Sustainable Development in Nano-Perspectives – An Innovative Student Initiative

Johanna Lönngren, Andreas Ahrens, Knut Deppert, Greger Hammarin, Elisabeth Nilsson

Lund University, Faculty of Engineering (LTH)

Abstract

This paper describes and discusses a novel class for sustainable development at the faculty of engineering at Lund University, Sweden. Based on personal experience and student questionnaires, the study discusses applied pedagogical approaches (case study, role play, matrix approach) and suggests improvements to the structure of the class. The project is a student initiative, making student involvement and its effects on learning for sustainable development central topics of this paper, thereby challenging the notion of engineering students as passive receivers of education for sustainable development.

Introduction

With sustainable development being one of the most important and most discussed topics of the time, education for sustainable development (ESD) is a fast growing discipline, recently supported by the UNESCO's declaration of the 2005-2014 Decade of ESD [1]. In Europe, the restructuring of higher education programs in the wake of the Bologna reform [2] has offered valuable opportunities for higher education institutions (HEIs) to introduce ESD into program curricula [3]. However, ambitions vary greatly among the different HEIs. One of the most positive examples is Chalmers, a university of technology in Göteborg, Sweden, where ESD initiatives have been backed by the top management of the school and where common guidelines for the introduction of ESD have existed for several years [4,5,6]. This paper focuses on an innovative class developed through a student-led initiative at the faculty of engineering at Lund University in Sweden (LTH). The class is part of the compulsory course work for third-year students within the program Engineering Nanoscience at LTH.

Recognizing the special challenge (and importance) of introducing ESD into engineering education [3], the authors have developed a class based on nontraditional teaching methodologies [1,7,8]. The class "Sustainable Development in Nano-Perspectives" is based on a case study in combination with role play activities. Students represent a variety of societal stakeholder groups while trying to create a roadmap for sustainable development for a given case project, this year's case being the planned construction of ESS (European Spallation Source), a €1.5 billion scientific complex in Lund, Sweden. The class is structured according to a "matrix" approach with stakeholder groups and interdisciplinary groups. This approach is reported elsewhere to facilitate intensive group interactions with cooperation, communication and compromise, while also ensuring individual activity and commitment. Furthermore, by interaction within the different groups, students are forced to shift perspectives [8]. In an iterative process, culminating in a 24-hour general meeting, the groups negotiate a common roadmap for sustainable development (SD) in relation to the case they were given to study. Directly thereafter, the students defend their work at a simulated press-conference which is rendered possible through collaboration with the Department of Journalism at Lund University. All activities are mandatory.

With this class structure, the authors are hoping to "train the students in critically reflecting about their role within and their influence on the society in which they are active, and to thus enable them to work for a sustainable development" [9]. This process is often called "transformative learning" in ESD literature [10,11].

Our experiences with above described approaches, based on direct observations during class activities, standardized as well as non-standardized student evaluation documents and direct student

feedback, are fundamentally positive. Still, we have learned a number of important lessons which we want to share with the ESD community in this paper. These lessons concern mainly how to facilitate a shift of perspectives without creating too much frustration, the importance of clarity and motivation, as well as the effects of student involvement.

Methods

The project described in this paper was born out of a student initiative and was originally not intended to be a scientific project. Throughout the project, however, the authors have become increasingly aware of the project's significance – for practical efforts of integrating SD into engineering education, as well as for the emerging academic discipline ESD. The nature of this study is therefore mainly conceptual: The authors' experiences while teaching the class are described, and qualitative data obtained directly afterwards is used to offer valuable insight for those who might be interested in applying similar pedagogical approaches.

The authors have developed the class during a period of approximately three years, including activities as diverse as lobbying for the inclusion of the class into the mandatory course work, designing the teaching methods, contacting potential lecturers, discussing lecture contents, designing a case and formulating stakeholder group descriptions, etc. In addition, the authors have also taken on the responsibility of supervising and assessing the students. This continuous and close contact with the project, the lecturers and the students has offered extremely valuable subjective insights about the applied pedagogical approaches.

The subjective insights are here combined with more objective data. The main source of objective data is the official report from the Course Experience Questionnaire (CEQ), a standardized, anonymous evaluation form which is distributed online to students at LTH after the completion of each class. Unfortunately, only 24 students (57%) filled out the CEQ [12]. This low response rate gives low significance to the answers and low validity to conclusions drawn exclusively on the basis of these data.

