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Teaching Social Sustainability in an Engineering Context

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Abstract

At the KTH Royal Institute of Technology concerted efforts have been made in recent years to integrate sustainable development into the university's Bachelor's and Master's programmes. While a self-evaluation study conducted in 2012 revealed a significant degree of integration of ecological aspects of sustainable development into KTH's engineering education, teachers and programme coordinators expressed considerable confusion in how to approach the issue of social sustainability. The learning outcomes specified in the Swedish Higher Education Ordinance explicitly state that social aspects of sustainable development should be addressed in all engineering education in Sweden. However, a study conducted in 2013 showed that many of those who participated in the self-evaluation study believed that they did not have sufficient knowledge to address social sustainability issues to a satisfactory degree (Edvardsson Björnberg, Skogh & Strömberg, 2015). As a response to this, a course module on social sustainability, corresponding to 1.5 ECTS credits, was commissioned by KTH-Sustainability, the centralized organization for implementing sustainable development in education. The course module, which is available to all programmes at KTH, including Engineering, Architecture, Industrial Management and Urban Planning, was taught to around 150 first-cycle bachelor students in Mechanical Engineering in autumn 2015. This paper describes the development and implementation of the course module. The main focus of the module, which was developed by a group of teachers drawing competences from different knowledge areas such as social life-cycle assessment, ethics and political philosophy, motivational psychology, behavioral sciences and organizational development, has been to find ways of teaching social sustainability to engineers that make the topic appear relevant and urgent for them in their future occupations, i.e., to make the students identify the link between this topic, perhaps viewed by some as a 'soft' issue, and their engineering skills.

1 Introduction

Scientific and engineering advancements have consistently brought the world higher levels of well-being and led to increased production growth. This is truer than ever since the industrialisation in the middle of the 19th century. Since then many aspects of society and human life have experienced exponential growth. Engineers play an substantial role in the dissemination of the scientific advancements that have brought us the countless solutions that we take for granted.

For this reason it is necessary to provide students with the underlying principles that allow people understand and consider this topic. As engineers design such a multitude of solutions for people, it should be deemed as imperative to integrate and discuss principles of social sustainability in order to ensure that these solutions lead to fruitful societal outcomes.

An example of a highly successful, in terms of dissemination, technical solution is Facebook. Facebook has grown and reached a large user-base within a short period of time and is through an economic standpoint a success story. However, time spent on facebook has been linked to feelings of depression and anxiety due to social comparison (Steers, Wickman & Acitelli, 2014). In a german study of 584 people

from 2013, one third of the respondents reported negative feelings associated to their facebook use. Furthermore they found that passive consumption of content on facebook exacerbates feelings of envy which negatively impact life satisfaction, and their study is not alone in their findings (Krasnova et al, 2011). Facebook has recently gained interest in behaviour and had a group dedicated to researching behaviour and impact on users, that until recently called themselves the "Trust Engineers" (Bejar, 2015).

Yet another reason for why knowledge of these principles is of importance is because they empower the individuals own self-leadership and they can inform team-leaders or managers as to what considerations are necessary in order to ensure a work environment is conducive to employee health and efficiency. The founding dean of Lassonde School of Engineering, Janusz Kozinski states that the most important factor to success as an engineer in today's globalized world is the ability to work in a team. Engineers work, despite potential prejudices, extensively with other people and often with leadership roles. An alumni report at the Royal Institute of Technology (KTH) from 2015, of alumni with 2 years working experience, showed that 48% of them had some form of leadership position at their place of work (KTH, 2015) and a 2006 study of USA's S&P 500 CEOs showed that 33% of them had engineering backgrounds (Spencer Stuart, 2006). These statistics are likely not unique for the United States or for Sweden but show that engineers commonly work with people and may even achieve positions where they have significant influence over other people's daily lives.

With greater knowledge of the principles of social sustainability engineers would be empowered to design and create solutions that deliver value more efficiently and contributes to more positive dynamics in society, as well as be empowered to improve their own leadership and self-leadership.

2 Development of the course module

2.1 Assignment goal and starting points

The project goal was to achieve a 1.5 credit module (corresponding to one week, or 40 hours, of full-time studies) that concretizes the social aspect of sustainability to a broad engineering audience, that is to say that it should be generally applicable and relevant to all engineering disciplines. The starting point was a common definition within the group of the social aspect of sustainability. In literature, there is not one commonly agreed definition of the concept. However, in this project, the concept of social sustainability was agreed to represent the aim for a development towards a society "allowing all people to reach their full potential".

