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Integration of sustainable development in sanitary engineering education in Sweden

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In the Swedish Act for higher education, as well as in the policies of technical universities, it is stated that sustainable development (SD) should be integrated into engineering education. Researchers argue that SD needs to be integrated into the overall course content rather than added as a specific course. In this paper, six engineering lecturers have been interviewed to give their views on how SD can be integrated into teaching water and sanitation engineers. Engineering lecturers seem unsure how to interpret SD in relation to their own specific courses. Students are said to request technical knowledge rather than fuzzy ideas of SD and lecturers struggle to open up the teaching to more problem-based perspectives. Sanitary professionals in work practice relate to SD as a core in water treatment processes and regret that responsibility for SD issues fall between traditional departmental structures in society.

Keywords: sanitary engineering; sustainable development; EESD, engineering education

1. Introduction

Engineers within municipal water and sanitation organisations in Sweden acknowledge that the core of their work is sustainable development (SD), although they admit confusion about definitions of the concept. They take on a large responsibility for SD in general and sustainable water and sanitation technology in particular (Palme 2007, Rydhagen *et al.* 2008).

Responsibility for SD is also expressed in the educational system training sanitary engineers. The Swedish Act for higher education states that all universities shall promote sustainable development (SFS 1992:1434). For technical and engineering degrees, it is specifically stated that the students shall show ability to design and handle processes and systems with regard to society's aims for SD (SFS 1993:100).

The aim of this paper is to discuss relevance, possibilities and difficulties with integrating SD in engineering education with reference to individual lecturers' and engineers' experiences. A further aim is to contribute to a discussion about what engineering students need during their education in order to be prepared for future work and how this can be implemented. The study is limited to sanitary engineering at Master level.

2. Background and related research

2.1 Future work responsibilities of engineers

‘Engineering is not as much about technology as we tend to think. [...] It is more about understanding the task, realizing the context... in short – to take responsibility for your practice’ (Backlund 2006, p. 191; present authors’ translation). In engineering, the connection to societal questions is close, since technologies are developed to meet different needs and solve problems in society. Social studies of technology show the interdependence with society during both development and implementation of socio-technical systems such as electricity and urban water (for a comprehensive overview, see Hård and Jamison, 2005, for the specific sanitation perspective, see Hegger 2007).

Several researchers argue that a responsible way of working as an engineer ought to be more proactive and innovative, not merely improving efficiency in existing artefacts, infrastructure and systems (Ashford 2004, Mitchell *et al.* 2004, Fokkema *et al.* 2005). Stakeholders need to be involved early in different processes of planning and decision-making in order to achieve changes.

2.2 Sustainable development as an epistemological base in engineering education

The Swedish Government has, in line with international agreements, introduced SD in the education system at all levels. In the integration of SD within higher educational programmes such as civil engineering, it is pointed out that sustainability is not a specific subject, but an integrative principle (Mitchell *et al.* 2004). According to Mitchell *et al.* (2004), SD requires a new way of thinking about engineering work, opening it up for the inclusion of values, participatory decision-making processes and openness about uncertainties. Taking future generations into account necessitates reflection about priorities and choices of paths to move along in technological development. *‘If engineers are to contribute truly to SD, sustainability must become part of their paradigm and affect everyday thinking’* (Holmberg *et al.* 2008, p. 272).

2.3 Educational structure

Today, engineering education is rather compartmentalised, which may result in engineers searching for narrowly defined problem solutions (Ashford 2004). SD has, in this context, been introduced into specific courses added to the curriculum. In these courses, definitions and

different aspects of SD can be discussed and related to examples relevant to the students' fields of interest. According to Kelly (2008), this kind of special course will be necessary for a transitional period, while the ideal is that the concept becomes fully integrated into engineering courses. Special SD courses often differ in teaching methods, examination and epistemological approach compared with main engineering courses. As a result, students may complain that the courses are fuzzy, that lecturers are biased and that problems without solutions are presented (Lundholm 2004). Lundholm suggests that lecturers need to be clear about the values behind their choice of examples and the theoretical frameworks need to be clearly related to practical examples with direct connection to professional and day-to-day activities of the students.

