Student's perspectives on Education for Sustainable Development in a problem based learning environment

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Abstract

In a society characterized by fast technological advances and increasing pressure on economic, ecological as well as social systems, it is important to educate engineers with a broader, reflective and sustainable perspective in alignment with their professional practice. This poses challenges to most engineering programmes, and scholars argue that a paradigm shift is needed to develop engineering education (EE) to embrace education for sustainable development (ESD). However, some of the more innovative pedagogies as for example problem based and project organised learning (PBL) already seem to bring EE on the right trajectory to ESD. For example, the pedagogical recommendations for ESD include active and student-centred learning, which are two of the basic principles of PBL. Some engineering educational systems have already implemented PBL and the question is whether engineering students at these PBL institutions experience the strength of this pedagogy when being educated for sustainability. This paper aims to investigate how students perceive and integrate ESD in a PBL environment. Results exemplify how PBL moves beyond awareness about sustainability as the problem based learning model encourages students to contextualise engineering problems and solutions and apply knowledge about sustainability in real life contexts.

1 Introduction

Technological innovations are market-valued assets that easily can be translated to economic growth, but economic growth that does not integrate sustainable development principles will continue to perpetuate the sustainability crisis we are facing today. Technological innovation needs to be "shaped" to contribute to sustainable societies, with economic growth and development that meet principles of sustainability (Engineering Education for Sustainable Development, 2004; Bourn & Neal, 2008; Royal Academy of Engineering Education, 2005; Mulder *et al*, 2011). On one hand, the focus is on skills and competencies to innovate and create market-valued technologies and on the other hand the crisis of sustainability is continuously stressed in the global and political debate. And the more the unsustainable growths of human societies become visible and contemplated on the global political agenda, the more push for sustainable engineering practice that can lead to a sustainable economic growth (Bourn & Neal, 2008; Grasso & Burkins, 2010).

The technological innovators, the engineers, thereby also need to be "shaped" if they are to "shape" sustainable technological innovations. Engineers should be capable of solving and preventing environmental, social and economic problems by integrating sustainable development principles in their professional practice. The role of education for sustainable development (ESD) has been recognized as crucial to address the sustainability crisis, and redirect the evolution of human societies. Engineering education is no exception, but the change is slow (Grasso & Burkins, 2010; Bell, 2011).

Therefore increasing attention is given to the drivers for change to integrate the view of ESD into every engineering education program. Regarding the pedagogical drivers for ESD, Steven Sterling (1996, 2004a, 2004b) has among others emphasised the importance of real life experiences, collaborative and communicative learning processes, action orientation as well as contextualisation. As pointed by Guerra (2012) many ESD experts that these principles overlap principles of PBL.

Problem Based Learning (PBL) is a learning approach constituted by problems in contexts as well as interdisciplinary, collaborative and participatory principles. In some of the more comprehensive models, problems are characterized as ill-structured, as they are drawn on real life situations, and the problem solving process and final solution are thereby unknown to the students (Kolmos *et al*, 2009). The project-organised problem solving process corresponds to the technological innovation process in companies as well as ESD pedagogy. PBL have a potential double function 1) equip students to face the profession challenges of technical innovation, and 2) educate engineers to be capable of integrating sustainability in their professional practice.

As noted by Sterling (2004a: 64):

> "*Instead of higher education being largely confined to instruction and transmission, it becomes: much more a participative, dynamic, active learning process based more on generating knowledge and meaning in context, and on real-world/situated problem solving"*

In line with this, Sterling (2004a, 2004b) argues for the importance of moving beyond learning **about** sustainability by creating awareness to learning **for** sustainability where the students gain skills and competencies to act and critical reflect on the knowledge gained.

However, very few studies report on the actual experiences of ESD in a PBL environment. In several curricular change processes PBL is highlighted to integrate ESD in higher education in general and engineering education in specific. However, this pedagogical strategy seems to be more related with modules, courses, or programmes within sustainability sciences and environmental engineering (Ferrer-Balas & Mulder, 2005).

This study aims to contribute to the experience-base of ESD in a PBL environment by taking the student's perspective. We are specifically interested in whether students from a PBL environment express signs of learning **for** sustainability; and from that point discuss the role of PBL. We take our point of departure in the following research question:

What are students' perspectives on learning for sustainability in a PBL environment?