The development group of the module composed of a multi-disciplinary and diverse team, contributing with their own experience and theory, thus facilitating the process of identifying rich and diverse theories and aspects into a cohesive end-product.

2.2 Developing the Intended Learning Objectives

2.2.1 Constructive Alignment

With the goal and definition set, the course module was designed using constructive alignment. Constructive alignment is an approach to course design which aligns teaching activities to the intended learning outcomes (Biggs and Tang, 2011). The underlying assumption is that learning is facilitated by selecting and organizing the teaching activities (instruction and examination) in such a way that they contribute to the achievement of a pre-determined set of intended learning outcomes, which are communicated to and ideally internalized by the students. Consequently, the next step in the development

of the module was to agree upon and formulate a set of intended learning outcomes and deciding on ways to communicate them to the students.

In constructive alignment, the intended learning objectives should be formulated using verbs that clearly describe what the student should be able to do after having taken a course or a degree programme. Often, verbs are chosen that mirror different steps in a learning taxonomy, such as Bloom's SOLO taxonomy (1956). Four learning objectives were set for our social sustainability model. We developed them collaboratively and by using the above-mentioned principles:

1. *Explain* the concept of social sustainability in a global as well as local context, and the way it links to the ecological and economic perspectives of sustainable development.
2. *Discuss* of the concept of social sustainability from an equity perspective, including aspects of inter- and intra-generational distribution.
3. *Reflect* on the engineer's responsibility for sustainable development and give examples of how the engineer's work can affect people's ability to live a good life now and in the future.
4. *Describe* the array of decision-making tools available and discuss their applicability in various aspects of engineering work.

Outcomes 4 and 1 are on a basic level of the learning hierarchy, corresponding to Bloom's categories of "remembering", "understanding" and "applying". They involve basic propositional knowledge of sustainability terminology, facts, classifications and categories, tools, and general principles, as well as being able to identify and organize the three dimensions of the sustainability concept at different spatial and temporal scales. Outcomes 2 and 3 partly reflect learning on a higher level by including skills like being able to analyze various relationships, such as those between inter- and intra-generational distributive justice and between technological development and welfare generation, and synthesize the acquired knowledge by generating proposals for how to improve the social sustainability aspects of a selected technology or technological artefact (see section 3.3 below).The learning outcomes were included in the course memo and communicated to the students orally at the first lecture.

With the learning outcomes in place the team progressed to operationalize them based on the theory behind social sustainability and on pedagogy for learning complex subjects. The process was inevitably iterative, with learning outcomes having slight changes in wording and the operationalisation passing through different phases.

2.3 Developing the Course Contents

Sustainable development – even when restricted to the social dimension – is a complex subject that involves many different aspects related to technology and technological development. Since our task was to develop a 1.5 credit module, a targeted selection of content had to be made. Our selection was based on a set of principles developed by Kember and McNaught (2007).

Fundamental concepts: The module was designed to help the students gain understanding of the key aspects of the social sustainability concept and how to implement "social sustainability thinking" in engineering practice, rather than covering the broad spectrum of issues falling under the umbrella of sustainable development education. In the first iteration of the module, the aspects being identified as fundamental to the social sustainability concept were: operationalisation of the social sustainability concept through a set of social boundaries (Raworth, 2012), which essentially express what resources or capabilities people need access to in order to live good, or fulfilling, lives; the necessity of looking to

fundamental needs for human well-being, rather than cultural adaptations of those needs (Ekins & Max-Neef, 1992); and equity regarding the distribution of opportunities for welfare across spatial and temporal scales, as derived from the Brundtland definition.

Relevance: To ensure that the module felt relevant whilst still giving the entire picture of the concept the module was structured in two parts, one generic and one specific/tailored to the targeted audience group. Furthermore, we related the course contents to current sustainability issues (the newly adopted Sustainable Development Goals, poverty issues and the role of technology in furthering poverty relief, technology's role in enhancing social cohesion/inclusion, etc.) and real-life technical examples, both general and others that were more specific to a certain target audience (development of Fairphone, Hilti's hammer drill, etc...) whenever deemed appropriate.