2.4 Respons(ibiliti)es at universities

From a lecturer's perspective, it is important to have a long-term commitment from the organisation in order to legitimise the development of course content related to SD (Holmberg *et al.* 2008). This means resources need to be allocated to learning processes among lecturers to develop SD competence. Individual lecturers need to be recognised as sources of knowledge when SD is introduced as an aspect of different subjects. In this way, lecturers within their specific subjects can develop their courses in dialogue with SD resource persons within the university. Holmberg *et al.* conclude that the responsibility needs to be spread among a majority of lecturers, although there needs to be skilled resource persons available in a permanent structure.

With reference to the inclusion of philosophy in engineering programmes, Hyldgaard Christensen and Ernø-Kjøllhede (2008) found that, although Danish engineering lecturers in general are positive towards the inclusion of subjects such as philosophy or ethics, there are few concrete examples of how to do it and who should do it. Melin Emilsson and Lilje (2008) even identified lecturers who were unwilling to give up technical courses in favour of courses addressing social competence such as group interaction, personnel management or budget work.

An important aspect found by Melin Emilsson and Lilje was that lecturers in higher engineering institutions rarely have an active connection to work practice. Some have been practising engineers, but many remain in the education system as lecturers right after graduation. They therefore lack experience of necessary work skills outside the purely technical problem-solving area (*ibid.*).

3. Method

The paper is a qualitative study, built on interviews with lecturers at two technical universities in Sweden, offering programmes for sanitation engineering, and with sanitation professionals in two municipalities. The presentation of sanitary engineering programmes at six official university websites has also been analysed.

On the websites, the front page for the university, the programme page for sanitary engineering and a number of course pages within sanitary engineering programmes were searched for core values appealing to potential future students. The websites were different in their set-up and the programmes including water and sanitary engineering courses were named differently. This made the comparison incomplete, but the core values as they appeared on different hierarchical levels on the official websites provided a background to the interviews with individual lectures.

The main focus is interviews with six lecturers; two made with lecturers in pairs and two individual interviews, at two technical universities. The selection of lecturers was based on their different involvement in the sanitation engineering education, including four who work with courses in water treatment and sanitary engineering for civil engineers (two at each university), one programme manager and one lecturer with involvement in SD courses for engineering students. In addition, sanitation professionals were interviewed in two municipalities, where there were two different pilot projects for sustainable sanitation. Focus groups were done with four professionals in each municipality.

The interviews with professionals raised questions about responsibility for SD and about communication with households. The interviews with lecturers raised questions about the meaning of the concept of SD, the inclusion of SD in courses and education programmes and attitudes among students. All interviews lasted 1-2 hours, were recorded and transcribed. During analysis, common themes in the interviews were identified to exemplify themes raised by the participants in response to questions about SD related to sanitary engineering.

4. Results

4.1 What engineers actually do

In the focus group interviews in two different municipalities, professionals refer to SD as an aspect of their work, relating to maintenance of water as a natural resource and to the use of energy and chemicals in treatment processes. Social dimensions are mentioned as an aspect,

requiring communication with users. In the smaller municipality, one of the engineers defines work tasks in broad terms, ranging from management of pumps to agricultural policy. Their pilot project is an intensified information campaign to a limited residential area to evaluate the effects of increased communication with householders. In this municipality, the professionals claim to be proactive in SD issues by interacting with, for example, environmental inspectors in campaigns. They are actively promoting eco-labelled products to consumers and negotiating with retail stores about harmful household chemicals. In the larger municipality, the professionals define their work more technically, claiming that it is beyond their work tasks to act in policy issues. Their pilot project is source separated collection of blackwater (toilet water) for nutrient recycling without particular communication with householders in the residential area concerned.

