Problem Based Learning and Sustainable Engineering Education

Challenges for 21st Century

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PROBLEM BASED LEARNING AND SUSTAINABLE ENGINEERING EDUCATION

CHALLENGES FOR 21ST CENTURY

AIDA GUERRA

Appendices

PROBLEM BASED LEARNING AND SUSTAINABLE ENGINEERING EDUCATION

CHALLENGES FOR 21ST CENTURY

Appendices

Volume II

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Aalborg University, Denmark

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Problem Based Learning and Sustainable Engineering
Education: Challenges for 21st century

Volume II: PhD thesis appendices

UNESCO Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability
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APPENDIX 1: Experts' contact letter

Subject: Request for expert interview

Dear <EXPERT NAME>:

My name is Aida Guerra and I am doing my PhD in Problem Based Learning (PBL) and Engineering Education for Sustainable Development (EESD). My PhD study aims to investigate the synergies and tensions of integrating education for sustainable development (ESD) in engineering education, in particularly using a Problem Based Learning (PBL) approach. I have done a case study at Aalborg University but to be able to put this work in perspective I would like to interview EESD, and ESD, experts. The selection of experts is based on a literature review where your institution and name came to my attention.

The aims of the interview are to point:

- What are challenges in integrating ESD in engineering education?
- How are these challenges overcome?
- What are the drivers to integrate ESD?
- What are the main strategies to integrate?
- What is the role of the different actors?

Therefore I kindly ask you if you are available to participate in my study through a brief interview through Skype (taking place between July and August, within a date suits you better).

I send the interview's questions before the interview. After interview I will send the interviewee a summary for approval and the data will be use anonymously for research purposes only.

If you need further information regarding the aims of the project and your contributions please do not hesitate in contact me.

I look forward to hear from you.

Sincerely

Aida Guerra

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APPENDIX 2: Experts' interview guide

Background information

1. What is your professional background?
2. How did you become involved/ interested in Education for Sustainable Development (ESD)?

Strategies

3. What are the main strategies to integrate ESD in you organization?
   - What are the levels of integration?
   - What was the point of departure? Who?
   - How is the organizational involvement? Staff and Students?
   - What are the pedagogical approaches? Why?

Challenges

4. What are the main challenges in integrating ESD in engineering education?
   - What is the nature of these challenges?
   - What do you experienced?
   - Do they have the same impact?
5. How are these challenges overcome?
   - Suggestions to other institutions?
   - Can you provide examples?

Drivers & barriers

6. What are the drivers to integrate ESD?
   - When, where, do they have their point of departure?
   - What are the barriers these drivers have to overcome?

Role of different actors

7. What is the role of the different actors?
   - What is the student role?
   - How do they perceive their learning?
   - What motivate them?
   - Do you think it is possible the construction of a new engineer profile with ESD embedded? How?
   - And what about others – staff, management, etc.?

Future perspectives

8. What do you think is the future for EESD?
   - What are your perspectives?

APPENDIX 3: Experts' interviews summaries

Francisco Lozano, PhD, ITESM, Mexico

Contact Information

Name: Francisco J. Lozano-García, PhD

Affiliation: ITESM, Monterrey Campus, Monterrey, Nuevo León, Mexico

Agrees with information given bellow: ☒Yes ☐No

Interview summary approved on: (August 26th, 2013)

Contact on: June, 19th, 2013

Interviewed on: August, 1st, 2013

Suggested literature

References/ DOI:

Lozano, F.; Delgado & M., Lozano, R. (2010). *Assessing the sustainability incorporation in the Engineering Division curricula at ITESM, Monterrey Campus*. Paper presented in: Engineering Education in Sustainable Development (EESD) 2010, 19-22 September, Goteborg, Sweden.

Lozano, F., Acevedo, J.; Lozano, R.; Mendoza, A. & Viramontes, F. (2010). *Designing the curriculum for a new career delving in sustainability: Engineer in Sustainable Development*. Paper presented in: Engineering Education in Sustainable Development (EESD) 2010, 19-22 September, Goteborg, Sweden

Lozano-García, F.; Huisingh, D. & Delgado-Fabián, M. (2009). An interconnected approach to incorporate sustainable development at Tecnológico de Monterrey. *International Journal of Sustainability in Higher Education*, vol. 10, no. 4, pp.318-333. **DOI**: 10.1108/14676370910990675

Svanström, M.; **Lozano-García, F.** & Rowe, D. (2008). Learning outcomes for sustainable development in higher education. *International Journal of Sustainability in Higher Education*, vol. 9, no. 3, pp. 339-351. **DOI**: 10.1108/14676370810885925

Background information

Dr Francisco Lozano-García has a PhD, master and bachelor in Chemical Engineering. He worked for 13 years in industry and in consultancy before joining Instituto Tecnológico de Monterrey, Monterrey Campus, in Mexico. At university, besides teaching basic courses in chemical engineering programme, Dr Lozano started to work with the cleaning production centre in eco-efficiency; Dr Lozano was also pointed director of Centre of Environment Quality at Monterrey Campus and become more involved in Education for Sustainable Development (ESD) in higher education, particularly in engineering education.

Presently, Dr Francisco Lozano-Garcia coordinates the Sustainable Campus Programme in ITESM, Monterrey Campus, as well as has been actively involved in promoting integration of sustainable development concepts in course and curricula, underlining interdisciplinary and systemic approach.

Interview summary

Strategy and role of actors: example of Monterrey Campus, Instituto Tecnológico de Monterrey, México

In 2001, a programme (Sustainable Campus Programme, composed by 6 sections) was implemented in Monterrey Campus (Instituto Tecnológico de Monterrey, Mexico) with the aim to integrate sustainability in all education and in all campus operations.

In 2007, for the newer curricula review, several courses and programmes at Instituto Tecnológico de Monterrey had sustainability aspects integrated.

In 2011 the courses and all curricula was review, and sustainable main themes pin pointed. Also three mandatory courses were design for all university and campus (Instituto Tecnológico de Monterrey has 31 campuses spread in several cities of Mexico). There was also a concern in involving university's alumni as a strategy to pin point, for example, what can be carried out from university into future practice. The 2011 strategy also aimed to consolidate the sustainability campus initiatives, like for example, its operationalizations from 2001 and 2007.

The strategy developed for Instituto Tecnológico de Monterrey University aimed not only to integrate sustainability in a diluted way in the curriculum but rather weave it (e.g. make it relevant as much as possible for as many courses as possible), without disrupt the discipline/ core content of the course.

The use of the discipline as a mean to contextualize the sustainability for learners, and academic staff, can also be used as strategy (it stresses less and make the courses more open). In general humans tend to go to a comfort area; using such strategy prevents much more resistance for people to integrate sustainability in their courses. There are programmes, e.g. STAUNCH software (see, for example, in http://www.org-sustainability.com/), capable to evaluate the curriculum and balance between the three pillars of sustainability in its courses.

Also a course is set up for staff development in sustainability. The course includes experts in sustainability and workshops with case examples for each discipline and area.

Main pedagogical approaches:
The main pedagogical approaches depend very much on the specific institutions (the 31 different campus), courses and educations within Instituto Tecnológico de Monterrey.

Drivers:
In the case of the Instituto Tecnológico de Monterrey the point of departure was from the Monterrey Campus president, which led to middle management and lecturers to integrate sustainability. Some may be against but they carry out the task nevertheless.

On the other hand the students understand the relevance of sustainability in their educations and are very open to it.

Challenges:
One of the biggest challenges, experienced with 2001 programme, was the difficulties to spread information across the campus. To address such challenge, university acquired the Chronos® on line course (see, for example, http://www.sdchronos.org/) an e-learning platform to facilitate the share of information and resources.

Presently, one of the biggest challenges is change people's mind set change to enrol them into educational vision towards sustainability.

In general, if top level is not involved the sustainability hardly become part of the institution's agenda, even if the bottom level supports it. Acknowledgement, and rewarding, systems are one of the factors that may bring out to the light some initiatives carried out in a bottom level in institutions, but also to enrol academic staff.

Integration of sustainability in engineering education should face less difficulties and barriers because from the content point of view, it deals with materials and energy flows inherently forming part of engineering curricula.