The site for the investigation is Aalborg University, Denmark, where the curriculum is organized around problems from bachelor to master level programmes. In Faculty of Engineering and Science, the problem analysis and solving are organised as project work. At each semester there is one project module and courses. The organizational PBL approach puts strong emphasis on students' development of skills and competencies to prepare them for professional practice (Kolmos *et. al*, 2004).

The study involves students from second semester of the specialization Urban Planning and Management (UPM), a specialization of the Master Programme of Environmental, Energy and Urban Planning, from the Faculty of Engineering and Science at Aalborg University, Denmark.

2 Research methodology

The study was conducted between May and July 2012, which corresponds to the second semester of the master programme. The data was collected along these three months, and in different moments and by use of different research methods including observations, semi-structured interviews and content analysis of project reports (Figure 1).

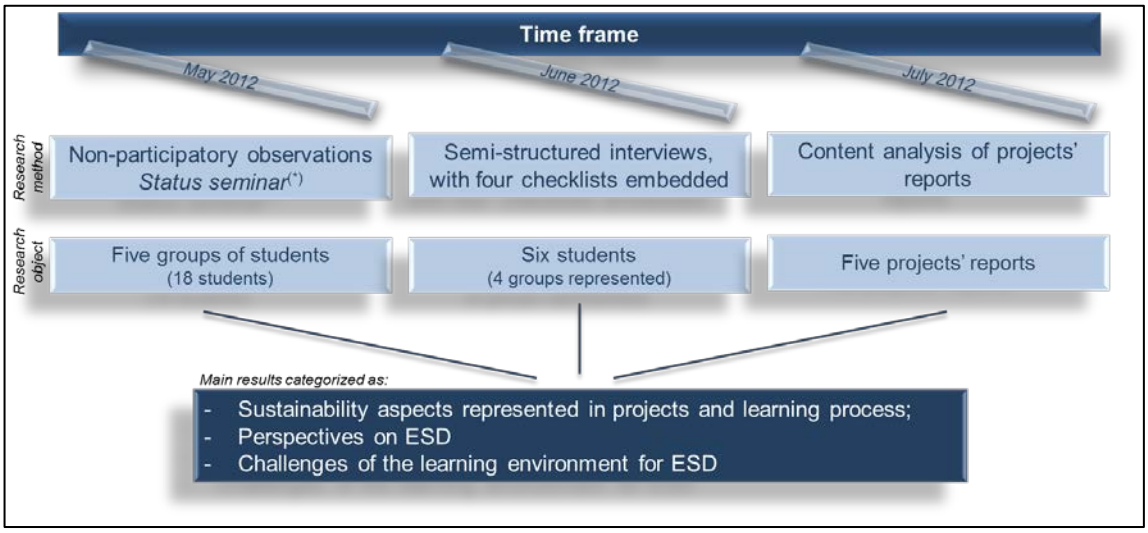

Figure 1: Data collection time frame, with inquiry methods used, object of research and main results.

All five groups of students were observed during their status seminar, and at the end of the semester all 5 students' reports were analysed. All 18 students from the 5 groups were contacted for interviews, however, only six out of the eighteen were available. From the five groups only one entire group was able to participate, which constitutes the only group focus interview of the study, with three students.

The students that participated in the study have different educational and cultural background: one Lebanese student, raised in Denmark, has a degree in Civil engineering, from Aalborg University, and participated in projects for Engineers Without Boarders in Palestine. Another student is an English student finishing her master degree at Aalborg University. Her bachelor background is in Urban Planning as well. The four remaining students have been educated in Urban Planning and Management at Aalborg University doing their bachelor. All participants are very familiar with PBL (with exception of the student from UK, who experienced project work in her home university), being the educational system they experience at the bachelor level.

In the status seminar observation grids were used including indicators for sustainability based on the Global Report Initiative (GRI, 2011). The same indicators were used in the interviews and in the project analysis. In the interviews, the indicators were presented as checklists for the interviewee to fill out.

The interviews included three more checklists with indicators related to ESD principles as well as the type of knowledge and discipline that the students develop during their education. Students filled out all four checklists during the interview and commented on their learning process in relation to ESD. A semi-structured interview guide was also used, including open questions related with students perspectives on sustainability, and the challenges they face in this particular learning environment.

The interviews were transcribed and coded using the software N-vivo 9. Thematic transcript was prepared, and together with the content analysis of the students' reports and the observation grids from the status seminars, patterns of students' perspectives on ESD in a PBL environment were extracted.