In both municipalities the professionals take part in negotiations on regional and national level on issues that affected their treatment processes, although they are ambivalent about their role. The senior professional in the larger municipality summarised the dilemma of SD in society as follows: *'Sustainable development - the institutional structure is not made for that, there is a drainpipe structure and with sustainable development, issues falling in between arise'*.

4.2 Recruitment through the web

In the recruitment of students, most technical universities in Sweden refer to SD and to holistic approaches in general and programme-specific web information. A multifaceted work situation is described and knowledge about technology as well as societal aspects is requested, according to the information.

On one website, the civil engineering programme is presented as focusing on the interplay between humans, environment and technology (www.lth.se). Similar formulations are used by another university, which also stresses the need to provide knowledge contributing to SD of society (www.chalmers.se). At a third university, the education is characterised as a: *'holistic view where all different aspects on constructing a sustainable society are included'* (www.teknat.uu.se). This is specified to address collaboration between different stakeholders. Close collaboration with industry and other potential employers is marketed by a fourth university (www.ltu.se). Presentations and work in projects are also brought up as important aspects of the studies.

The universities selected for interviews differ in their emphasis on SD. University A highlights traditions and new technologies, while University B has a well-developed SD policy centrally placed in their presentation material.

4.3 Perspectives from lecturers: Engineering in focus

Lecturers A1, A2, B1 and B2 teach courses in water and sanitary engineering at universities A and B respectively. Interviews were conducted in pairs.

4.3.1 Definition and integration of SD

The lecturers regard work with water and sewage as SD *per se* and talk of SD mainly in terms of environmental aspects. B2 specifies the reduction of chemical and energy use in water treatment processes as an aspect of environmental sustainability, although economic aspects are also central. A1 and A2 interpret their work to be in the realm of technology and see the importance of the students having thorough technical knowledge. When asked about social and economic dimensions, they point out that they work with technology and not with aspects of society as they, as engineers, cannot be proactive or influence society. A1 is reluctant to introduce the concept of SD into the education, since technical training is of main importance. *'I think it is easier to understand SD if you are a good engineer than to solve the problems of sustainability without understanding the technology'* (A1).

4.3.2 University and individual efforts

The education programme where A1 and A2 teach is described as put together from courses that can be offered depending on competence among lecturers, rather than from an idea of the programme as a whole (A1). From the interview with A1 and A2, it is understood that the integration of SD is not coordinated within the educational programme and that the university board does not have an overall strategy for the integration of SD in education.

Lecturers B1 and B2 explain that their university runs a project for integration of SD. Because of this there has currently been a lot of talk but, so far, SD is not integrated in courses. Both lecturers express uncertainty about the concept and how to apply it into their respective courses.

B2 expresses bad feelings for not having integrated SD in her courses. According to her, the concept of SD is difficult, as it is very wide and says she wants discussions more closely

connected to the field of water engineering. The lecturers emphasise they need assistance from experts.

4.3.3 Students; expectations and responses

It is the lecturers' experience that students regard engineering as pure calculations. A2 describes a need to teach the students that equations do not describe the truth, but are tools to solve problems.

B1 and B2 argue that students do not ask for aspects of SD in courses. On the contrary, students express a view that SD is fuzzy and they are '*afraid their education will become eroded and that they do not learn enough to become good engineers*' (B2). According to B2, the students do not know enough to understand the importance of SD, but will as they mature. A1 however assumes that the students will be quicker than the university system to find their ways to integrate their adequate competences.

4.3.4 Work definitions

Lecturer A1 claims that his most important task is to train competent engineers who can do advanced calculations in order to solve technical problems, but the engineer also needs to be able to communicate with other professionals. Communication with water users is, however, not regarded as important. '*They will have to learn that at work if they need to*' (A2).

