Finnish Engineering Education for Sustainable Development in 2016

Call for collaborative learning

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INTRODUCTION

In 2008, the National Collaboration Group for Finnish Engineering Education stated that the mission of engineering education in Finland is ‘‘*to benefit people and environment through the provision of knowledge and skills, research and innovations for society and business life”*. To live up to this mission, the Collaboration Group conducted a study on sustainable development in engineering education, and based on the findings, created a proposal for action in 2009 (from here on this report and the proposal for action will be referred to as FEESD, Finnish Engineering Education for Sustainable Development) [see 1, 2].

All seven universities providing engineering education in Finland were represented in the group, so all universities were committed to develop engineering education from the point of view of sustainable development. The project and its results were presented at SEFI 2009 [3]. Now that SEFI will take place in Finland, we return to this project, and discuss the transformations and current status of sustainable development in Finnish engineering education.

This paper is based on interviews and observations that are supported with a review of other studies conducted in Finland analysing the state of sustainable development and higher education. In 2008-2009, we conducted 66 interviews and in 2015, further 15 interviews to update the situation. Interviewees represented the universities,

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government, and industries (employers). Both authors have been involved with the development of engineering education in Finland, and, thus we also use our observations in this study. In addition to the interviews and observations, we utilise documents (university strategies, web sites, and other public documents), and discuss our finding in relation to literature.

We discuss the state of sustainable development in Finnish engineering education both on institutional level (universities) and societal level (engineering community). All in all, the study is qualitative in nature [4].

1 CONTEXT OF LEARNING FOR SUSTAINABLE DEVELOPMENT

Environmental challenges, such as climate change and excessive use of natural resources, social challenges like inequality and extremist movements, instabilities and weaknesses of the economic system, and overall global changes such as digitalization and automatization, have made the quest for sustainable development more topical than ever.

Especially in the field of sustainability science, the concept and idea of planetary boundaries has been strongly advocated since 2009 [5]. Studies on the planetary boundaries analyse quantitatively ecological limits to show the safe operating space for human development. Furthermore, Oxfam's Kate Raworth has presented the "sustainable development doughnut" which adds social foundation to the environmental ceiling formed by the planetary boundaries [6]. This doughnut visualisation can be said to sum up the current mainstream discourse on sustainable development.

Even with the better understanding of the ecological and social boundaries, sustainable development still cannot be defined exactly and unambiguous policies cannot be derived. Sustainable development is complex and contested; it is not a goal, but a process of transformation to a more sustainable society [7, 8]. This transformation process requires collective and collaborative learning [9, 10]. As Sterling puts it, what distinguishes a sustainable future from a chaotic future is learning [11].

2 SUSTAINABLE DEVELOPMENT IN THE FINNISH CONTEXT

In 2013, the Finnish Government decided to replace the traditional strategy of sustainable development with Society's commitment to sustainable development, *The Finland we want by 2050*. The idea is to engage all societal actors, such as companies, municipalities, NGOs, and educational institutions to make their own operational commitments to promote sustainable development. Three of the Finnish universities educating engineers have made a commitment. Lappeenranta University of Technology (LUT) is committed to improving workplace well-being, Aalto University actively supports its partners in their attempts to fulfil their social commitment, and University of Turku is planning to increase the environmental awareness of staff and students by creating an electronic environmental guide [12].

Thus, Finnish approach to sustainable development can be characterized as collaborative. According to Rouhinen, Finnish politics on sustainable development is based on shared expertise and collaborative learning of government together with administration, business life, scientific community, and civil society [13].

In general, Finland usually performs well in international sustainability comparisons [13]. For example, in the Environmental Performance Index 2016, Finland was ranked at the top [14]. Rouhinen argues that even though Finland is considered to be a country of extremely strong engineering, its biggest strength in international sustainability

comparisons are social innovations and social capital especially based on the excellent school system. [13] Despite the excellent scores in many comparisons, Finland still struggles with high energy intensity and material consumption. Thus, we argue that engineering needs to play a bigger role in future aspirations for sustainable development.

3 ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

The World Commission on Environment and Development stated in 1987 that: "*The fulfilment of all these tasks [to solve challenges of sustainable development] will require the reorientation of technology the key link between humans and nature"* [15]. It was also agreed in the FEESD that sustainable development is a crucial part of engineering education, and that all engineering graduates should have sustainability competencies. In practice this entails that they should have a basic understanding of the planetary boundaries and especially understanding of the material and energy flows, and furthermore, understanding of the systemic nature of challenges of sustainable development.

In addition to this content, the most important part of FEESD competencies consist of tools to cope with the uncertainty, complexity and ambiguity, including holistic understanding, systems thinking, communication and collaboration skills, ability and willingness for critical and reflective thinking, creativity, innovativeness, and entrepreneurship.

