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Sustainable development for ICT engineering students - "What's in it for me"?

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Abstract

The importance of sustainable development (SD) is hardly possible to refute; however, sustainable development has been a relatively peripheral subject in computer-related engineering educations. Sustainability, with its global and potentially all-encompassing connotations, is still seen by many Information and Communication Technology (ICT) students as a topic of little relevance to their future careers. So how can teachers convince these students that sustainability is a topic that can be both relevant and interesting for them? From the point of view of the student; "What's in it for me?".

In this paper we describe and compare our efforts to plan and teach three introductory courses on SD in three different ICT-related educational programmes at KTH Royal Institute of Technology. The courses were planned separately, but they will be analysed together. We discuss two dimensions that we have found to be imperative in our endeavour to engage our students. The first dimension is to handle the balance between sustainability on a general level versus sustainability as specifically related to ICT. The second dimension is to handle the tension between teaching facts versus an emphasis on students' reflections and/or practicing skills. We argue that overcoming the challenge of making sustainability relevant to the students is central for successfully teaching these courses.

1 Introduction

The importance of sustainable development (SD) is hardly something that can be refuted in contemporary society. SD encompasses global and to some degree abstract issues such as planetary boundaries and human well-being (Raworth, 2012; Griggs, Stafford-Smith et al., 2013; Steffen, Richardson et al., 2015). Information and Communication Technologies (ICT) are one of the most influential instruments presently shaping our societies, and these technologies also harbour the potential for creating opportunities for sustainable development (GeSI, 2012; Becker, Chitchyan et al., 2015). Hence, it is imperative that the future ICT and computing professionals have a thorough understanding of SD.

However, from our students' point of view, these issues can be perceived as distant from their focus on computers and programming. For example, according to a 2015 questionnaire that was answered by all new students at KTH Royal Institute of Technology (from here on referred to as "the university" or

"our university"), the three main reasons for students to apply to our three computer-related educational programmes were: 1) the reputation of the university, 2) career opportunities and 3) an interest in technology and the natural sciences. As to "contributing to a sustainable society", this option was chosen by a meagre 8% of the new Information and Communication Technology students, 6% of the Media Technology students and a dismal 2% of the Computer Science students. Our students imagine their future selves as busy writing code, designing apps or developing media content in their future professions, but not as working with anything related to sustainability. So, how can we get this particular group of engineering students to care about topics such as climate change, ecological crises, overpopulation, overconsumption, resource depletion, energy scarcity, global poverty, inequality etc.? From the point of view of a typical student, we as teachers need to be able to answer the question "What's in it for me?", as well as "Why should I care?" and "What can I do?".

In this paper we describe and compare our efforts to plan and teach three different mandatory introductory courses about SD to three different groups of ICT students at our university. The courses were separately, but we have all faced the same challenges of engaging these groups of students in sustainability issues. Moreover, in all three cases, the course in question constitutes a scant 6 or 7.5 credits out of five-year long, 300-credit educational programme. Furthermore, as these are stand-alone courses (rather than being part of an integrative (Mann, Smith et al., 2008) or transformative approach (Sterling, 2004) to SD), the issues that are raised in our courses might clash with other, dominant narratives within computing such as a belief in an almost law-bound ever-increasing availability of (progressively more inexpensive) computational power (e.g. Moore's law). The challenge for us, which will be discussed in this paper, is how to make sure these introductory courses are perceived as relevant and that they make a strong enough impact for the students to carry the knowledge and perspectives with them throughout the remainder of their education.

2   Background

In 2011, a central decision was made that each Master of Science in engineering (5 years, 300 ECTS credits) programme at our university should include at least a 7.5 credit course relating to sustainability, although the long-term goal is to better integrate sustainability into all parts of the educational programmes. Three of these programmes are related to Information and Communication Technology (ICT): Media Technology, Computer Science, and Information and Communication Technology. As is the case for all programmes at a technical university, after graduating our students usually end up working primarily in research- and technology-heavy industries and in consulting. For these three programmes in particular, this means traditional non-ICT industry companies, large ICT and telecom companies (e.g. Ericsson, IBM, Oracle) as well as a larger number of smaller (primarily) software companies. See table 1 for a short description of the programmes and their respective emphasis on curricula, student group, and job market.

In the Media Technology programme, at the school of Computer Science and Communication (CSC), the course Sustainability and Media Technology (DM2573) was developed by teachers connected to the program. It has been taught as a compulsory course for approximately 70 fourth-year students every year since 2012.