In an effort to achieve higher validity, CEQ data will here be complemented with data from a written (anonymous) feedback from 41 students (98%) and an oral (non-anonymous) feedback from 42 students (100%). This written feedback was collected in specifically designed evaluation forms which were distributed directly after the simulated press-conference. The oral feedback was given during a concluding discussion and reflection session the day after. Statements from each of those sources were sorted on the basis of a simple content analysis**.**

Perspective shift without frustration

> *"Education for sustainability, above all, means the creation of space for transformative social learning. Such space includes: space for alternative paths of development; space for new ways of thinking, valuing and doing; space for participation minimally distorted by power relations; space for pluralism, diversity and minority perspectives; space for deep consensus, but also for respectful disagreement and differences; space for autonomous and deviant thinking; space for self-determination, and; finally, space for contextual differences."* [11]

According to many scholars of ESD, conflicts, pluralism of thought [11], and even "disorienting dilemmas" [10] are prerequisites for higher learning and ESD, since it is necessary to "critically reflect on your knowledge and experiences, continuously question your assumptions, beliefs and values, and act accordingly in your personal life, professional life and community life" [1]. Scholars also seem to agree that the most important lessons for students to learn are generic skills, attitudes and values, because sustainability is seen as a "social learning process rather than as expert predetermined and teachable products" [11]. For achieving this ambitious goal, new pedagogical approaches, such as those applied for the class "Sustainable Development in Nano-Perspectives", are embraced and supported within the ESD community [4,7,8,10]. Even the students express their approval in the written course evaluation: *"It is easier to learn about SD by discussing and reflecting on the subject than by reading a textbook."* and *"We had to rethink instead of simply studying facts about the environment."* The students also mentioned that this active form of education has improved their learning: *"Learning slipped in automatically."* and *"I don't think I will ever forget what I have learned in this class."* At the oral feedback session, more than half the students also mentioned feeling excitement, expectation and curiosity throughout the duration of the class.

Nevertheless, as teachers, the authors have experienced difficulties in encouraging students to focus on SD. As the students were confronted with entirely new subjects, new methods and new ways of thinking, they were thrown out of their intellectual comfort zone and instinctively tried to hold on to anything familiar to them – which they found in the science-related case they were asked to study. Continuous reminders to focus on SD rather than ESS finally set the students on the right track, yet leaving most of them (about 70% according to the oral evaluation) feeling frustrated with the teachers' feedback throughout the course: *"It felt harsh to get so much criticism on a piece of work which we had put a lot of effort into, and that the criticism was that we had written about the wrong subjects."* While part of this frustration and unsettling experience may be necessary for "help[ing to] construct the self concept of the student as a life long learner and agent of change for SD" [1], it could have been alleviated by introducing the different elements of the class in stages, preferably in the following order: 1) SD, 2) stakeholder groups, 3) the case. This setup would have given the students an opportunity to experience their personal "disorienting dilemmas" in smaller, easier digestible portions. While decreasing their level of frustration, a staggered introduction of the class elements would most certainly have led to an increased level of conflict within the case itself, and thus better discussions in the inter-group meetings, since the students would have had more time to identify with their stakeholder group before immersing themselves in discussions about the case. The setup would also have allowed the students to relate to SD from many different perspectives: first their own perspective, later their stakeholder groups' perspective, and last but not least in relation to the case.

Ideally, of course, the students would have been confronted with SD during classes taught at an earlier stage in their curriculum. A gradual introduction of the subject matter throughout the entire educational program would facilitate for both teachers and learners. It is our ambition to present a positive example and to actively promote the integration of SD into all classes taught within the program of Engineering Nanoscience, and ultimately into all curricula taught at LTH.

The importance of clarity and motivation

As discussed above, most students report a successful learning experience. Yet, there also seems to be a large percentage of students who are dissatisfied with the class as a whole (46% of those who have answered the CEQ). From discussions with the students, as well as the different evaluation materials, we must conclude that this dissatisfaction is mainly due to two problems: a) insecurity about class goals and assignments, and b) insecurity about the relevance of the subject matter for the students' future careers as engineers.