It is not only sustainable development, but also another megatrend, digitalization that forces us to rethink the curriculum, and above all, the learning environment [1, 16]. The nature of expertise needed by the society and working life is changing. It is quite obvious that above listed skills cannot simply be added as new content to existing courses or by creating new courses. Instead, sustainable development and digitalization challenge us to rethink education all together [11, 17, 18]. Sustainable education emphasizes 'deep learning' (or transformative learning) [see 8, 11]. Thus, the development of learning methods and environments is crucial. As Wals [18, p. 41] argues "*quality of education and a more sustainable world are two sides of the same coin.*"

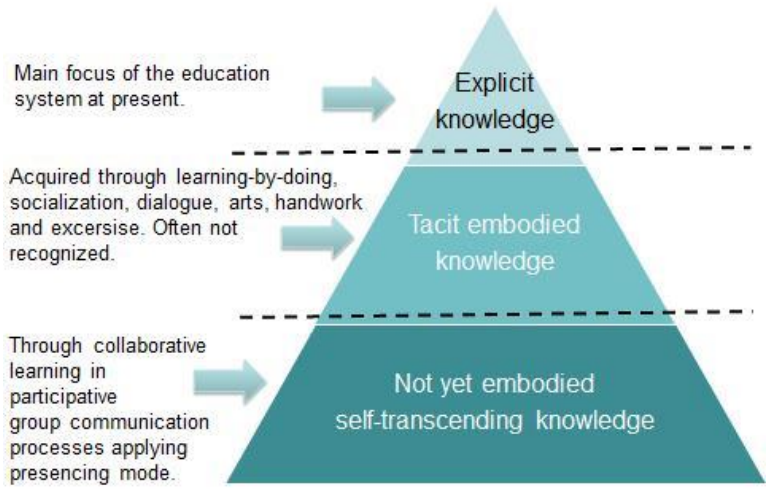

Fig. 1 The focus of university education and nature of knowledge [1]. Nature of knowledge applied from Scharmer [9].

The education system has been designed to serve primarily the distribution of explicit knowledge and to foster the development of individuals as professionals and information retrievers promoting the substance skills of a particular field [19]. The enormous challenge for universities, as illustrated in *Figure 1*, is that digitalization and the nature of complex interdisciplinary problems, including those related to sustainable development, emphasize importance of tacit embodied knowledge and not yet embodied self-transcending knowledge acquired through collaborative learning.

Because of the practical nature of engineering discipline, the engineering profession reflects more than most professions the immediate environment within which it operates [20]. Engineering graduates need to be developed from technical problem-solvers to collaborative creators capable of defining relevant questions, and creating solutions, to complex transdisciplinary problems. The most critical skills shortages are in graduates' abilities related to collaborative learning [1].

In the future, universities need to be inspiring interdisciplinary learning environments including pedagogically skilled teachers that enable individual and collaborative learning. *Figure 2* illustrates an ideal university learning environment from the viewpoint of social and pedagogic aspect, culture, learning space and support services [21]. Combination of architecture and latest pedagogical knowledge are needed to design learning spaces for universities.

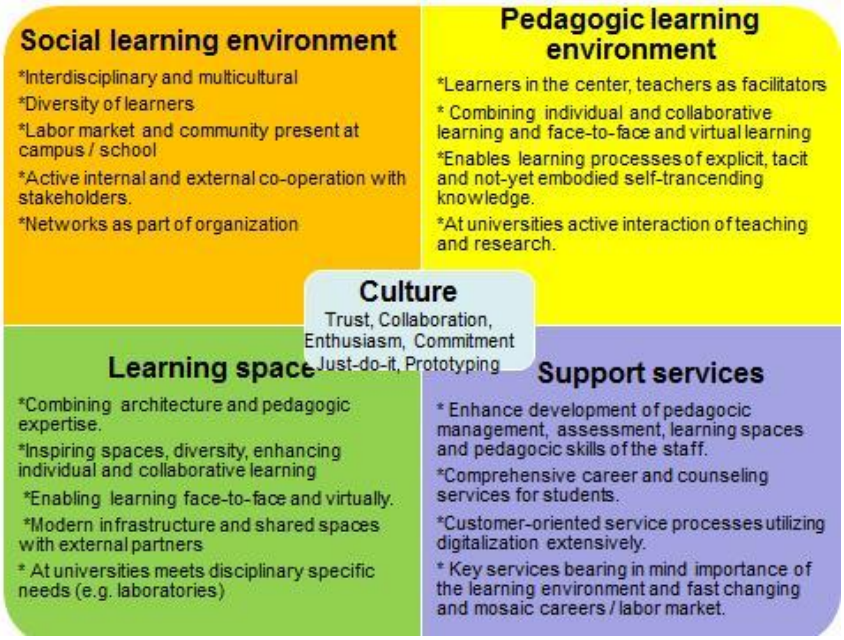

Fig. 2 Ideal university learning environment [21]

It is evident that engineers and technology cannot alone solve complex and systemic problems, like sustainable development challenges. Ideally engineering, humanities, medicine, arts and design are all represented also in the learning community during university studies.

