education for sustainable development and organizational change. A brief theoretical background is provided along with a multi-level model for embedding sustainability in engineering education at LTH. We give our own examples, reflecting on the opportunities and challenges observed, and ultimately the need for a combined approach.

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II. Education for sustainable development & sustainability competencies

The following definition of education for sustainable development is given by UNESCO: "Education for Sustainable Development (ESD) sees education as the key to unlocking progress in all the global development goals. It teaches individuals to make informed decisions and take action, both individually and collectively, to change society and protect the planet. It equips people of all ages with the knowledge, skills, values, and ability to tackle issues such as climate change, biodiversity loss, overuse of resources, and inequality that impact the well-being of people and the planet." [1]

Redman & Wiek [2] suggest a framework which puts key competencies in sustainability (the four interconnected planning competencies systems-, futures-, values-, and strategies thinking) as well as implementation and integration competence in the context of other professional, disciplinary, and general competencies. While some of these competencies can be practiced independently, their integration – and practicing them in an integrated way - is key (and thus even highlighted as its own competence). *How can we ensure our students have the opportunity to learn this?*

III. Change theory in a nutshell

Organizational change is difficult and often slow. Reinholz et al. [3] investigated what theories of change were used explicitly in 97 cases of change in STEM higher education. They find that 70 of those 97 cases use one of 8 change theories, with more than a quarter of the cases attempting to build communities of practice [4]. The aim of the latter is to change how people learn together in a community, focused on a domain of interest and in a shared practice, i.e. a cultural theory of change. Kezar & Holcombe [5] suggest that instead of focusing on one theory, it is beneficial to leverage multiple theories of change. For example, knowledge and skills can be built within organizations (organizational theory) by creating networks in which knowledge and experiences can be shared, or where learning can happen together (network theory).

However, there can also be conflicts between different approaches. For instance, if competition between organizations is fostered as a motivational tool (institutional theory, where focus is on status), this can hinder or prevent cooperation and learning from each other (a potential goal from an organizational learning and/or network theory position).

In a study specifically on what hinders Lund University as a whole from systemically integrating sustainability into courses and curricula, Lidgren et al. [6] work with Meadows' [7] leverage points to intervene in a system, and specifically point out the paradigms that we need to address and change: "If teachers believe that they risk receiving criticism for introducing elements of sustainability into their curricula (paradigm: *knowledge evolves through criticism*) and if they believe that they do not have enough knowledge to do it (paradigms: *knowledge should be delivered by experts, inch wide, miles deep*) nor that a university should be teaching value related issues such as how to make the world a better place for future generations (paradigm: *a university is an institution of rationality*) then one will have to provide very strong incentives to empower them to proceed with it anyway."

IV. Context

Although the management structure for education at LTH is complex, a simplified hierarchical structure which fits the purposes of this paper is provided in Figure 1. At the highest level, the Education Board (LGGU) holds responsibility for making decisions on shared educational matters, including developing strategic plans, implementing quality improvement initiatives, determining program structures, and allocating financial resources for education. In the middle, there are engineering programs led by program committees whose leadership usually include teaching and administrative members of staff from various departments at LTH. Courses within each program are created and headed by a single or group of teachers from one of the 17 departments at LTH.

According to Lund University's strategy for sustainable development 2019-2026: "All students acquire knowledge and understanding of sustainable development and how their programmes relate to this and thereby contribute expertise in their future roles in society" [8]. Each faculty is responsible for their own action plans, and one of LTHs objectives is: "LTH is to provide qualified and modern training of architects, designers, doctoral students and engineers who promote the sustainable development of society and higher education" [9]. However, the degree to which sustainability is currently embedded in programs and courses at LTH is unclear and varied.

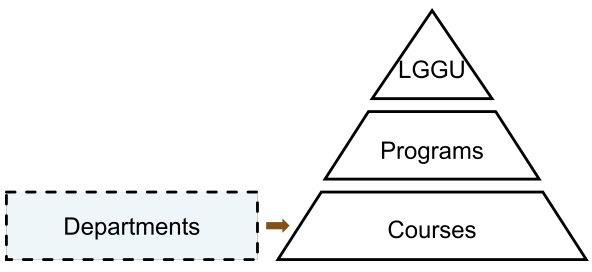

Figure 1. A simplified organizational structure for education at the LTH

V. Embedding sustainability in engineering education – a multi-level approach

A. Bottom-up approach

In a bottom-up approach, changes are instigated by a group of active teachers. These grassroots movements support local transformation of individual or groups of courses and may even extend to an entire program. The changes these movements yield may reflect managerial visions and strategies but are distinct in that they have not been explicitly delegated.