Meshing theory and practice: Aside from using real-life examples from society and companies, the more specific part of the module contained a case-study (the examination), where the students chose a dynamic or product/service, related to their field of study, and analyze it from a social sustainability perspective with the help of certain tools that were taught in the module.

Challenging beliefs: Kember and McNaught (2007) argue that "if they are to get grips with fundamental concepts of a discipline challenging preconceptions is important". In our module, this was done through two learning activities: a seminar on the individual perspective of social sustainability and a role play focusing on the concept of justice (intra-/intergenerational, distributive/procedural, justice between humans and non-human animals). Both these activities were specifically designed so as to challenge the preconceptions that the students might have regarding happiness, human needs, equity and ethics.

2.4 Setting the Learning Activities

The module consists of two parts with learning activities within each of them. The first part is a generic part that looks similar regardless of where it is implemented, providing a foundation of knowledge in the subject. The second part is adapted to each implementation, and includes the main examination. Furthermore, it can be added a specific lecture (according to preference based on the students' specialization) to the second section that clarifies the link between social sustainability and program area. The generic part includes four activities: The first is an introduction to the subject and its relation to other aspects of sustainability (1 lecture). The second activity is a deep dive into what the personal social sustainability (1 lecture + 1 seminar), based on philosophy of happiness and the lesser known psychological needs of autonomy, competence and relatedness (Ryan, E. & Deci, R. 2006). The third activity problematizes the concept from a global perspective and a justice perspective (1 lecture + 1 seminar). The fourth activity gives tools for how to think about the issue and how the subject can be treated in a structured manner in the context of an engineer (1 lecture). The activities of the first part are also somewhat tailored to the target audience through the use of relevant examples and tools. The Tailored part of the module comprises one lecture and two seminars.

Seminar on personal values: Learning outcomes in the area of Social Sustainability are strongly based on the ability to reflect upon the concept and link it to daily practices. To a large extent the different views on Social Sustainability that exists are based on values. Therefore, it is necessary for the students to detect, discuss and reflect upon the values that are embedded in statements on Social Sustainability, and to find their own approach to it based on their own values. This seminar is designed to make the students reflect upon their values in a proven set-up.

Role play: A new role play was developed to facilitate achievement of learning outcome 2. Role plays can help students broaden their perspectives on issues and are powerful tools for "making the students aware

of the different dimensions that frame a decision making process" (Doorn and Kroesen, 2013, p. 1524). They have been used to teach sustainability and environmental issues to science and engineering students around the world, many times with promising results (Maier et al., 2007; Hoekstra, 2012).

Our role play took the form of a public hearing conducted by a fictitious *United Nations Council on Sustainable and Fair Trade* and focused on ethical issues related to natural resource extraction and waste management in the electronics sector in the imaginary country Baruba. The hearing was led by a board consisting of three students and followed a pre-set agenda with four items to be discussed: justice in an intergenerational perspective, global justice (today), public participation in decision-making concerning sustainability issues, and the social responsibility of the engineer. The role play lasted for two hours and was concluded by a teacher-led general discussion of the issues discussed during the hearing. Before the hearing the students were asked to read a collection of news articles related to the issues covered by the role play.

The module also wished to include a more active learning and experiential learning approach to help the students to connect with the material and gain further insights into its relevance. Active learning appears to improve the learning process amongst students (Segalàs, Ferrer-Balas & Mulder, 2010), (MacVaugh & Norton, 2011). A key element of the module to get a higher degree of active learning is to get theme social sustainability to be something abstract to something more concrete and connected to the student's own personal passions and values.

2.5 Examination forms

The examination was designed as a short assignment aiming at the students to apply social sustainability in their own discipline, supported by the models and tools learnt within the course. Some of the intended learning outcomes (outcomes 2 and 3) was clearly aimed at deep learning (*reflect* and *discuss*). This relates to experiential learning and the related learning cycle (Kolb 2014) where the application of tools and model in their own field corresponds to build new knowledge by active experimentation , practising theories learnt in the abstract conceptualization step in the learning cycle.