Learning-by-doing and prototyping are an essential part of applied learning methods in the curriculum. Multidisciplinary projects form an important part of studies. The surrounding society - including enterprises, municipalities, associations and NGOs - are core part of university campus ecosystem not only from the viewpoint of research, but also education. They provide real-life case studies and problems to solve and important work experience for students and graduates.

4 CURRENT STATE OF FINNISH ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

So, the UN Decade of Education for Sustainable Development has ended and it has been more than five years since the FEESD was published, it is time to discuss what has happened. We will discuss progress on general level and give some examples from Finnish universities providing engineering education.

4.1 Legitimization of sustainable development

In a keynote address at the 7th Conference on Engineering Education for Sustainable Development, Dr Karel Mulder analysed why sustainable development had progressed so slowly in engineering education although there are no enemies to the cause [22]. Same applies to Finland as well. Everyone seems to agree that sustainable development is something very important and that it should be integrated in engineering programmes. This is, for example, manifested in the strategies of many universities. Tampere University of Technology's (TUT) strategy for the years 2016–2020 states "*Students learn to understand the importance of technology in addressing the challenges of sustainable development and have the opportunity to develop their entrepreneurial skills*" [23]. According to Aalto University's strategy, their vision "*carries a strong commitment to building a sustainable society driven by innovation and entrepreneurship*" [24].

Including sustainable development in the strategies is a significant step forward. One could argue that it shows that sustainable development has been legitimized, and that the university leadership is committed to it. However, it is debatable how well this shows in practice, i.e. how well strategies have been implemented.

4.2 Implementation of sustainable development

Most of the universities' activities seem to be directed towards greening of the physical environment [see also 25]. Lappeenranta University of Technology, for instance, has created a very impressive *Green Campus* that has been internationally recognized [26].

In addition to the progress of greening campuses, universities offer several courses and programmes focused on sustainable development. For example, Aalto University offers an international Master's Degree Program in Creative Sustainability. Campus greening and courses and programmes on sustainable development are very important, as it is important that the physical environment is in line with what is being taught, and as it is important to educate experts on sustainable development. However, these activities are not enough if we want to say that all engineering graduates are competent in sustainable development.

Furthermore, some of the interviewed sustainability coordinators and promoters felt they do not receive actual support or resources from the management despite the fact that sustainable development is strongly present in strategies. The universities do not systematically monitor fulfilment of their strategy on goals and targets related to sustainable development. Many interviewees hoped for more guidance through legislation and financing. Similar observations were made also in a survey conducted among Nordic higher education institutions [25]. The Finnish Ministry of Education and Culture has not enforced the implementation of sustainable development in universities. According to the interviewed official, there are no plans to do this either. Progress on integrating sustainable development would probably be faster if it would be included as a financing criterion. However, taking into account the complexity and dynamic nature of sustainable development, and the autonomy of universities, it is

questionable whether strong guidance would be sustainable in the long run or not. As Nokelainen [27] points out, rigid and formalized strategizing can actually inhibit creativity and working towards shared organizational goals.

4.3 Engineering and sustainable development

According to one interviewee representing university management, sustainable development does not need to be specifically implemented as it is naturally inherent to engineering education. This is a somewhat surprising statement as the more general perspective seems to be that sustainable development is not compatible with engineering education because it is too political and ambivalent, whereas engineering is exact and value-free [28, 29, 30]. Whether or not sustainable development is inherent to engineering education, depends on how you understand sustainable development and engineering; i.e. what is the role of engineering and engineers in a society.

This question is at the very heart of sustainable development. The idea is not to give clear guidelines of what is to be done, but rather sustainable development can act as a catalyst to reflect meanings, and to foster a dialogue [see also 7, 8]. In this case, sustainable development can help us to think anew what engineering is and what it does. The risk is that if one perceives sustainable development to be inherent and built-in to engineering education, it can suppress the dialogue, questioning, and all in all, the learning process.