3 Results and discussion

In the following, we outline the results on students' perspectives on ESD in a PBL environmental by addressing their perspectives on sustainability content, PBL and finally ESD in a PBL environment.

3.1 Perspectives on sustainability content – reaching out to the three pillars

All data sources converge towards a strong emphasis on the social pillar of sustainability as public policy and legislation, local government and local community engagement are commonly addressed. This came to no surprise as they all work under the umbrella of the semester theme: "Power in Planning", which draw attention to social relations.

However, in some projects students have chosen themselves to address a problem, which motivates considerable attention to the other spheres of sustainability. This is in fact visible just by looking at the titles of the projects (Table 2).

Table 1 Number of groups in the second semester of programme and the respective projects' titles

Group no.	Titles of the project reports
1	One role to rule them all? A case study of the hybrid role of collaborative planners in Skive Municipality
2	Bridging gaps through community collaboration: A case study from the regeneration of Groruddalen, Oslo
3	A fight for the right to the city: The case study of an urban social movement and the fight against neoliberal planning in Wilhelmsburg
4	Keeping the discourse on track – An analysis of the light rail project in Aarhus
5	Collaboration in climate change adaptation: A case study of Copenhagen

One group (no. 4) addressed sustainable transport and another group (no. 5) analysed the power relations during collaboration in climate change adaptation. Besides, at the status seminar yet another group (no. 2) referred to biodiversity as an environmental aspect of sustainability, and the very same groups also addressed economic aspects of sustainability when presenting their project at the status seminar (no. 2, 4 and 5).

So even though the semester theme only stresses social sustainability, three out of five groups in fact touch upon all pillars of sustainability. One of the students explains:

In this semester it is about power. I wouldn't think it [Sustainability] *was that relevant but I think we have kind of been raised in the years, always to have it in mind and it always sort of pops up.* (Student A)

This indicates that sustainability in fact has become integrated in the way students address problems related to their profession.

3.2 Students' perspectives on PBL – self-directed coping by process competences

From the checklist students characterize their educational programme as interdisciplinary and metacognitive (as type of knowledge), which is very much aligned with the PBL philosophy. Furthermore, one of the students expresses that the self-directed learning approach develops their self-confidence:

> *I think I've gained more confidence, I've learned so much. I've learned that, first of all, we don't have one answer to any problem, but we can solve it in many ways. I am not sitting here holding all the answers but by sitting here, I've learned how to reflect, I've learned how to use tools.* (Student B)

This confidence builds on "being able to cope with something" rather than "knowing something". This represents a fundamental cultural change moving from a teacher centered to a student centered learning environment. Another indicator of self directed learning is that students are not afraid to bring subjectivity into the problem solving process – as one of the student said:

> *But that's the whole thing with projects as well. I don't even know if you can give the PBL the medal of it, because I think it is general when you start learning.* […] *it may due to working in real contexts which helps me to come further, I think it is. I won't be able to answer that. Maybe it is because I am so much into this that I think it is obviously that you will transform and a chance that your values may change afterwards* […] *It is not a theory read about or history, but actually people you talk to or that you are analysing something you really see.* […] *And many discussions are based on feelings and reasons why.* (Student C).

The same student explains that another type of knowledge is in play by using the notion of strategic knowledge in relation to the problem solving process:

> *Strategic knowledge, you know somehow structure the process, you know when you should do what but at same time you never know. You cannot go from 1 to 2, to 3 to 4, you always jump back and forward all the time. Of course it is about knowing when to apply knowledge that you get from theory.* (Student C).

Another students also stress this "other type of knowledge", this time referring to tacit knowledge, highlighting the risk of becoming so autonomous in moving through the problem solving process that you stop reflecting on and questioning the process:

> *It* [the problem solving approach] *is about tacit knowledge that we become experts in doing it* [problem solving approach]. *Maybe when we meet this international environment I think it is pretty healthy for us because than we see. I actually realize how brain washed I've been. It is not that I don't like it or anything, but there is other way of looking into it.* (Student D)

In this way the students highlight the importance of keeping the educational system open – how innovative the system may seem.

3.3 Perspectives on ESD in a PBL environment – learning for sustainability

The checklists on Education for Sustainable Development (ESD) principles all indicate that students perceive their education as highly interdisciplinary and their answers indicate high levels of learning. Students ticked for example "*adaptability and flexibility*", "*problem solvers*" and "*systemic and holistic*" to express the ESD approach taken.