Future perspective for ESD:

It is needed more education. The UN Decade for Sustainable Development is finishing, and a lot has been achieved, but it is needed to go further, not only in HE but in all educational levels, starting with primary school making the integration of SD more systemic in all schooling levels. In this way, students that reach HE will more literate but also those that not reach have some level of education for SD.

Karel Mulder, PhD, TU Delft, Netherlands

Contact Information

Name: Karel Mulder, PhD

Affiliation: Department of Technology Dynamics & Sustainable Development, TU Delft, Netherlands

(**personal webpage**: http://www.tbm.tudelft.nl/en/about-faculty/departments/values-and-technology/tdsd-section/staff/karel-mulder/karel-mulder/)

Agrees with information given bellow: ☒Yes

Interview summary approved on: (DATE)

Contact on: June, 19th, 2013

Interviewed on: July, 10th, 2013

Suggested literature

References/ DOI:

Mulder, K.; Segalàs, J.; Ferrer-Balas, D. (2012). How to educate engineers for/in sustainable development: Ten years of discussion, remaining challenges. *International Journal of Sustainability in Higher Education*. Vol. 13 No. 3, pp. 211-218. DOI: 10.1108/14676371211242535

Mulder, K.; Ferrer, D. and Van Lente, H. (2011). *What is sustainable Technology? Perceptions, Paradoxes, and Possibilities*. Greenleaf Publishing: UK.

Ferrer-Balas, D. & **Mulder, K.** (2005) Engineering Education in Sustainable Development. *International Journal of Sustainability in Higher Education*. 6(3), 215-315

Background information

Dr Karel Mulder has PhD on corporate decision making on R&D projects, a master degree in Philosophy of Science and Technology and a bachelor in Physics.

Dr Karel Mulder became involved with technology management and innovation, sustainability and sustainable development since 1992 through PhD supervisions. He also was part of a committee to integrate sustainable development in TU Delft. In 1998 he became the leader of sustainability and sustainability education issues in the TU Delft, and involved in the 7 year programme aimed to integrate sustainability in all educational programmes. Now is part of Department of Technology Dynamics & Sustainable Development, Faculty of Technology, Management and Policy, continuing to work with engineering education for sustainable development.

The summary of this interview is focus on Dr Karel Mulder expertise on education for sustainable development in engineering education and the TU Delft integration strategy.

Interview summary

Strategy and role of actors:

In 1998, TU Delft developed a 7 year programme to integrate Sustainable Development (SD) in all educational through main fronts by:

- Set up basic course to all engineering students
- Integrate sustainable in every course where it is relevant to integrate
- Option for specialization in master programme (possibility to get a “sustainability certificate” on any master programme)

The programme can be classified as top down strategy to integrate SD, and was envisioned by university boards; however there was a concern since the beginning to include students, and lecturers, starting with first committee established (with aim to have bottom up approach as well). In sum, there is a combination of top down and bottom up approach.

This is considered an important combination in order to change because it enrols the main actors of an educational system.

Sustainable development aspects still being integrated in all education programmes through the main strategies pointed in the above three bullets points.

Trigger and drivers to integrate SD:
The trigger for developing a programme was with criticisms from "outside" the university, claiming a very strong technical and "nerdish" approach. Industry and society claimed another type of education for future engineers.

Main pedagogical approaches:
Overall approach used is a combination of more traditional lecturing with project work, bringing together people within, and across, departments.

An example is the project called the boat week. Students meet (without knowing each other before hand) and are confined in a boat for a week. Students along this week visit places with sustainable interest and/ or have experts visiting the boat for brief lectures. After this boatweek, they have to collaborate in a project, which consist in create a strategic plan to full fill certain needs in a more sustainable way.

The basic courses are lecture based. The teaching approaches differ from programme to programme, and normally the course is taught by someone from the department who is working with sustainability within the programme/ discipline. For example, Architecture, Aeronautic engineering, or Civil engineering programmes have someone from the field, who also works with sustainability, teaching the course.

Challenges:
Beside the successful integration of SD in TU Delft there are still some challenges. There is some academic resistance to change, and integration of subjects out of the STEM core disciplines. Some students show resistance and criticism to approaches like "SD is not real engineering", or the lack of link to real life engineering which is often supposed to only about earning money.

A suggestion to address such challenge is to provide some ownership to staff and never substitute, or give away, the core discipline for sustainability.

Even though sustainability is accepted in TU Delft and it has become (to some degree) part of the culture, it is still a social issue and calls for a strategic thinking in a long term. Engineering departments are still, to some extent, very closed.

Future perspectives for SD:
There is a need for more interdisciplinary and transdisciplinary education, in the bachelor level and master level (master programmes tend to be very specialized). There is a lot of prejudice for interdisciplinary and transdisciplinary education. University boards could encourage them more. (Which they do not at the moment. In fact The TU Delft board is emphasizing "disciplinarity" at this moment)

Teach a combination of deep technological- and strategic skills and managing for ESD.

There is a need to make sustainability more contextualized and applied to real life problems and situations.

Make a more systematic combination of lecture and project work in the bachelor levels, organized, for example, in two courses and the rest project work.

There is a possibility to build a new engineer identity with ESD as part of it but probably will it need a new department with strong culture and against the common suspicion that SD is not being part of real engineering (that still remains in some institutions).

Mark Henderson, PhD, Arizona State University (ASU), USA

Contact Information

Name: Prof Mark Henderson

Affiliation: College of Technology and Innovation, Arizona State University

(**personal homepage**: http://sustainability.asu.edu/people/ss-search.php#pid=7570)

Agrees with information given bellow: ☐Yes ☐No **Interview summary approved on**: (DATE)

Contact on: June, 19th, 2013 **Interviewed on**: August, 6th, 2013

Suggested literature

References/ DOI:

Global Resolve programme: http://globalresolve.asu.edu

Background information

Prof Mark Henderson has a PhD in Mechanical Engineering. Between his master and PhD studies, Prof Mark Henderson worked seven years in industry before returning to academia.

Prof Mark Henderson main research areas were in geometric modelling, however the desire to get involved in multidisciplinary teams, and to move behind engineering traditional work were the driven to create the Global Resolve.

He is one of founder members and director of Global Resolve (see http://globalresolve.asu.edu/), which is an elective programme at Arizona State University (ASU).

Global Resolve born from a "get together in a coffee shop" between Mark Henderson, and other faculty members from ASU's global studies, businesses and engineering and the need to make something related with sustainability in developing countries. Global Resolve was formalized in 2006 but it begun in 2003 by mobilizing contacts and network of contacts between ASU previous students (students' body president) and Ghana.

Interview summary

This summary focus on two examples of integration of sustainable development in engineering education: through elective programmes and through formal education programmes.

Strategy and role of actors:

The Arizona State University (ASU) is one of the largest community/ public colleges in United States of America (U.S.A.). In U.S.A it is common the existence of elective programmes for students to attend while is having their formal education. EPICS and Global Resolve are two examples of these programmes in Polytechnic Campus of ASU, which bring engineering students to real learning contexts and to the implications and impacts of the engineering profession.

The Global Resolve (see: http://globalresolve.asu.edu/) has, approximately, 150 students enrolled from different educational and cultural backgrounds, involves students in real world projects, to solve real world problems in underdevelopment countries. The programme has its principles down upon sustainable development, and encloses all its dimensions:

*"GlobalResolve works together with a range of partners to develop sustainable technologies and programmes in the areas of energy, clean water and local economic development for rural communities in the developing world" (*http://globalresolve.asu.edu/*, accessed October, 26th, 2013)*

For Arizona State University, Global Resolve also works as a tool for students' recruitment, but also brings a humanitarian perspective to engineering education.

Students' motivations to get involved in Global Resolve, or other elective programmes, vary, some students are more altruistic, and others are driven by curiosity or desire to serve.

Another strategy of ASU to integrate ESD in the engineering education is through the educational programmes. In 2006, a new engineering curriculum is established and it is organized around research oriented pedagogies. In here sustainability is integrated in all programmes, in all university, by the ASU President's initiative.