In the Computer Science programme, also at the CSC school, the course Sustainable Development for Computer Science and Engineering (AG1814) was developed by teachers at the school of Architecture and the Built Environment (ABE). The ABE School teaches a large number of sustainability-related courses and can be seen as "external sustainability experts" in this context. The course was given to

first-year students the first two times (2013 and 2014), but has since then moved to the second year (2015), receiving approximately 180 students every year.

In the Information and Communication Technology programme, at the school of Information and Communication Technology, the course Sustainable Development, ICT and Innovation (AG1815) was also developed by teachers at the ABE school. Since 2013, it has been given twice as an elective and twice as a compulsory course. It has approximately 65 students every year.

Table 1: Information about the engineering programmes.

Programme and school	Main subjects	Student group and job market
Media Technology@ School of Computer Science and Communication	The three largest subjects are mathematics, computer science and media-related subjects (all three are roughly equally large).	About 70 students per year. 48% female students in 2015. After graduating, students end up working in traditional mass media and in new media industries.
Computer Science@ School of Computer Science and Communication	The two largest subjects are mathematics and computer science.	About 200 students per year. 14% female students in 2015. After graduating, students end up working primarily as consultants, software developers and programmers.
Information and Communication Technology@ School of Information and Communication Technology	The three largest subjects are mathematics, computer science and finally electronics and computer technology.	About 80 students per year. 23% female students in 2015. After graduating, students end up working primarily as project managers, software developers and programmers.

Even though the three programmes have different foci, they have in common that sustainability has not been a major topic in the curriculum, and that it is oftentimes difficult for both students and teachers in the programmes to see how SD relates to ICT and computing. While SD is well integrated into several educational programmes at our university, the topic is seen as less relevant in other programmes, and it has to be said that the ICT-related programmes belong to the latter category. At the same time, ICT is a strong force in reshaping and transforming our society, and most of our students will end up doing exactly that to a smaller or a larger extent, and, this transformation needs to be sustainable. For example, when alumni were polled and asked about their employment and work tasks 2-4 years after graduation, about 50% of all students from these three programmes stated that their current job involved making assessments of aspects relating to sustainable development.

3   Method

As university-level teachers, we are used to reflect on the courses we give on a regular basis. Course evaluations from students help us rethink, reshape and develop our courses incrementally. In this paper, we have gone one step further. As part of the process of writing this paper, we met regularly to discuss and compare similarities and differences between our courses and between our experiences of teaching

sustainability to ICT and computing students. Through these discussions we honed in on two dimensions that we found to be particularly important in our endeavour to engage our students:

- How to handle the balance between sustainability on a general level versus sustainability as specifically related to ICT.
- How to handle the tension between teaching facts versus an emphasis on students' reflections and/or practicing skills.

Measuring student engagement or the extent to which implemented measures have led to the effect intended is obviously a methodological challenge. For the purposes of this paper, we have used two sets of indicators to gauge student engagement: 1) student feedback through course evaluations and 2) student-initiated extra- or post-curricular activities related to sustainability.

4   Results and Analysis

In the following, we elaborate on the two dimensions of engaging our students, and describe how our courses were designed to address those.

4.1   *General or specific sustainability perspective?*

Sustainability is clearly linked to a global perspective as it concerns issues such as planetary boundaries, climate change and societal development. Knowledge about sustainability on a general level is consequently needed, to impress the students of its importance, and to show the overarching connections between problems and solutions as well as to introduce systems thinking (Easterbrook, 2014). However, if we were to teach "generic sustainability", we would be in danger of losing the interest of our students, as they tend to focus on technology, programming apps and finding solutions to specific problems. Hence, we also need to become specific and to show our students how sustainability can be connected to their specific skills and interests.

In DM2573 (Media Technology), we had at first outsourced the first, smaller part of the course to teachers who were experts in environmental issues and sustainability but who did not succeed to sufficiently connect these topics to computing. The students were very critical and while we outsourced this part of the course once more, we switched to another "supplier". We have since the second year used a modified version of the game GaSuCo (Pargman, Hedin et al., Forthcoming), with partly customized questions related to media technology and accompanied by "insourced" lectures on general sustainability issues (Eriksson & Pargman, 2014). The ratio between general issues and ICT-specific sustainability issues is in the range of 40/60.