It is a "learning to apply" approach the students experience when working with sustainability in relation to urban planning. One of the students states the following:

> *I've learned during my project to do strategic environmental assessment and stuff like that. We learn how to understand the tool, we got a lot of knowledge of the way we can use, we can do it in different ways, and we can choose within these frames to. I think that is a little a lot of everything. I think somehow I've seen this as this; I got a lot of skills and knowledge about Sustainable Development through the bachelor and last semester. Very much, and then now taught how to use that, how to actually with my eyes open go into the world actually do something about as much as I can.* (Student D)

Besides the emphasis on applying the gained knowledge, this quote also illustrates the progression build into the curricula; where the students seem to learn **about** at first and then learn **for** sustainability acting for change based on the awareness they have gained.

However, moving into an ill-defined problem field opens up for a range of problem formulations as well as delimitations and this means that the sustainability content is dependent on the scope of the problem. This is of cause a challenge to accept this diversity in students' sustainability skills. In one project the problem might call for a strategic environmental assessment, and the students will learn to apply these specific methods, other problems might call for risk analysis and so on. But no matter how tempting it might be to predefine the needed knowledge and skills in relation to a specific discipline, and to make sure that they are covered in the curricula, there might also be a point in letting the students define sustainability by themselves – if they are to generate not only knowledge but also **meaning** in context as requested by Sterling (2004a). At least this quote from one student makes this impression:

> *I've been working with sustainability at least two semesters, and I know I have a very clear and comprehensive understanding of what sustainability is but it would be very interesting if this institution kind of have its own official understanding of sustainability. That also would have*

> *limited us, in some of my projects, because there was this one semester where I, myself, used a lot of time describing what sustainability could be in urban planning context. And I wouldn't have done that if they had an explicit explanation of what it was. Then… Ok, we may have used our time in something else but however this was the way we learn what sustainability is, or at least how we see it.* (Student E)

Although this quote also stresses that it takes time for students to digest and appropriate sustainability to their line of study and line of thinking; it still might be worth it to let them address sustainability openly as the students then are motivated to reflect, take a stand and see the potential relations to their field of study and their projects. Actually, this student says that it would be demotivating if a clear definition of sustainability were presented up front.

4 Conclusions and perspectives

This paper aims to exemplify students' perspectives on learning for sustainability in a PBL environment. Results exemplify how PBL moves beyond learning about sustainability as the problem based learning model encourages students to contextualise engineering problems as well as solutions and apply knowledge about sustainability in real life contexts. Furthermore, the empowerment of the learner deeply rooted in the PBL philosophy made the student confident in "being able to cope" and to be self-confident in bringing own subjectivity and even feelings into play – an important asset in addressing the rather value based and complex concept of sustainable development as "*head, hands and heart*" (Sterling, 1996). PBL was reflected in the perspectives on ESD as several students stressed the opportunity to actually do something by gaining knowledge about sustainability and in addition experiencing how this knowledge can be brought to use when addressing real life problems.

However, it remains a challenge to select and appropriate sustainability content in the engineering discipline. It is a balance in the curriculum development process. On one hand, it is important to make the curriculum so open that the students can in fact construct their own view and select the most relevant for their specific project, and on the other hand still make sure that all students are guided through all relevant aspects of sustainability in relation to the profession. In the Aalborg case this has been handled by integrating sustainability into course modules and at the same time introduce thematic boundaries for the project that make room for learning sustainability.

Bringing sustainability into the course modules, however, does not mean that the students cannot take an active role. This study shows that some students actually like to take an active role in the search for awareness about sustainability and to appropriate sustainability to their own discipline. But if this means that construction and appropriation process take place in the projects, in relation to a specific problem, the interrelation between discourses of sustainability and the particular discipline though become blurred. In other words, if all students are to be guided through the all relevant aspects of sustainability – who is then to decide what the relevant aspects are, and how do you delimit what are relevant in an often crowded curricula? These questions indeed call for further research to make the picture less blurred and the selection less random.

Integrating sustainability does not mean an explicit call for sustainability in every semester theme. Even though the semester theme did not call for it, students seem to have integrated sustainability into their mind-set by having an awareness that makes them relate to sustainability in their choice of problem or in their problem analysis. "It always sort of pops up" as one of the students expressed it.

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