The initiative for integration of ESD in ASU is mainly characterized as top-down, however, and at same time, there was some bottom up initiative (like elective programme Global Resolve) that was aligned with top-down initiative.

Main pedagogical approaches:
As mentioned above the new engineering curriculum is based on research pedagogies, mainly Problem Based Learning (PBL), and project organized. An engineering programme encloses 8 semesters, and in all semesters students work in projects solving problems. It starts with small projects, in the 1st semester, and ends with a capstone project (8th semester).

Drivers:
Through Global Resolve programme, students develop a systems thinking in context. It also provides a link between university learning and environment with community service learning (which is very weak, or even absence, in many universities).

Challenges:
There is a remaining resistance from the engineering community to integrate ESD in the programmes, partly due to the lack of practical knowledge of how to integrate, and to some misunderstanding from both worlds (engineering and social science). To overcome the challenge of integration of sustainability across different campus, faculties and schools it is important the collaboration among academic staff. For such it is needed the creation of conditions for collaboration. For example, at a faculty level it is nominated a senior sustainability scientist who make the link between others seniors scientists from the others faculties and schools. To all senior sustainability scientist is given an office in the school of sustainability. Through this strategy the academic staffs is brought together with the possibility to collaborate, and develop strategies to move further to create a multi-disciplinary community for sustainability.

Students also take inspiration from this kind of collaboration.

Another challenge is the students working groups that are formed across schools and programmes, bringing together students from engineering but also form liberal arts, or social sciences. Some students feel intimidated by the engineering students when do they have to collaborate in projects. Some of these challenges are overcome by engaging students in exercises where they have to build a common understanding and conceptual ground. One example is the concept generates exercise.

Future perspective for ESD:

There is a need to develop models on Problem Based Learning (PBL) on sustainability that can be used by academic staff and students.

Richard Fenner, PhD, University of Cambridge, UK

Contact Information

Name: Richard Fenner, PhD

Affiliation: Centre for Sustainable Development, University of Cambridge, UK

Agrees with information given bellow: ☒Yes

Interview summary approved on: 15th October 2013

Contact on: June, 19th, 2013

Interviewed on: August, 30th, 2013

Suggested literature

References/ DOI:

Cruickshank, H.J. & **Fenner, R.A.** (2012). Exploring key sustainable development themes through learning activities. *International Journal of Sustainability in Higher Education*, Vol. 13, no. 3, pp. 249-262

Fenner R.A., Ainger C.A., Cruickshank H.J., & Guthrie P. (2006) Widening horizons for engineers: addressing the complexity of Sustainable Development. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability Journal*, Volume 159 ES4 pp145-154. Winner of Institution of Civil Engineers George Stephenson Gold Medal 2007

Fenner R.A., Ainger C., Cruickshank H.J., & Guthrie P., (2005) Embedding Sustainable Development into Cambridge University Engineering Department. *International Journal of Sustainability in Higher Education*, Volume 6, No. 3, pp. 229-241)

Background information

Dr Richard Fenner is a Civil Engineer and a Water Engineer and has been working in environmental engineering since the 1970s.

In University of Cambridge, Dr Richard Fenner integrated the academic body of general engineering department in 2002, where the programmes' content is more related with engineering sciences rather than specific engineering fields like civil engineering for example. Although students specialise in the 3rd and 4th year, they graduate with a degree in engineering.

Dr Richard Fenner always had a strong interest in environment and always taught civil engineers "environment issues", so he considered a natural step to broaden up that and cover sustainability. Dr Fenner became involved with sustainability in engineering in late 1990s through the Royal Academy of Engineering. In 1997, the Royal Academy of Engineering had an initiative which provided funding to host visiting professors in universities departments across UK. The idea was they would get people from industry and talk with undergraduate students about how industry was dealing with sustainable development.

In the University of Cambridge, the engineering department receive prof. Peter Guthrie, and it was through these contacts that Dr Fenner initiate to develop courses and programmes to integrate sustainable development (SD) in the engineering education. The strategy and actions taken for the integration of SD is explained in more detailed next in the interview's summary.

Dr Fenner is also member of the Centre for Sustainable Development (see http://www-csd.eng.cam.ac.uk/), at Engineering Department - University of Cambridge.

Interview summary

The interview's summary is regarding the integration of Education for Sustainable Development (ESD) in Engineering Education in University of Cambridge, and encloses the following cluster themes.

Strategy and role of actors:

The integration of ESD in engineering education at Engineering Department Cambridge University had its points of department from two initiatives, one from Royal Academy of Engineering (mentioned above) and one from Cambridge MIT institute.

The Royal Academy of Engineering Initiative provided support to visiting professors and that was very much focus on the undergraduate level teaching, coming out of it a specialist module in sustainable development which is still running.

From the support from the Cambridge MIT institute allow to develop postgraduate master programme. Dr Richard Fenner was recruited to set up, lead and run the master programme in Engineering for Sustainable Development. The master programme started in 2002, with 14 students, and counts now with 375 alumni, and will start running this in 2013 with 35 students.

The process of integration of ESD in University of Cambridge, in particular in General Engineering Department, evidences the alignment between the top down requirements and support (not only at academic institutional level, but at government level) and the bottom up initiatives (from a number of enthusiastic academic members).

Engineering department also has a small research unit for sustainability – Centre for Sustainable Development – where a growth in research has been observed in the last 10 years. This is not the exclusive research unit in sustainability in the department, others small units exist in relation with, for example, sustainable freight transport, sustainable manufacturing (in manufacturing division).

There is a need for external funding to start the process, but it is also the carry out the process beyond that, which is observed in Cambridge.

For example, the Royal Academy of Engineering initiative also allowed bringing people together inside the department, and thinking about what can be done and by whom to integrate ESD to undergraduate levels. The actions were carried into ways:

1) Try to established champions, in similarity with was done in TU, Delft (Netherlands), in each area. Nominate people, and colleagues that are committed to make their teaching more related with sustainability and make them champions in their own areas. The engagement with people also moves beyond the engineering department, where is established informal relations and cooperation with people from, for example, business school, department of geography, department of land economy, etc. Accordingly with Dr Fenner, it is important to establish collaboration and community of practice for sustainable development involving different departments and seek help from individuals from different departments.
2) Through a project called "Improving Engineering Education for Sustainable Development", funded by the Cambridge MIT institute, develop ESD materials and resources for colleagues to use in their teaching, in their own lectures, in their own ways. It was reasonable effective because there are a considerable number of themes that go on in the undergraduate curriculum and can be link with SD.

The strategy, according to Dr Fenner, was to light several fires and see which could hold and all hold and still burn.

There is no formal staff 's training as part of the strategy and activities to integrate ESD, however the project "Improvement of Engineering Education for Sustainable Development" brought staff members together to discuss how sustainability could be brought to the different departments, courses and lectures. It was also developed materials to support the people in their teaching, and which could be taken to the different teaching groups.

Main pedagogical approaches:

The strategy and actions taken lead to integration of sustainable development into formal education at two levels: elective course in undergraduate level and master programme in engineering for sustainable development.

The creation of master programme allows a more freedom to design a curriculum which reflects the view towards sustainability, and how engineers should be educated towards sustainability. At a postgraduate level, Dr Fenner, and his collaborators, tried to encourage their engineering students to think a bit differently when comparing with undergraduate level. The aim is not necessarily teaching them particular solutions, although clearly there is a focus on certain tools, techniques, methodologies and so on, but to start thinking about problems differently and by that essentially, trying to add to the traditional engineering education what they call the reductionist approach a more holistic and broader view, emphasizing that there is NOT always analytical answers to every problem and some problems are the right approach and achieve across different ranges of complexity.

According to Dr Fenner, the pedagogical strategies are several and based in experiential learning, like for example the embrace change challenge with focus on how to change and how to embrace change. In this approach students pick and embrace a challenge that can start by trivial and personal challenge. Such approach allow students to be innovative, look into new solutions and reflect on of how they can change and it is a step for them to embrace bigger challenges aiming change at a professional level.

Other examples of strategies are role-play, negotiation for multi criteria decision, field work. The ultimate aim is to education engineers as change agents and not detached of a context (social, economic, etc., in which engineering exist and operates in the real world). In the courses and master programme has a great emphasis on how students can use their engineering knowledge and skills in real world facing the society new demands and challenges.