One example of a bottom-up approach at LTH concerns embedding sustainability into an existing course on structural engineering [10]. The course traditionally had relatively low focus on sustainability and we, authors 1 and 2, developed a case-based role-playing seminar focusing on sustainability impacts in structural engineering. Embedded into the initiative was an evaluation phased, which involved critical self-reflection, consultations with critical friends (authors 3 and 4) as well as seminar auditing by author 3 and another colleague. This was the basis for subsequent course developments as well as further collaboration within an extended community of practice [11] (which is described further in the next section). The overall outcome of these activities was a more harmonized integration of sustainability into the course. We also observed that the student engagement was generally high, with meaningful discussions supporting sustainability-oriented learning outcomes.

B. Middle-out approach

A middle-out approach refers to establishing and maintaining supporting structures or units which are in place for teachers who want to develop and transform themselves and their practices, i.e. leadership-approved support for bottom-up grassroot initiatives. Participation is voluntary, although there may be incentives for teachers to join, e.g., to support their own (documented) pedagogical development and improve their practice.

At Lund University, a community of practice has been established which supports *teaching for sustainability* activities for teachers [12-13]. The initiative is led by LU Sustainability Forum's Education Coordinator (author 5) and an academic developer from CEE (author 3). The activities offered to teachers are varied and flexible. For instance, information and inspiration can be sought by reading an active blog, receiving newsletters, or by attending workshops. Teachers can even become active collaborators and contributors in the group, e.g., by writing a blog or giving their own workshops.

One example of such activities at LTH is a collegial course supported by CEE "Teaching sustainability for a circular built environment". We, authors 1 to 3, developed and held the course for 8 teachers from the Civil Engineering program [11]. Participants were required to develop their own courses to increase the focus on sustainability and circularity. Our work was directly supported by the LTH profile area Circular Building Sector (coordinated by author 4) and received financial support from the faculty through a call linked to the "green transition"; although the structure of the course is general

and suitable not only for the building sector. In total, 525,000 SEK was granted to support course development and implementation as well as reward each participant for their time and effort (each received 40,000 SEK). In addition, participants received two weeks of pedagogical qualification. The course was very much appreciated with one teacher commenting that participation in such a course should become compulsory for all teachers at LTH. This brings us to top-down approaches to change.

C. *Top-down approach*

In a top-down approach, focus is on decisions made at higher levels in the organization. These decisions may impose or require changes further down which ultimately influence individual programs and even courses. The exact way these changes are implemented may vary, but these initiatives have the characteristic that they can target the entire faculty, in contrast to bottom-up or middle-out approaches, which rely on voluntary participation.

In this paper, we have no specific example of top-down sustainability embedding strategies. However, there are historical examples of top-down decisions that have influenced teaching and learning at LTH. Examples include teacher requirements in terms of a set number of weeks of pedagogic training (both for employment and promotion) or that students in all programs must take mathematics at certain levels.

Since the key competencies for sustainability need to be taught and practiced in an integrated way, it is difficult to ensure adequate preparation of all students for an unknown future and relying on bottom-up or middle-out initiatives places a lot of responsibility on the initiative and engagement of individual or groups of teachers. In this light, top-down approaches might be considered by leadership to kickstart working towards higher levels of transformation. Possible strategies could focus on teaching staff, e.g., through mandatory training, as well as students, e.g., by making certain courses mandatory. On the other hand, it is important that these initiatives are not seen as something ad-hoc or external to the existing program structure, which also highlights the importance of communicating clearly how they are incorporated. The overarching aim is to support students to think broader and more open-minded, enabling them to make informed and responsible decisions and understand their discipline and its contribution in the context of a complex world. A relevant challenge is in embedding this into existing programs in an effective and meaningful way.

VI. Discussion

In our experiences, bottom-down, middle-out, and top-down approaches have their own challenges and opportunities. For instance, the top-down approach imposes the changes envisaged directly and allows for reaching all the students or teachers. However, there is understandable resistance due to worries about what effects these changes will have on existing courses and programs, workload, resource distribution, and general resistance against imposed changes. The middle-out approach, on the other hand, alleviates this opposition as involvement is voluntary. The flip side is that outreach can be limited, i.e., indifferent, overworked or stressed individuals will not engage. In addition, it may be difficult to realize more ambitious initiatives as these require participants to commit more time and resources. The bottom-up, grassroots, approach is an exemption, as it involves ambitious participants enacting change locally. Changes may be realized in a specific program, but it is unlikely that enough impetus is created to enact meaningful changes throughout the organization. Overall, we feel that a combination of the different approaches is the way forward, leveraging opportunities from each while alleviating some of the challenges. However, it is critical that we are aware of and deal with any unintended and unjustifiable consequences, e.g., in terms of added workload and stress, for both students and teachers.

During the round-table discussion, we will open the floor for you to provide your own experiences and perspectives on these issues, so we can learn together. Your experiences and opinion matters!

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