In AG1814 (Computer Science), the program coordinator specifically required for the 2015 round, that the course should clearly connect to the students' ICT skills and their future job market and that the course should also have a stronger focus on social sustainability and ethics. A significant share of the course content is clearly connected to software development and to ICT in general. At present, the course consists of a lecture/seminar series corresponding to 3.5 credits and a project module corresponding to 2.5 credits. Only one out of six lectures and two out of four seminars treat more general SD content. The remaining lectures and seminars are specifically focusing on positive and negative impacts of ICT.

In AG1815 (Information and Communication Technology), an explicit request from the program coordinator was that the course should clearly connect SD to the students' ICT skills, future job market, and to ICT innovations. The course therefore has a very limited amount of general SD content. The major part of the course consists of lectures, a group project, and an individual literature

assignment, all addressing SD challenges in different industries or societal sectors where ICT is currently being used, or could potentially be used, for solving SD problems and for contributing to new products and markets.

4.2 Focus on facts versus reflection/practicing of skills?

Teaching at a technical university, an emphasis on objective facts and measurable data are at the heart of education. However, in our analyses of the courses, we have all tried to handle the tension between on the one hand facts (that for the students can turn into surface learning strategies and cramming for exams (Biggs, 2011) and on the other hand reflections on values as well as learning practical skills. While sustainability undeniably involves facts about climate change, biodiversity loss and health in developing countries, it is as a subject simultaneously deeply value laden and pathways to more sustainable societies are inherently normative as well as crypto-political (Baker, 2006), We have tackled this tension with slightly different strategies in our respective courses. In DM2573 we have counterbalanced facts with mainly reflections, while in AG1814 and AG1815 we have focused more on integrating SD into the practicing of skills as a counterweight to a unilateral emphasis on facts.

In DM2573 (Media Technology) the focus on reflection and values is primarily connected to a series of seminars where students have to read texts and reflect on a new theme each week. Each student also contributes to the seminars by formulating and submitting a topical question ahead of each upcoming seminar. The question represents a topic that the student suggests we should discuss at the seminar, and the teachers then chose seminar questions from the list of students' suggestions. Furthermore, students are also asked to submit more personal reflections through home exam questions each week.

In AG1814 (Computer Science), the students are encouraged to reflect on SD goals and values, and the role of ICT and computer science in contributing to those goals/values, mainly through a written self-reflection assignment as part of the project work. The project work consists of developing a prototype and it requires students to synthesize from both general and more field-specific SD knowledge to develop a prototype with the potential of having a high impact in terms of sustainability. This includes considering the problem addressed, materials used, reflecting on the potential uses and misuses of the product as well as global, rebound and other effects.

In AG1815 (Information and Communication Technology), the practice of ICT skills in connection to SD is realized in a group project, constituting around half of the course workload. The project assignments are formulated by companies and research institutes that are either currently active in developing ICT solutions to SD problems or that are interested in exploring such opportunities. A large variety of project assignments have been used in the course but what binds them together is their reliance on students' ICT skills. This approach provides a natural connection to their education but there is also a risk that problem solving and developing ICT solutions happens at the expense of dwelling on SD aspects of the problem.

4.3 Student engagement - indicators of success

In DM2573 (Media Technology), questionnaires have been sent out before, during, and after the course. The replies show that students' relationships to sustainability change during the course; shifting from being indifferent or concerned to becoming more concerned but also towards acting upon that concern. In the final evaluation, the students are generally very positive about the course, as exemplified in the following quote: "Very relevant course and I have enjoyed it. I do however think that the media technology/ICT aspect could have been a bit more central in the course." The quote also

shows that despite having worked hard to connect sustainability to other topics in the educational programme, there is still more to do.

In AG1814 (Computer Science), a questionnaire was sent out after the last lecture in the 2015 course. When asked about "stimulating tasks", 64% of the students answered that they were working with important and interesting tasks and that it was encouraging to work with a specific purpose or goal of the society. "I think this is an important course, and I will always remember what we learnt". However, only 12.4 % of the students answered that the course was challenging in a stimulating way. Maybe it is too early to teach this course in the second year since the students don't have enough knowledge in computer science yet. The students particularly liked the seminars: "I liked the arrangement with seminar assignments and how they were linked to the home exam". "The seminars were a very good opportunity for discussion and everyone had something to say/contribute to the discussion".