Drivers:

There were very types of external and internal drivers which lead to integrate ESD in engineering education. Example of external drivers is the accreditation bodies in UK for engineering education demanding a demonstrate presence and knowledge on sustainability at undergraduate level. Example of the internal driver is the motivation and vision of some engineering students regarding the relevance of learning about sustainability for future, like student body "engineers without borders". Some students overlap their formal education projects with projects carried out within the "engineers without boarders" projects.

Challenges:

The challenges are several, and also are different between the undergraduate and postgraduate level. At an undergraduate level, there is challenge of the time and space in the curriculum because in the undergraduate it is fundamental to provide them the engineering fundamentals and basics. Therefore at an undergraduate level it should be given to students an awareness regarding sustainable development while at graduate level you have more freedom to develop other type skills, type of knowledge because students are more mature and have some job experience as engineers and see the other in a different way.

Another challenge is related with attitude issues, being now less than in the past. Some academic staff sees sustainable development as trendy, fluffy and vague in its content. However it is given the time the

benefit to cure and change attitudes, Dr Fenner and his collaborators started the master programme 11 years ago and continue to recruit around 35 to 50 students per year. Also the number of research projects increase.

Also the research approach taken regarding ESD is a multidisciplinary approach which is more acceptable along with others initiatives carried out in the department.

Future perspective for ESD:

It is of the most importance to encouraging students to embrace change and become change agents (mainly at a postgraduate level), it is a step for changing mind sets and move from a reductionist approach to a more holistic and complex view of problems and the world - i.e. moving out from the traditional engineering view. Students need to know fundamentals of engineering skills but also a different way of applies them in broad context society so before solving a problem students need to know how to analyse the context and situation of the problem.

It is also needed some reflection regarding the antagonism towards sustainable development, which may constitute a barrier to change but rather look into its principles and aims as a purpose for education even if it is used a different words. Dr Fenner gives the example of civil engineering programme from an UK university which change its name for Earth Systems Engineering.

Rodrigo Lozano, PhD,

Contact Information

Name: Rodrigo Lozano, PhD

Affiliation: Copernicus Institute of Sustainable Development, Utrecht University, Netherlands

Agrees with information given bellow: ☒Yes

Interview summary approved on: August, 20th 2013

Contact on: June, 19th, 2013

Interviewed on: July, 12th, 2013

Suggested literature

References/ DOI:

Lozano, R. (2010). Diffusion of sustainable development in Universities' curricula: an empirical example from Cardiff University. *Journal of Cleaner Production*, 18, pp.637-644. **DOI**: 10.10196/j.jcleprod.2009.07.005

Lozano, R. (2011). Addressing stakeholders and better contributing to sustainability through Game Theory. *The journal of Corporate Citizenship*, 43, Autumn, pp.46-62.

Lozano, R. (2011). Creativity and organizational Learning as means to foster sustainability. *Sustainable Development*. **DOI**: 10.1002/sd.540

Lozano, R. (2012). Orchestrating organisational changes for corporate sustainability: Overcoming barriers to change. *Greener Management International*, 57, pp. 44-64.

Lozano, R. (2013). A holistic perspective on corporate sustainability drivers. *Corporate Social Responsibility and Environmental Management*. **DOI**: 10.1002/csr.1325

Lozano, F.; Delgado & M., **Lozano, R**. (2010). *Assessing the sustainability incorporation in the Engineering Division curricula at ITESM, Monterrey Campus*. Paper presented in: Engineering Education in Sustainable Development (EESD) 2010, 19-22 September, Goteborg, Sweden.

Lozano, F., Aceved,o, J.; **Lozano, R.**; Mendoza, A. & Viramontes, F. (2010). *Designing the curriculum for a new career delving in sustainability: Engineer in Sustainable Development*. Paper presented in: Engineering Education in Sustainable Development (EESD) 2010, 19-22 September, Goteborg, Sweden

Background information

Dr. Rodrigo Lozano has a bachelor in Chemical Engineering, a master in Environmental Management and Policy, and a PhD in Sustainable Development (SD). The summary of this interview is focus on Dr Rodrigo Lozano expertise on education for sustainable development (ESD).

Interview summary

Strategy and role of actors:

In ESD each actor has a role, for example:

- Lecturers - should see them as educators, and as means to empower students rather then just "transferring" knowledge.
- Administrators and management - should support organizational change.

To make change towards SD, ideally all actors should be involved - study bodies (which have a lot of power within organization), administration and academic staff. Which strategy (top-down or bottom up) works better depends on the context. Normally top-down changes are quicker in corporations than in institutions.

Integration in engineering education should be quicker because engineers are more pragmatic and problem solvers ("give me a problem and I solve it"), however there still exist a strong technocratic approach in the way engineers solve problems, which may represent a barrier to integrate SD in engineering education in all its fields.

Engineering education for sustainable development should be more transdisciplinary, with a "step" by "step" approach. First, it is needed to educate good engineers, and 2nd, provide courses where the implications of their decisions can be seen, reflected upon and problematize and tools for such purpose be given.

Courses should not be an add-on to the curriculum, but rather in relation of what is the content of the specific course (a more embedded/ integrated strategy). Sustainability has a lot of elements, which allows reflecting on how does sustainability is interpreted and its viability for each specific disciplinary context.

Courses should focus on the engage and empower students. Start with small and easy steps/ actions like for example the operations (e.g. initiatives for greening campus); educate the educators for SD; make links with real world and outside the university.

An embedded strategy should go through all operations and structures of institutions, faculties, and university campi.

Main pedagogical approaches:
Pedagogical strategies should focus on active learning and foster students' critical thinking, engagement. They can be problem based learning, project based learning, role play, case study, etc.

Drivers:
The triggers and drivers for change should be internally and externally. They also depend on each context.

Challenges:
Organizational changes and culture face barriers towards change similar as people. Each university, each campus, is a case because it depends on contextual issues, including culture. The overcome of the challenges depends very much on the type of challenge.

One of the main challenges is to break the reductionist and Newtonian vision of teaching to a more holistic one.

Future perspective for ESD:
It is needed to:

- fight disparities among rich and poor (countries, for example)
- develop an education which create and give opportunities to all people, and each one be able to reach and full fill he/ she potential
- allocate resources, including money, for alternative technologies, lifestyle change, reduce capitalism and re-direct its competitiveness for people's potential full fill.

Basically, change the entire world.

Roger Hadgraft, PhD, RMIT, Australia

Contact Information

Name: Roger Hadgraft, PhD

Affiliation:

Agrees with information given below: Yes

Interview summary approved on: 14 Oct 2013

Contact on: May, 25th, 2013

Interviewed on: September, 2nd, 2013

Suggested literature

References/ DOI:

Dowling, D., and **Hadgraft, R.** (2013). *A Graduate Capability Framework for Environmental Engineering Degree Programs: A Guide for Australian Universities*. Office for Learning and Teaching, Department of Industry, Innovation, Science, Research and Tertiary Education. Sydney.

Hadgraft, R. (ed.) (2012). *The Project Handbook*. RMIT University, available at: http://project-handbook.pbworks.com.

Smith, D. & **Hadgraft, R.** (2007). *The 'Melbourne Model' and new Engineering Degrees at the University of Melbourne in 2008*. Proceedings of the 2007 AaeE Conference, Melbourne

More references at: http://rmit.academia.edu/RogerHadgraft

Programmes in RMIT: http://www.rmit.edu.au/browse;ID=bdtj9l936298

Background information

Dr Roger Hadgraft has a background in Civil Engineering. He worked as a young engineer with water resources commission (government department), which was the point of departure to get interested in environmental and sustainability issues as part of engineering practice.

After work with industry for some time, Dr Hadgraft returned to academia, to Monash University, later joining the Royal Melbourne Institute of Technology (RMIT), and taught a range of technical subject. However he considered himself lucky to be able to work in a department where one or another person were interested in sustainability as much as him. He got to be involved in developing degrees in environmental engineering and sustainable engineering practice.