One aspect tested for in CEQ is called "Clear Goals and Standards". On a scale from -100 to 100, the project scored -56. Despite doubts about the validity of the test, this strong result indicates a lack of communication. Both in the commentary section of the CEQ and in the written evaluations, students requested clearer instructions about what is expected from them to do well in the class. And despite the fact that they were given constant feedback on their work, they felt unassured about their own performance. Partly, this is due to the unfamiliarity of the subject: "The class seemed a little bit fuzzy all the time. I guess that is because we are not used to that way of thinking". This line of thought is in agreement with a study by Lundholm, who reports that "students' difficulties with environmental learning activities can be as much due to issues of attitudes and values as to challenges of knowledge and understanding." [13]. For students of engineering, who are used to a culture in which there is a right and a wrong answer, it may be difficult to accept that it is attitudes and values which they have to practice rather than pure subject matter. What teachers can (and should) do to alleviate these problems is to be very clear about communicating which the important challenges are and which kind of learning they expect from their students.

Another problem which Lundholm points out as a challenge for learners of ESD is a perceived irrelevance of the subject for their future profession. The following statement from the commentary section of the CEQ clearly indicates that we have failed to properly motivate the class: *"In general, I don't think the class should be mandatory. I would much rather have spent my time and money on other classes with a focus on engineering, classes which will be useful for me in the future"*. Another student wonders: *"does this really belong to our curriculum?"* Even others working in the area bear witness to similar problems: "students do not see how the courses in environment and SD are relevant

for their education" [7]. In order to improve learning (and student satisfaction), it is therefore of utmost importance to put considerable effort into communicating both learning outcomes [1] and relevance for the profession of engineers. Only if students understand why the subject is important and how they can apply the lessons learned, will they be able to become active agents for change. Thus communication is crucial for achieving transformative learning.

Effects of student involvement

Student involvement is an integral part of this project. Two kinds of student involvement are implemented: a) the class is based on a student initiative, with active participation of students in creating and designing the class, and b) students who are enrolled in the class are given extensive responsibilities to influence their learning experience.

It is safe to claim that this project would not have been feasible without the devoted effort which the student authors of this paper have put into motivating and creating the class. Despite their relative lack of experience in teaching and pedagogy, we believe that their involvement has been crucial for the success of the project.

The student members of the project team also served as a link between the more experienced lecturers and the students who are enrolled in the class, thus encouraging involvement and active participation from the latter. According to Wals and Blaze Corcoran, active participation is helpful for "developing discourse and ownership by utilizing the learner's knowledge and ideas" [11]. In "Sustainable Development in Nano-Perspectives", a group of six enrolled students (the "organizational committee") was entrusted with the responsibility to organize the general meeting and the press-conference. The students were autonomous in all decisions concerning the structure of the meeting and were even responsible for managing the event. The authors' experience with this approach is that, far from exploiting their freedom, students were extremely motivated and encouraged. Discussions and negotiations about the common road map continued until late at night without any pressure from the teachers.

Students who were part of the organizational committee were asked to fill out a special (anonymous) questionnaire for evaluation. The students *"think it is weird that [they] are allowed to decide freely"*, but overall they seem to be very positive about the approach. One of the students remarks: *"We have 'created' or formed the class ourselves"* and adds that he/she thinks this had a positive effect on the outcome of the class. Another student agrees: *"It made the class even more stimulating and instructive, and at the same time it gave everybody even more opportunities to influence the class. I think that was a good thing!"*.

But student involvement is crucial for another reason: It encourages students to become active agents for SD by "making the development of action and action competence an integral part of the learning process" [11]. Therefore, we believe that ESD depends on student involvement in all aspects of learning and teaching. Students should be given more responsibilities in influencing their own education and work for a sustainable future.

Conclusion

We have in this paper presented a novel class in sustainability for students of Engineering Nanoscience at LTH. We have discussed our experiences with using nontraditional teaching methods such as a case-study, role play, a matrix approach, as well as intensive student involvement. On the basis of our experiences, qualitative data from student evaluations, and scientific literature, we have suggested improvements to the structure of the class. We have highlighted the importance of finding an appropriate level of disorientation for transformative learning without discouragement. We have also stressed the importance of clearly communicating and motivating course goals.

Despite the conceptual nature of this study, we believe that it carries a number of practical implications for colleges of engineering who wish to improve their teaching for sustainable development. It is our ambition to contribute to a shift from traditional to more participatory teaching approaches for ESD. We also wish to challenge what we perceive as a dominant view of students as

passive receivers of education. This project has shown that a student initiative can lead to innovation and improvement.