In AG1815 (Information and Communication Technology), when asked about the students' sense of "meaningfulness" of the course, about 80% agreed that "I worked with interesting issues" and "I could learn by trying out my own ideas". Students were generally positive about the group project and rated the contacts with industry as stimulating and as good way to practice SD knowledge in relation to ICT skills. Still, only about 50% agreed with the statement "The course was challenging in a stimulating way". It might be that the course contents are not advanced enough and a certain level of ambiguity of having to study SD as an ICT student can also be read into the comment "It's needed, although I don't enjoy it very much. It's good to be introduced to sustainability, regardless of what you study".

4.4   Other examples of extra- and post-curricular activities

In DM2573 (Media Technology), students last year (2015) asked for the seminars to continue also after the course ended. This resulted in regular student-led lunch seminars where different aspects of sustainability were discussed throughout the rest of the semester. There has also been a significant increase in interest to write both bachelors' and masters' theses about sustainability-related topics from both DM2573 and AG1815 students.

Older students often become engaged as teaching assistants in software programming courses. This has been tried once in one of our courses when a student from AG1815 worked as teaching assistant in AG1814. We see this as an excellent way for older students to act as role models for younger students and this may hopefully contribute to engaging the students in the topic. Furthermore, a possible sign of long-term impact of these SD courses would be when students end up working with problems relating to SD in the ICT sector. One examples of this is a student from DM2573 being part of a green energy start-up company, Greenely[1]. Another example is a former student returning to AG1815 after graduation to supervise course projects, but this time representing her new employer.

5   Discussion

We have elaborated here on how we, in three introductory courses, have met the challenge of engaging students studying ICT and computing in the topic of sustainability. We have in particular focused on two different dimensions; 1) how to handle the balance between sustainability on a general level versus sustainability as specifically related to ICT and 2) how to handle the tension between teaching facts versus an emphasis on students' reflections and/or practicing of skills. There are several other tensions that arise in sustainability education (Pargman & Eriksson, 2013), but we have found these two the most interesting to explore in unison.

[1] https://greenely.com/

We stress the necessity of meeting the students where they are, emphasising the connection between ICT and sustainability. Something to be aware of is however that this emphasis could potentially dilute the importance of sustainability in its own right, if the learning activities and lectures become more inspirational than connected to larger sustainability concerns. We also hasten to add, that even if we have highlighted meeting the students where they are, it is equally important to prepare the students for their future professions, for example linking sustainability to system development project processes.

There are also some significant differences that could be mentioned when comparing these three courses. As teachers, we have different (disciplinary) backgrounds. Three authors have a background in computing and have moved towards sustainability, while the other two authors have a background in environmental and sustainability fields and have moved in the other direction. Working with the paper, we have noted an interesting element of "overcompensation"; some authors with a background in computing have felt the need to read up on and emphasise sustainability, while another author with a background in environmental strategies instead have felt the need to put in effort to display her "street cred" when it comes to IT development (showing that she understands key concepts and can use industry acronyms competently). This has led to the course given by the computing teachers (DM2573) has a stronger emphasis on the importance of sustainability in general than the other two courses.

Finally, it is possible to raise the discussion to a more general level, and ask what the mission and goal of these courses are. Here, a minimal goal is to formally fulfil the degree objectives for engineering educations that are established in the Swedish Higher Education Ordinance. However, we as teachers are invested in sustainability and believe there is more to the subject than the relatively general formulations of the Ordinance. We have all strived to make sustainability relevant, and to make our courses meaningful and engaging for these particular groups of students, i.e. we have gone into clinch with the question in the title of the paper: if students (justifiably) wonder "what's in it for me?", we all strive to make it relevant for them in our respective courses.

However, it is possible to aim yet higher, and the next level would be to strive for "impact". Taking into account that our courses constitute only 7.5 credits in 300-credits (five year long) engineering programmes, can we aim for having an impact above and beyond the small "footprint" of our courses in the larger curricula? How can we encourage students to carry questions related to sustainability with them to the other courses they study (for example querying or challenging other teachers), to their thesis projects, to their work life and perhaps into their personal lives? Furthermore, yet a higher aim would be to educate and encourage students to themselves become sustainable "change agents" in the various contexts that they will later encounter (both in working life and in their private lives). This is however a high, and perhaps not fully realistic goal, to reach for in just one short course. A more practical goal in the here-and-now then, could be to strive to influence other teachers to incorporate issues relating to sustainability into their courses (for example by making connections to the UN SDGs) and working towards better integrating sustainability into the educational programmes - rather than only setting aside one single course "where everything should happen".

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