After RMIT, Dr Roger Hadgraft worked for University of Melbourne and got involved in university curriculum development, the so called Melbourne Model (see at: http://rmit.academia.edu/RogerHadgraft), resulting in a publication in 2007.

Dr Hadgraft is now at RMIT (again but in a different School) and involved in the new bachelor programme "Sustainable Systems Engineering" (see at: http://www.rmit.edu.au/browse;ID=BH076) under the school of Aerospace, Mechanical and Manufacturing Engineering.

Interview summary

As is mentioned above, Dr Roger Hadgraft became involved in developing degrees related with environmental engineering and sustainability. Integration of sustainable development (SD) in engineering education can be through creation of courses and programmes for, and in, engineering schools. The following interview's summary is regarding the development of the mentioned programmes and its relevance for

engineering education. So instead of being more focused on strategies, the interview was more focused in actions already taken and programmes providing an example to take inspiration from.

"Strategy" and role of actors:

One of the first programmes Dr Roger was involved in was the environmental engineering and how to deal with environment degradation and "taking out" the responsibility from other engineering disciplines. Also the focus was mainly in the environmental perspective of sustainability. It is needed to broaden up, and include other dimensions that are not only the environment impacts. One of the main points stressed by Dr Roger Hadgraft is the idea of human interface between human and technology developed.

It was in Melbourne University, in only undergraduate programme related with environment that it was possible to start to explore the interface between human use of technology and the development of the technology itself. The first year was composed of six electives courses and two core courses. One of the core courses is related with natural environment while the second course is about the re-shaped environment (e.g. natural resources and world and its change by human actions and technologies).

Another programme Dr Roger was involved in developing is the bachelor in "Sustainable Systems Engineering", being one of the core principles of the programme to take a systems approach close to students, and enable them to think in term of systems as part of their professional practice. The first two years are focused in teaching about engineering systems approaches and bring together engineering fundamentals and sciences (e.g. thermodynamics, fluids dynamics, mathematical modelling). In 3rd year can choose between two specializations: energy or transport logistics, and in the 4th year is a kind of capstone project with some courses integrated.

This programme educates engineers in terms of systems and mainly in looking into human factors, and while several engineering disciplines tend to focus on specialization this specific education focus on provide students with fundamental engineering skills but also broader skills and more flexibility when comparing with other engineering educations.

According to Dr Roger, engineers always worried about how to design a better system but not always an engineer student learn an explicit intellectual framework to help them how to operate in such terms. To some extent is engineering education is provided and build. Normally students taken what education give them, and what education gives is a narrow and technical oriented view of problems and world. When company consultants are questioned about what type of graduates they would have in their offices, the replies normally fall on "*we want flexible people, we want people that work well with other people, and who are flexible problem solvers*".

Education instead of given a systems view of a problem tends to give a more narrow view. In Dr Hadgraft words "*we can't just design a device instead we need to meet a need, and to meet a need you probably need to design a system, and a system needs to be used by humans, so you need to understand the human interface as well and I don't think that much happens in education*".

In general the education towards sustainable development (ESD) in engineering education is quite spread. There are programmes as the one describe above, and some elective courses. How these courses are designed and delivered to students go down to each school. One example is the "Engineers without Boarders" project, run to all first year students in engineering; however the project runs in different ways in the different schools.

Main pedagogical approaches:

The main pedagogical approach used is problem oriented, project based learning. Normally project comes in the final year of programme, called capstone project. Actually, there is a project in each semester in SSE, with final year being half project.

One of the most interesting ideas is the use of studios as an innovative learning strategy, and an alternative to overcrowded curriculum. The idea of creation of studies relies on a curriculum organized where in the first two years a lot of attention and time is put into develop engineering fundamentals skills, and the following years students have studios (as the same exist in Architecture education) they can come together with different experts explore other possibilities. For example, one student where students area able to work with something that is totally technical along with a top class expert, while in other studio there is possibility to broaden up and study the impact of a certain technology in society. Underlying these studios are real world, life situations, and where students can stretch their mind in several directions: more technical and more social. In this way university provide the students the starting point for them to shape their world view and build their profile. And after, wherever they go they can develop themselves further.

Challenges:

According to the state above one of the challenges is the students' lack of ability to understand complex and unstructured problems. In general, the problems given to students to solve in their education tend to be structured - students don't like ambiguity - which lead them to see the problems in a very particular way which is from a reductionist and technical point of view. It is needed to develop the students the capacity to analyse and ability to ask the right questions when it comes to real world situations and contexts, in order to formulate the right problems.

One of the biggest challenges is to bring people to work together. One of the practical ideas concerning the use of studios is to bring different disciplines experts together and to work closely in with students, giving an idea how systems functioning in reality, take part of the bigger picture, the bigger puzzled in collaboration with others.

Future perspective for ESD:

Regarding the future for the programme of "sustainable Engineering systems", Dr Roger understands that there are improvements and details to work with. For example, have the project sequence throughout the entire programme; and also make sure the projects are meaningful in a real context world.

There is also some work to be done regarding to bring in and collaborate with other experts that are not only in engineering. It is also important to be aware the practical issues underlying the initiatives and activities like for example more pragmatics issues in terms of organization such as timetables - give students room and space to work in their projects.

Yona Sipos, University of British Columbia, Canada

Contact Information

Name: Yona Sipos

Affiliation: Integrated Studies, Faculty of Land and Food Systems, University of British Columbia, Vancouver, Canada

Agrees with information given below: ☒Yes – as amended ☐No

Interview summary approved on: August 16, 2013

Contact on: June, 19th, 2013

Interviewed on: July, 17th, 2013

Suggested literature

Reference/ DOI:

Sipos, Y., Battisti, B. & Grimm, K. (2010). Achieving transformative sustainability learning: engaging head, hands, and heart. *International journal of Sustainability in Higher Education*. Vol. 9, no. 1, pp. 68-86. **DOI:** 10.11081/14676370810842193

Background information

Yona Sipos has a bachelor in Biology and a Master in Forestry. It was during her master education that Yona became interested and involved in sustainability, especially in university context (reflecting in questions like how sustainability is taught & learned).

Yona Sipos after her master become involved with the Centre for Teaching and Academic Growth (now renamed: Centre for Teaching, Learning, and Technology) (University of British Columbia, Canada) due to her strong interest in non-formal education, and in lifelong learning. Yona Sipos was also involving in the design and delivery of a sustainability course for academic staff members (see for example: http://blogs.ubc.ca/tagsustainability/). As result of course design and implementation, a paper was produced, with Yona as second author. The reference for this paper is: Cassidy, A., Sipos, Y., Nyrose, S. (2013). Supporting Sustainability Education & Leadership: Strategies for Students, Faculty & the Planet. Chapter 12 in: Handbook of Research on Transnational Higher Education, Vol. 1., IGI Global. ISBN13: 9781466644588

(The paper cited above in "suggested literature" is based on my master's thesis)

At the moment is doing her PhD in Integrated Studies in Land and Food Systems, focusing on Education for Sustainability (ES) and community-based experiential learning (including: community service learning and community-based research), with a focus on food system study as an example of an integrative learning theme. She expects to finish in December of 2013.

A recent paper from my PhD studies: Rojas, A., Sipos, Y., and Valley, W. (2013). Reflection on 10 Years of Community-Engaged Scholarship in the Faculty of Land and Food Systems at the University of British Columbia-Vancouver. Journal of Higher Education, Outreach & Engagement, 16(1): 195-211

Interview summary

Strategy and role of actors:
The Centre for Teaching and Academic Growth (now renamed as the Centre for Teaching, Learning, and Technology) become responsible for developing a course of sustainability education for academic members of university, which constitutes one of main strategies to integrate sustainability education in the institution.

The course grew out of a sustainability education community of practice, and has a strong emphasis on learning, and works to move towards sustainability education among academic staff members.

The course is called Sustainability Education Intense (SEI), and ran for two years (2009 and 2010). It started by involving deans and head of departments, who were contacted by letter and asked to point academic staff to participate in course. The course description is as follows:

Duration: Two days and half

Aims: Advance a community of practice towards sustainability education among faculty members and those interested in ES. Also foster integration of sustainability in several programmes of university through academic staff.