The municipal water and sanitation office has complained to lecturers that the knowledge of what work in a municipality might mean is very vague among the students. The lecturers also worry that the students are not interested in issues such as treatment processes and effluent control programmes. They invite guests from municipal offices or do study visits to give the students more concrete pictures of what sanitary engineering work could be.

4.4 Perspectives from lecturers: Broadening the perspectives

Lecturer A3 is manager of a program educating environmental engineers including water and sanitation courses. B3 teaches the environmental course that is compulsory for all engineering students. She is not an engineer by training. A3 and B3 were interviewed individually.

4.4.1 Definition and integration of SD

Lecturer A3 says that environmental aspects are part of the curriculum today, and in the coming curriculum economy will be compulsory, but that social aspects are still neglected. A3 has

ambitions to integrate social aspects in a better way and, in his courses, he tries to bring up real-life examples for discussion. At the same time he admits that it is easy to leave the responsibility of integration of SD with lecturers who run the compulsory course in environmental studies. He also says that many colleagues have the opinion that, with the compulsory course, integration of SD is done.

B3 describes her definition of SD as a concept starting in environmental problems but including economic and social dimensions. She finds it important to discuss values as an intrinsic part of the concept. She knows that many lecturers find the concept problematic because of its supposed relativism and that they find it difficult to handle values in the educational situation.

4.4.2 University and individual efforts

Lecturers A3 and B3 refer to the paragraph of SD in the Swedish enactment of higher education when relating to the efforts at their universities. A3 admits that little has been done at university A. According to B3, university B currently runs a project to integrate SD in all educational programmes on programme and course level. Seminars and discussions on SD are held for all lecturers at both universities, with efforts that relate to the different subjects. A3 and B3 claim that, in reality, the responsibility for changes falls on the individual lecturer. A3 argues for specific courses in SD, saying that: *'the risk is that we distribute it here and there and in the end there is nothing'* (A3). Many lecturers clearly state that SD does not belong in their course content, according to B3.

4.4.3 Students; expectations and responses

Students are said to focus on narrow technical knowledge, and to fear open-ended questions requiring discussions and motivations of integrated answers. It is, however, the task of the lecturers to challenge this attitude. A3 says that students are brave enough to discuss and argue when issues like SD are raised.

B3 says her course is very different from the other first year courses. and that the students appreciate the course. In her teaching, the concept of sustainable development is central and the focus is discussions and problem solving. Her experience is that students use the word 'fuzzy' to describe courses where values are discussed and where there are no given answers.

4.4.4 Work definitions

Lecturer A3 argues that engineers need competence not only in engineering but also in communication and user participation activities, since many future work positions will involve this kind of work. The future work arena for civil and environmental engineers is very diverse, according to A3.

For B3, SD with all three dimensions is essential for an engineer in her/his work practice, but *'I believe that the engineer first of all needs to be "a good engineer"'*. Even if they do not have all the competences, they will need to collaborate and understand other professionals. In working life, professionals regard communication with users and other stakeholders as a natural task, according to B3.

5. Discussion

The Internet-based university information about engineering education in Sweden referred to above seems to be in line with the work descriptions given by professionals. Future students are expected to be attracted by holistic work processes combining technical expertise with consideration of other aspects leading to a sustainable building of society. On an overarching university level, the ambition seems to support the integration of SD into the education of engineers. Professionals likewise relate to rather broad work descriptions and to SD as integrated into their work (Palme 2007, Rydhagen *et al.* 2008). It was not deliberately chosen but a necessity since SD did not belong to any particular (other) department and since their work required diverse approaches.

Although websites indicate that SD or related aspects permeate the programme, it was found that the interviewed lecturers gave a picture of a fragmented responsibility. The engineering lecturers A1, A2, B1 and B2 seemed insecure and confused about the process of integrating SD. At both universities, engineering lecturers lacked confidence in the meaning of SD and insight into how it is presented in the education as a whole. Similar to Lundholm's (2004) study, interviewed lecturers expressed reluctance to impose a fuzzy concept on students, who, they claimed, want concrete and exact knowledge that they identify as necessary to become good engineers. Lecturers A1, A2, B1 and B2 also expressed a traditional view of engineering as something separate from society and social issues. This was partly confirmed by professionals in the larger municipality, who were reluctant to extend their responsibility beyond the technical field.