Throughout our work with the class, we have been in contact with a large number of people from greatly different disciplines. The class has received media attention which has a potential to influence the image of colleges of engineering in general and LTH in particular. As Chalmers has realized years ago, we believe that it is crucial for HEIs to foster an image of caring about our common future by investing in high quality ESD in all curricula. We urge Lund University and LTH to establish ambitious guidelines for introducing ESD in individual classes as well as educational programs.

The field of ESD is still relatively new and research opportunities are abundant. Yet, reliable quantitative analysis of complex issues such as learning outcomes for transformative learning is all but trivial. We hope to improve the assessment of our class by developing an assessment questionnaire which would be administered to the students both prior to the class and after its conclusion. The questionnaire could for example be based on a list of change agent skills and characteristics as presented by Svanström et al. [1]. Thus, we hope to be able to analyze the success of the adjustments suggested in this paper and further contribute to the academic discourse about ESD.

Acknowledgments

References

1. Svanström M., Lozano-García F.J., Rowe D. (2008) Learning outcomes for sustainable development in higher education. *International Journal of Sustainability in Higher Education*. 9:3, 339-351
2. European Commission (2010) The Bologna process – Towards the European Higher Education Area. Available at: http://ec.europa.eu/education/higher-education/doc1290_en.htm (accessed 30 July 2010)
3. Holmberg J., Svanström M., Peet D.-J., et al. (2008) Embedding sustainability in higher education through interaction with lecturers: Case studies from three European technical universities. *European Journal of Engineering Education*. 33:3, 271-282
4. Lundqvist U., Svanström M. (2008) Inventory of content in basic courses in environment and sustainable development at Chalmers University of Technology in Sweden. *European Journal of Engineering Education*. 33:3, 355-364
5. Arbetsgruppen för miljöundervisning på Chalmers, GMV (2005) Den gemensamma kärnan. Available at: https://document.chalmers.se/workspaces/chalmers/gmv/esd-chalmers/rapporter-delprojekt/den-gemensamma-karnan (accessed 15 June 2010)
6. Arbetsgruppen för miljöundervisning på Chalmers, GMV (2009) Vägledande text om Chalmers obligatorium i miljö och hållbar utveckling. Available at: https://document.chalmers.se/workspaces/chalmers/gmv/esd-chalmers/rapporter-delprojekt/vagledande-text-om (accessed 24 July 2010)
7. Svanström M., Lundqvist U., Arehag M., Holmberg J. (2008) Addressing the quality of engineering education for sustainable development – experiences from Chalmers University of Technology. Paper presented at Engineering Education for Sustainable Development, 22-24 September, Graz, Austria, available at http://publications.lib.chalmers.se/cpl/record/_index.xsql?pubid=78489 (accessed 25 May 2010)
8. Karen Ir., Fortuin P.J., Bush S.R. (2010) Educating students to cross boundaries between disciplines and cultures and between theory and practice. *International Journal of Sustainability in Higher Education*. 11:1, 19-35
9. FAFF15, Course description (Sustainable Development in Nano-perspectives), available at: http://www.ka.lth.se/kursplaner/index%20eng. cfm (accessed 25 May 2010)
10. Svanström M., Fröling M., Bialik M. (2008) To utilise student diversity to train the ability to change perspectives – experiences from a master level course on sustainable development. Paper presented at Engineering Education for Sustainable Development, 22-24 September, Graz, Austria, available at http://publications.lib.chalmers.se/cpl/record/index.xsql? pubid= 78491 (accessed 25 May 2010)

11. Corcoran P.B., Wals A.E.J. (2006). Sustainability as an Outcome of transformative learning. Holmberg J., Samuelsson B.E. (Ed.), *Drivers and Barriers for Implementing Sustainable Development in Higher Education*, UNESCO, Technical Paper No. 3, 103-110

12. LTH (2010) Arbetsrapport CEQ, FAFF15, available at http://www.ceq. lth.se/rapporter/ from October 2010 (accessed 14 July 2010)

13. Lundholm C. (2006). The Challenges facing learners in EE and ESD. Holmberg J., Samuelsson B.E. (Ed.), *Drivers and Barriers for Implementing Sustainable Development in Higher Education*, UNESCO, Technical Paper No. 3, 55-58