Strategies and activities: in opposition of a typical university education lecture based and teacher centred, the course is more participatory and focus on university changes (e-g- fundamentals like defining critical points of what knowledge is, what and how to teach, etc.).

Course had a strong link to specific disciplinary field of the participants. Participants had to develop a project where they should explore the link between sustainability education, what ES mean, and how it can be link with their specific field of expertise/ education programme.

See more in, for example, http://blogs.ubc.ca/tagsustainability/

The reward system is very important to engage people participating in initiatives regarding sustainability in higher education. Examples used are: symbolic monetary reward, certificate, nominate as sustainability champions.

As key actors, students can have an important role in integrate ES and foster change in educational systems. Students can be a powerful link between university and community, with continuity for future. This perspective can be used to integrate ES and in educational strategies - make university a more visible and explicit open system, integrated in the overall society.

Main pedagogical approaches:
Pedagogical approaches vary from Problem Based Leaning (PBL) to community based learning, living library. Different strategies should be always looked into and how they can be combined with already existing strategies like field trips, laboratory works, etc. It is a way to innovate teaching and learning processes towards ES (for academic staff and students).

Drivers:
The main driver to contact and get the support from top management was the fact that sustainability education is part of faculty vision and mission.

Challenges:
The HE need to change towards an ES facing challenges at different levels, structures and needs.

There is a need for systematic changes towards a more interdisciplinary, collaboration, community based education. There is a need for more transformative learning (which challenge HE perspectives, values, views and beliefs). All these changes meet challenges, to cope with the challenges it is needed for example, to create systems of recognition, and those are involved.

At an educational level, examples of how to address challenges are: create an integrative learning theme (with potential for ES); a strategy is to explore what are relevant in core curriculum e use as integrative theme and to contextualize ES; and promote systems thinking.

Another example is the use of PBL. PBL allows students to work with real and open problems and in close relation with community. It is out of university that students will understand better the role of university, and consequently their role, in society - what can be done, improved and explored.

APPENDIX 4: Selection of cases for study

Paper submitted at EDULEARN12 - International Association of Technology, Education and Development (IATED) 2012, Barcelona, Spain

In the following in the extended abstract as it is provided by conference website at:
http://library.iated.org/view/GUERRA2012PRO

PROBLEM BASED LEARNING AND EDUCATION FOR SUSTAINABLE DEVELOPMENT: AN OVERVIEW IN ENGINEERING EDUCATION

A. Guerra
Aalborg University, UNESCO Chair in PBL in Engineering Education (DENMARK)

The integration of knowledge and competencies that will allow students to develop innovative and sustainable technologies for future is one of the main challenges of engineering education. An engineering education that integrates education for sustainable development (ESD) perspectives claims for a learning approach centered on students, interdisciplinary and problem oriented and this cannot be achieve through a "add on" strategy. Example of such active learning approaches are problem based learning (PBL), project based learning (PjBL), case study, role play, group discussion, field work (Sterling 2004; Bourn and Neal 2008).

However engineering education still mainly characterized as traditional, focused on the transmission of knowledge through lectures, with an overcrowded curriculum with no space to explore new learning approaches and integrate content (Shepard et. al. 2009). The learning approaches mentioned are capable of integrating education for sustainable development (ESD) in engineering education at different levels, and do not aim to substitute the core scientific and technological knowledge but instead aligned with the social, economic and environmental dimensions of the professional practice (Lambrechts et. al. 2010).

It is agreed among ESD experts that PBL it is a suitable learning approach to integrate ESD in the engineering curricula (Segalàs 2009). PBL is characterized as an enquiry process where problems – mostly from real and complex situations – are formulated and drive the whole learning process. Several variations (models) of PBL are used, however each model shares some basic learning principles: (i) cognitive (contextualize learning, participatory, critical and are based on the students' experience); (ii) content nature (different types of knowledge are required as well as disciplinarity) and (iii) social environment (students learn through collaboration, where dialogue and communication among peers takes place) (Savin-Baden and Wilkie 2004; Kolmos et. al. 2009).

PBL approach promotes the development of competencies essential for ESD (e.g. critical thinking, participatory, problem orientated, interdisciplinary and transdisciplinary, creativity) (Huckle and Sterling 1996; Sterling 2004). There is a lack of studies that state which institutions in engineering education combine both, and what are the challenges and dynamics involved (Ferrer-Balas and Mulder 2005).

The paper aims to give an overview of engineering education institutions which have an explicit use of PBL and at same time integrate ESD in the curriculum. The main research question posed is: Which engineering education institutions, which explicitly make use of PBL, integrate ESD?

The methodology used was documentary analysis carried out in two phases. In phase one, reports, journals, and proceedings where analysed through content analysis to point and narrow down institutions. In phase two, the education vision and mission, and curriculum of the institutions selected from phase one were analysed though content analysis.

The outcomes from the study are mainly empirical and give an overview of the institutions make a use of PBL and integrate ESD and some insights of their discourses. For example, sustainable development is mainly visible in certain fields (e.g. civil engineering) and levels (e.g. master). PBL is not that visible as a learning approach at a university/ faculty level but more as a course or module level.

Keywords: problem based learning, sustainable development, engineering education, higher education institutions.

APPENDIX 5 Case Study – Strategy for data collection

Questions, methods and sources of evidence

Main questions & sub questions aimed to research

Question	Sub-questions
How, and why, is education for sustainable development integrated in the programme?	
	1. What was the point of departure to integrate SD in the programme?
	1.1. Is it for all university or only this programme?
	1.2. Why?
	2. Who was involved in programme design to integrate SD?
	2.1. Why?
	3. What are the main challenges?
	4. How can these challenges be addressed?
	5. What is the SD integration strategy in the programme? (e.g. stand-alone course, embedded in other courses...)
	5.1. Why?
	6. What are the SD learning objectives/ outcomes (content, skills and competencies) regarding to the SD?
	6.1. Why?
	7. How is the assessment done? Why?
	8. What is the main pedagogical approach used to teach SD content?
	8.1. Why?
	9. Who teaches SD?
	9.1. Why?
How is the curriculum organized around problems?	
	10. What was the educational intention in implementing PBL? (Any other programme uses the same approach)?
	11. What are the main phases of the PBL process?
	12. How does PBL process is related with the overall structure of the programme? (e.g. alignment between other curriculum elements, such staff, lectures and courses, collaboration with industry, etc.)
	13. In which ways are the problems presented to students?
	14. What are the main types of problems? (terms of content, context and structure)
	15. Who formulate the problems?
	16. What is the type of knowledge (e.g. factual/ objective; cognitive, procedural, metacognitive…) developed by students?
	16.1. Why?
	17. What is the type of disciplinarity students are involved in?

Question	Sub-questions
	17.1. Why?
	18. How do students report, and document, their PBL learning process?
	19. How, and when, are the learning objectives assessed?
What are the process competencies developed by students?	
	20. What is the level of criticality developed by the students?
	21. How do students **creatively** solve problems and integrate SD areas?
	22. How are the groups formed?
	23. How collaborative work supports students learning?
How do students use SD in the PBL process?	
	24. In which phases of the PBL process, do students apply SD knowledge?
	25. What areas of SD do students apply?
	25.1. Why?
	26. What are the challenges faced by students in relation to the areas of SD applied?
	26.1. How do students address these challenges?
	27. How do PBL and ESD affect the students' motivation towards the learning process?
	28. How staff supports students learning process and address the challenges mentioned? (e.g. facilitation process, type of facilitation, resources, field trips, etc.)
	29. What do students reflect on in the learning process, from a SD perspective (process oriented)?
	29.1. Why?
	30. What do students reflect on in the technological solutions from a SD perspective (product oriented)?
	30.1. Why?
	31. What importance do students attribute in integrating SD in their PBL process?
	32. What other SD content, skills or competencies would students like to learn?
	32.1. How
	32.2. Why?
	33. In which ways the learning environment change students' perspectives regarding to SD?