Sustainable development is not so much about explicit knowledge or technical skills, as it is about values and attitudes, worldview [31]. According to Mulder, it seems that despite all the activities and declarations to include sustainable development into engineering education, the students are drawn into a technocratic identity which is counterintuitive with sustainable development [22]. Cech claims, based on longitudinal survey data of US students, that the epistemic culture of engineering is one of disengagement with the society [32]. The intertwined history of the Finnish industry and engineering education [1] enhances meeting the needs of the industry, but similar concerns related to meeting the needs of society at large, were also raised in the interviews regarding Finnish engineering education. The identity of engineering education is still rather technocratic. Similar concerns apply to doctoral education in engineering sciences, as shown by Naukkarinen [33]. According to her, engineering sciences lack discussion about philosophical grounds.

Academic Engineers and Architects in Finland TEK together with Finnish universities have conducted graduate feedback surveys since 2011 that explore the importance of competencies and also assess how well they have been acquired through the formal education and working-life [e.g. 34, 35]. These studies seem to support the “gut feeling” of interviewees, as it seems that throughout the years, competencies like sustainable development and ethics have been considered relatively unimportant in comparison to other generic competencies, and they have not really been acquired through studies or work-experience. This is a topic that requires further research and more detailed analysis: what is the epistemic culture Finnish engineering education fosters; what kind of attitudes, value systems and world views are enforced; and how are these in relation to higher education in general.

In the interviews, the epistemic culture of Finnish engineering was discussed especially in relation to role of the profession. Several interviewees were hoping that TEK would take a more firm stand on sustainable development, participate more in societal discussion, and communicate more openly on the role of engineering in society.

4.4 Collaborative learning for sustainable development

If we want future engineers to be engaged, understand the societal context and be able to work for sustainable development, collaborative learning process is necessary. Unfortunately, Korhonen-Yrjänheikki maintains that the most critical skills shortage of a Finnish engineering graduate is related to collaborative learning as explicit knowledge and individual learning in clearly defined disciplinary boundaries have been the main focus of engineering education [1].

Transition to the learning mode enabling collaborative learning is a huge change to engineering education. As presented in chapter 3, the learning environment as a whole including the culture, social and pedagogic aspects as well as learning space would need to be transformed. This would require engineering education to embrace continuous open dialogue in the university ecosystem.

Since 2009 progress has been made in the learning environment that has improved quality of education, thus improving engineering education from the viewpoint of sustainable education and collaborative learning. Pedagogic management has been developed. The value of teaching is increasingly appreciated. This is concretely shown in the fact that pedagogical competence is an important recruitment criterion for university staff, and training for pedagogical skills is widely available.

Engineering education research (EER) is more active in Finland. For example, in the beginning of 2016 TUT appointed the first EER professor in Finland. TUT has also made extensive investment to develop the learning space enabling innovative group work, hands-on projects in FAB lab, spaces for start-ups and established companies. Furthermore, multidisciplinary project studies and problem-based learning are increasingly applied. Aalto University Design Factory and Start-up Sauna are examples of leading-edge concepts enabling systemic change towards entrepreneurial project- and problem-based learning.

Aalto University was established in 2010 when Helsinki University of Technology, Helsinki School of Economics, and University of Art and Design merged. LUT has a shared campus with Saimaa University of Applied Sciences and will deepen its' cooperation year 2018 as they establish a common corporate group. TUT aims to merge with University of Tampere and Tampere University of Applied Sciences referred as Tampere3. These new institutional structures enable great opportunities to enhance multidisciplinarity and collaborative learning. However, realizing the potential of the new institutional structure requires shared vision, ability and tools for strategic management as well as extensive open dialogue strengthening community commitment and enabling cultural changes and collaborative learning.

5 CONCLUSIONS

The universities providing engineering education and other actors (i.e. professional organization for academic engineers) have included sustainable development in their strategies and goals. Thus, we can say that sustainable development is legitimized in Finnish engineering education. However, there is still plenty to do to implement these strategies. Furthermore, too rigid and restrictive strategy and guidance can suppress open dialogue, and counteract pursuit of sustainable development.

One of the key challenges is that despite the strategies and goals, education for sustainable development is not integrated in all engineering education, but is considered as a field of specialization. Several courses and modules cover sustainable development, but these tend to be separated from the core of degree programs and are usually optional for students. Furthermore, it is questionable whether this progress

has really changed the epistemic culture of engineering. Engineers today need to handle non-standardized social and technical processes where problems are complex and undefined requiring new ways of combing interdisciplinary knowledge.

We argue that in education for sustainable development, the learning environment and ways of learning are more important than the details of the curriculum. Engineers need to be provided with mental tools to cope with uncertainty, complexity and ambiguity. Key competencies include holistic understanding, communication and collaboration skills, ability and willingness for critical and reflective thinking, creativity, innovativeness, and entrepreneurship. Thus, we maintain that at the heart of education for sustainable development is collaborative learning, encouraging open dialogue and innovation.

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