Lecturer B3, who teaches broader subjects, said although students use words such as fuzzy they appreciate the opportunity to discuss and compare thoughts. Obviously, the student group is heterogeneous, but the scepticism towards non-technical course content is also dependent on the way ideas are presented by individual lecturers as well as within the programme as a whole.

According to the researchers referred to above, technologies and engineers are an important part of social development and contribute to the shaping of society. Training engineers to be proactive and taking on responsibility in society will increase their competences in future work situations in times when even sanitation engineering is contested in public debate. Interviewed professionals showed an ambivalent attitude but confirmed participation in policy negotiations. This competence was also partly recognized by lecturer A3, who attempts to integrate economic and social issues into courses. Collaboration with municipalities and companies, which some lecturers and universities give examples of, is one way to prepare students for their future work. This is especially valuable if most lecturers lack personal work experience outside the universities, as Melin Emilsson and Lilje (2008) found.

The present authors' experiences of integrating gender into education programmes show many similarities with the integration of SD. When a new concept is introduced, it is assumed that it will steal time from other courses. It may be necessary to introduce concepts in a specific course for a transitional period, as Kelly (2008) argues, since the understanding of the concept is not widespread and needs deepened reflection. More important, though, is the way the ideas are integrated into each course, influencing ordinary teaching in ways that open up technical courses to discussions about the meaning of what is taught, possible conflicting interests, etc. It is particularly argued that preparation for a complex and varied work situation requires varied student-centered pedagogical methods such as debates, role play, project management and media review.

In this case, education programmes seem to be put together by a selection of courses offered by lecturers or departments with limited communication or collaboration between them. The interviewed lecturers (with the exception of the programme manager) were unable to give an overview of the programme, indicating that they were responsible only for their own limited parts of the programme.

Integrating a concept such as SD, which ultimately changes the way that knowledge production and learning processes are regarded, will require a more collaborative process and discussion, in order to inspire others and share practical examples and to allow lecturers to discuss and deepen their own understanding of the meaning of SD in their particular subjects. Collaboration between lecturers within the programme is also necessary to create a joint idea of what it means to be an engineer and how this could be mediated in an attuned way to the students during their education.

As Holmberg *et al.* (2008) argue, this kind of thorough reform requires a permanent commitment from the university board, not only stating what should be done, but also to allow time and resources for lecturers to create periods for their own learning process.

6. Conclusions

In this study, it was found that lecturers teaching water engineering for sanitary engineering students express confusion or insecurity about the concept of SD and how to integrate it into the technical courses. Likewise, professionals relate to the concept, but adapt practices to its wider definitions with varying enthusiasm. Their recognition of the inadequacy of the institutional structure in society in handling SD-related issues indicates a need for reforms in division of responsibilities in society and among professional groups.

It is the present authors' understanding that the integration of SD into engineering education requires a change in epistemological values. Education needs to open up for reflection and discussion, both for deepened understanding and as a preparation for future work, which in many cases involve complex stakeholder negotiations and decision-making. Images of what it means to be an engineer ought to permeate the education programme and individual courses. This development of engineering education will require long-term commitment at all levels to allocate time and resources for learning, reflection and collaboration among lecturers and with practising professionals.

For further understanding of the complexity of introducing SD into engineering education, it would be of great value to study the perceptions of students before, during and after engineering studies. Lecturers and researchers refer to the students' attitudes and assume what they need to know as engineers. Students' worries about fuzziness of SD education may not be regarded in the same way after graduation. A more updated and systematic study of students' perspectives would contribute to successful and meaningful integration of SD perspectives.

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