Relation between research questions and data collection strategy

Question Sub-questions	Content analysis	Interview	Observation
How, and why, is education for sustainable development integrated in the programme?			
1. What was the point of departure to integrate SD in the programme?		**X**	
1.1. Is it for all university or only this programme?		**X**	
1.2. Why?		**X**	
2. Who was involved in programme design to integrate SD?		**X**	
2.1. Why?		**X**	
3. What are the main challenges?		**X**	
4. How can these challenges be addressed?		**X**	
5. What is the SD integration strategy in the programme?(e.g. stand-alone course, embedded in other courses...)	**X**		
5.1. Why?		**X**	
6. What are the SD learning objectives/ outcomes (content, skills and competencies) regarding to the SD?	**X**		
6.1. Why?		**X**	
7. How is the assessment done?	**X**		
7.1. Why?		**X**	
8. What is the main pedagogical approach used to teach SD content?		**X**	**X**
8.1. Why?		**X**	
9. Who teaches SD? (in terms of expertise field)		**X**	
9.1. Why?		**X**	
How is the curriculum organized around problems?			
10. What was the educational intention in implementing PBL? (Any other programme uses the same approach)?		**X**	
11. What are the main phases of the PBL process?		**X**	
12. How does PBL process is related with the overall structure of the programme? (e.g. alignment between other curriculum elements, such staff, lectures and courses, collaboration with industry, etc.)	**X**	**X**	
13. In which ways are the problems presented to students?		**X**	
14. What are the main types of problems? (terms of content, context and structure)	**X**		

Question Sub-questions	Content analysis	Interview	Observation
15. Who formulate the problems?		X	
16. What is the type of knowledge (e.g. factual/ objective; cognitive, procedural, metacognitive…) developed by students?	X		
16.1. Why?		X	
17. What is the type of disciplinarity students are involved in?	X		
17.1. Why?		X	
18. How do students report, and document, their PBL learning process?	X		
19. How, and when, are the learning objectives assessed?		X	
What are the process competencies developed by students?			
20. What is the level of criticality developed by the students?		X	X
21. How do students **creatively** solve problems and integrate SD areas?		X	X
22. How are the groups formed?		X	
23. How collaborative work supports students learning?		X	X
How do students use SD in the PBL process?			
24. In which phases of the PBL process, do students apply SD knowledge?	X	X	X
25. What areas of SD do students apply?	X		X
25.1. Why?		X	
26. What are the challenges faced by students in relation to the areas of SD applied?		X	X
26.1. How do students address these challenges?		X	X
27. How do PBL and ESD affect the students' motivation towards the learning process?		X	
28. How staff supports students learning process and address the challenges mentioned? (e.g. facilitation process, type of facilitation, resources, field trips, etc.)		X	X
29. What do students reflect on in the learning process, from a SD perspective (process oriented)?	X		
29.1. Why?		X	
30. What do students reflect on in the technological solutions from a SD perspective (product oriented)?	X		
30.1. Why?		X	
31. What importance do students attribute in integrating SD in		X	

Question Sub-questions	Content analysis	Interview	Observation
their PBL process?			
32. What other SD content, skills or competencies would students like to learn?		**X**	
32.1. How?		**X**	
32.2. Why?		**X**	
33. In which ways the learning environment change students' perspectives regarding to SD?		**X**	

Research methods by source of evidence

Content analysis

Research question Sub-questions	Curriculum	Students reports[(1)]
How, and why, is education for sustainable development integrated in the programme?		
5. What is the SD integration strategy in the programme? (e.g. stand-alone course, embedded in other courses...)	**X**	
6. What are the SD learning objectives/ outcomes (content, skills and competencies) regarding to the SD?	**X**	
7. How is the assessment done?	**X**	
How is the curriculum organized around problems?		
12. How does PBL process is related with the overall structure of the programme? (e.g. alignment between other curriculum elements, such staff, lectures and courses, collaboration with industry, etc.)	**X**	
14. What are the main types of problems? (terms of content, context and structure)	**X**	**X**
16. What is the type of knowledge (e.g. factual/ objective; cognitive, procedural, metacognitive…) developed by students?	**X**	**X**
17. What is the type of disciplinarity students are involved in?	**X**	**X**
18. How do students report, and document, their PBL learning process?	**X**	
How do students use SD in the PBL process?		
24. In which phases of the PBL process, do students apply SD knowledge?		**X**
25. What areas of SD do students apply?		**X**
29. What do students reflect on in the learning process, from a SD perspective (process oriented)?		**X**
30. What do students reflect on in the technological solutions from a SD perspective (product oriented)?		**X**

(1) Include: project catalogues, cases descriptions, scenarios, projects proposals, journals, reports, agendas, etc.

Interview

Research question Sub-questions	Study Board	Lecturers	Facilitators	Students
How, and why, is education for sustainable development integrated in the programme?				
1. What was the point of departure to integrate SD in the programme?	**X**			
1.1. Is it for all university or only this programme?	**X**			

Research question Sub-questions	**Study Board**	**Lecturers**	**Facilitators**	**Students**
1.2. Why?	**X**			
2. Who was involved in programme design to integrate SD?	**X**			
2.1. Why?	**X**			
3. What are the main challenges?	**X**			
4. How can these challenges be addressed?	**X**			
5.1. Why the strategies use to integrate SD?	**X**			
6.1 Why the SD learning outcomes/ objectives?	**X**	**X**		
7.1. Why the assessments approach?	**X**	**X**		
8. What is the main pedagogical approach used to teach SD content?	**X**	**X**		
8.1. Why?	**X**	**X**		
9. Who teaches SD? (in terms of expertise field)	**X**			
9.1. Why?	**X**			
How is the curriculum organized around problems?				
10. What was the educational intention in implementing PBL? (Any other programme uses the same approach)?	**X**			
11. What are the main phases of the PBL process?	**X**	**X**	**X**	
12. How does PBL process is related with the overall structure of the programme? (e.g. alignment between other curriculum elements, such staff, lectures and courses, collaboration with industry, etc.)	**X**		**X**	
13. In which ways are the problems presented to students?	**X**	**X**	**X**	**X**
15. Who formulate the problems?	**X**		**X**	
16.1. Why the type of knowledge?	**X**	**X**	**X**	
17.1. Why the type of disciplinarity?	**X**	**X**	**X**	
19. How, and when, are the learning objectives assessed?	**X**	**X**	**X**	
What are the process competencies developed by students?				
20. What is the level of criticality developed by the students?			**X**	**X**
21. How do students **creatively** solve problems and integrate SD areas?			**X**	**X**

Research question Sub-questions	Study Board	Lecturers	Facilitators	Students
22. How are the groups formed?			**X**	
23. How collaborative work supports students learning?		**X**	**X**	
How do students use SD in the PBL process?				
24. In which phases of the PBL process, do students apply SD knowledge?			**X**	**X**
25.1. Why the use of that (depend the answer of question 25) areas of SD?			**X**	**X**
26. What are the challenges faced by students in relation to the areas of SD applied?			**X**	**X**
26.1. How do students address these challenges?			**X**	**X**
27. How do PBL and ESD affect the students' motivation towards the learning process?			**X**	**X**
28. How staff supports students learning process and address the challenges mentioned? (e.g. facilitation process, type of facilitation, resources, field trips, etc.)			**X**	**X**
29.1. Why do students reflect on (depend on content analysis of students' documentation) when assessing the learning process?			**X**	**X**
30.1. Why do students reflect on (depend on content analysis of students' documentation) when doing technological assessment?			**X**	**X**
31. What importance do students attribute in integrating SD in their PBL process?			**X**	**X**
32. What other SD content, skills or competencies would students like to learn?				**X**
32.1. How?				**X**
32.2. Why?				**X**
33. In which ways the learning environment change students' perspectives regarding to SD?	**X**	**X**	**X**	**X**

Observations

Research question Sub-questions	Group[1]	Lectures[2]
How, and why, is education for sustainable development integrated in the programme?		
8. What is the main pedagogical approach used to teach SD content?		**X**

Research question Sub-questions	Group[1]	Lectures[2]
How, and why, is education for sustainable development integrated in the programme?		
What are the process competencies developed by students?		
20. What is the level of criticality presented (developed) by students?	**X**	
21. How do students creatively solve problems and integrate SD?	**X**	
23. How collaborative work supports students learning? (e.g. participation, discussion, accomplishment, progression, etc.)	**X**	
How do students use SD in the PBL process?		
24. In which phases of the PBL process, do students apply SD knowledge?	**X**	
25. What areas of SD do students apply?	**X**	**X**
26. What are the challenges faced by students in relation to the areas of SD applied?	**X**	
28. How staff supports students learning process and address the challenges mentioned? (e.g. facilitation process, type of facilitation, resources, field trips, etc.)	**X**	**X**

(1) Observations depend on….