Implementing the Course Module – the Case in Södertälje

2.6 Starting Points and Prerequisites

The mechanical engineering engineering bachelor at KTH Telge Campus (in Södertälje) accepted the course module in its entirety for both their second and third year students (a total of around 160 students) The module would be implemented in a particular course ("program-cohesive course") that runs over the entire three years of the program, and is built up by modules. None from the team had any previous experience with the target program or the dynamics and administrative requirements of a "program-cohesion course".

2.7 Adaptation of the Basic Layout

The module was designed for flexibility and adaptability, as a consequence the structure was not modified dramatically. Certain aspects of the lectures were not designed in detail and were created for the module implementation.

The examination and tools were adapted to the program, along with certain success story-examples, in order to become more relevant to the field of mechanical engineering. Due to the large number of

students, a peer-review process for the examination of the assignment, where the students gave feedback to each other in a group of fours students. Furthermore the role playing game's theme was well aligned with the material choice dilemma's of the target group. One support session, for the project that was given to the students as examination, was deemed superfluous for the target group and was removed. Aside from these changes the course was not modified.

2.8 The Outcome

The first implementation of the course module were deemed quite successful for the project group (also the teacher of the module). The module was also appreciated by many of the students with positive feedback such as (freely translated from Swedish):

- To be part of a course with new ideas and learn things that are emotionally important to us as people and colleagues
- Being able to speak out about things that you feel provides a good picture of oneself and others.
- It was interactive. Good combination of lectures and exercises.
- An experience to listen in to other people's thinking. To learn how others perceive the world.

Some learnings that the students' appreciated:

- That everyone has their own strengths and that we all are equal. That compassion for each other is important for a social sustainable future.
- Learned new ways to analyze sustainability issues.
- That there are no answers, only different complex issues.
- To better listen to and put myself in other people's narrative, and understand the other better.
- Finding myself and appreciate myself! Reflecting on the problems in the world and actually look for ways to solve them! To have a sustainable mindset
- I have learned about how social and environmentally sustainable development are interrelated.

Some areas that the students' wanted to learn more about:

- A deeper understanding of the tools and the concept. More concrete information and cases.
- How the various tools are used to analyze social sustainability. A deep-dive in system thinking.
- More about companies that are actually trying to contribute to a better world! As Fairphone etc., give some ideas on how we can embrace and initiate this way of thinking

Suggestions from students on improvement areas:

- The timeframe. It was too limited for me to feel involved in these big issues.
- More information about the tools, so as to have a better understanding when to write the analysis.
- Not having such a wide area. Social sustainability is quite large.

Some amendments, based on own experienced as well as the student feedback, will be done to the course module in the next round. Most importantly, the course assignments will be introduced in an earlier stage due to the short duration of the course module. By this, the students will be aware of on which problem they will apply the concepts, models and tools all along the course, and they can thereby follow the cycle from concrete experimentation and reflective observation (seminars and role play) to abstract conceptualisation (tools and models) and active experimentation (application, at least in their heads) for each step in the course module, instead of only doing active experimentation at the very end.

3 Discussion and Conclusions

The task of developing a course module for social sustainability for engineering students was a challenging one. Social Sustainability is an overarching, global and long-term concept. Therefore, the ability to link it to concrete action and apply it in specific areas is of great importance.

An important aspect of designing the learning activities is to consider the students; their background, pre-understanding of the subject, their motivation. In the case Social Sustainability, one tends to meet a lot of diversity. This is a topic that is by many considered 'soft' and unclear, perhaps in particular in the education of engineers, mostly trained in natural and technology science. This means that the pre-understanding of the engineering students in general is relatively limited. However, this is a topic that is widely covered in the media, and some students may have taken interest in the topic, developing a large engagement and pre-understanding. Also, this is a partly political issue; among the students there may be some that are firmly opposed to including this topic in the education of engineers. In order to get students to build knowledge in this area, the most important thing might be firstly to work with the pre-understanding, helping students to find links to the topic from their daily lives and present world views and handling cognitive conflicts and secondly to work with their motivation and engagement.

We have not used any diagnostics to get a picture of the level of knowledge and its spread. This is an area of improvement, to get a better view on the relative size of the group of student with substantial knowledge compared to the ones with very little knowledge. Also, it can be good to be aware of having one or several strong opponents in the group. To meet these individuals, it can be useful to start off by problematizing the topic and let them express their reservations and doubts, preferably in a peer-process with other students.

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