(2) Observations depend on….

APPENDIX 6 Case Study – Data collection instruments

Documentary analysis grids

Curriculum analysis

Aim

The aim of the analysis of the curriculum is to find out which programmes have an education for sustainable development approach. This implies the integration of knowledge, skills and competencies regarding to sustainable development and its link with the disciplinary field in the curriculum

Profile

NAME OF THE PROGRAMME:

DEGREE:

UNIVERSITY:

FACULTY:

DEPARTMENT/ SCHOOL:

STUDY BOARD:

ACCESS TO THE CURRICULUM:

Content Analysis Grids

1. Vertical analysis of the curriculum

1.1. Structure:

1.2. Overall learning strategies:

1.3 PBL profile:

Table 1. Programme overall qualification profile

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
Knowledge	Factual & Conceptual				
	Procedural				
	Metacognitive				
	Personal, evolutionary (*know-why*)				
Disciplinarity	Disciplinary				
	Multidisciplinary				
	Cross-disciplinarity				
	Interdisciplinary				
	Transdisciplinary				
Learning	Self-directed learning				

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
	Contextual learning				
competencies	Problem analysis & formulation				
	Problem solving				
	Critical thinking				
	Creativity & innovation				
	Communication				
	Collaboration				

1.4. Sustainable development/ sustainability profile:

Table 1. Overall programme qualification profile

Category	Quotes	In connection with (*)	Curriculum as
A. Environmental			
B. Human rights			
C. Labour practices and decent work			
D. Society			
E. Product responsibility			
F. Economic			
G. Ethics and professional practice(**)			

(*) Indicators from the Global Report Initiative (GRI) - https://www.globalreporting.org/Pages/default.aspx. The GRI presents a set of indicators for the categories referred as example of good sustainable practice. The codes present in the last column is referred to a code given (see table 2.2.1, page x)

(**) Add to the indicators stated by (*)

2. Horizontal analysis of the curriculum

2.1. Introduction to courses and project modules:

Table 2 Programme modules, main instruction strategy and codes of analysis

Semester	Programme modules	Main instruction type	Code
1st			
2nd			

3rd			
4th			

2.2. PBL profile

Table 3 Courses and projects' PBL profile

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
Knowledge	Factual & Conceptual					
	Procedural					
	Metacognitive					
	Personal, evolutionary (know-why)					
Disciplinarity	Disciplinary					
	Cross-disciplinary					
	Multidisciplinary					
	Interdisciplinary					
	Transdisciplinary					
Learning	Self-directed learning					
	Contextual learning					
Competencies	Problem analysis & formulation					
	Problem solving					
	Creativity & innovation					
	Communication					
	Critical thinking					
	Collaboration					

2.3. Sustainable development/ sustainability profile

Table 4 Courses and projects' modules SD profile

Category	Modules' code	Quotes	In connection with(*)	Learning outcome
A. Environmental				
B. Human rights				
C. Labour practices and decent work				

Category	Modules' code	Quotes	In connection with(*)	Learning outcome
D. Society				
E. Product responsibility				
F. Economic				
Ethics and professional responsibility (**)				

Students' projects analysis

Project's information

TITLE:

NO. PAGES:

AUTHORS:

PROGRAMME, SEMESTER & YEAR:

SUMMARY:

PBL profile

	PBL element	Presence	Remarks	Page(s)
I.	Background information & problem analysis	Yes☐ No☐		
	Real and open situation	Yes☐ No☐		
	Problem formulation	Yes☐ No☐		
II.	Solving process	Yes☐ No☐		
III.	Possible solutions	Yes☐ No☐		
	Problem answered/	Yes☐ No☐		
	Goals reached	Yes☐ No☐		
IV.	Reflexive in process	Yes☐ No☐		
V.	Other	Yes☐ No☐		

SD aspects and codes

	Quotes from the project	Word freq.
A. Environ-ment		
B. Human rights		
C. Labour practices and decent work		
D. Society		
E. Product responsibility		
F. Economics		

Interview guides by group of interviewees

Study board

Interview guide	Research questions • Purposes
Introduction and background information	• Collect background information about the interviewee and the programme
1. Presenting myself, my project & the choice of the programme (because has SD as core discipline)	
2. Name, field of expertise, time teaching the course, experience in PBL method	
3. How long has been the programme running?	
4. What were the main challenges in design the programme?	
5. What are the overall learning objectives of the programme?	
6. How the assessment is done? Why?	
7. What do you considered to be a gain for students in this programme?	**How, and why, is education for sustainable development integrated in the programme?**
Education for Sustainable Development (ESD)	• Know ESD vision and definition; • Understand how SD is integrated in the programme (actors, learning approaches, assessment strategies, etc.)
8. What was the point of departure to integrate SD in the programme?	
9. Is it for all university or only this programme? Why?	
11. Who was involved in programme design to integrate SD?	
12. Could you point some reasons why choose those professionals?	
13. What were the main challenges?	
14. How these challenges were addressed?	
15. Who teaches SD?	
16. Could you point reasons of that choice?	
17. Please, select what you think is relevant to educate for sustainable development (ESD) **(use checklist A & B)**	
17.1. Why do you considered those relevant?	
17.2. What could be added to these cards? Why?	
17.3. Do these cards reflect the ESD approach in the programme?	
17.4. How did ESD integrate in the programme?	
17.5. What are the main pedagogical approaches?	**How is the curriculum organized around problems?**
Problem Based Learning (PBL)	• Understand the PBL approach and its relations with the overall programme; • Outline the purposes of implementing PBL;
18. What was the educational intention in implementing PBL?	
19. What are the main phases of the PBL process?	
20. How do lectures relate with PBL process?	
21. What other kind of resources and facilities are need for PBL process?	
22. In which ways are the problems presented to students?	
23. Who formulate the problems?	
24. How, and when, are the learning objectives assessed?	
25. From the cards present, could you point out the knowledge students mobilized? **(use checklist C)**	
25.1. Could you elaborate on your choice?	
26. From the cards present, could you point learning students are involved more? (present cards with examples from different disciplinarity)	**How do students use SD in the PBL process?**
26.1. Could you elaborate on your choice? **(Q17.1.)**	• Know SD perspectives students develop in

Synergy between PBL and ESD **27.** In which ways the learning environment change students' perspectives regarding to SD?	their education

Lecturers

INTERVIEW GUIDE	**Research questions** • Purposes
Introduction and background information **1.** Presenting myself, my project & the choice of the programme (because has SD as core discipline) **2.** Name, field of expertise, time teaching the course, experience in PBL method **3.** How long do you teach the theme? **4.** What are the overall learning objectives? **5.** How the assessment is done? Why? **6.** What do you considered to be a gain from your lecture?	• Collect background information about the interviewee
Education for Sustainable Development (ESD) **7.** Please, select what you think is relevant to educate for sustainable development (ESD) **(use checklist A & B)** **7.1.** Why do you considered those relevant? **7.2.** What could be added to these cards? Why? **7.3.** Do these cards reflect the ESD approach in the programme? **7.4.** What are the main pedagogical approaches? Why? **8.** What were the main challenges in designing a SD course / to integrate SD in our lecture?	**How, and why, is education for sustainable development integrated in the programme?** • Know ESD vision and definition; • Outline the structure of the lecture (learning approaches, objects, etc.) • Understand SD delivery content through lectures
Problem Based Learning (PBL) **9.** What are the main phases of the PBL process? **10.** How do lectures relate with PBL process? **11.** What other kind of resources and facilities are need for PBL process? **12.** In which ways are the problems presented to students? **13.** Who formulate the problems? **14.** How, and when, are the learning objectives assessed? **15.** From the cards present, could you point out the knowledge students mobilized? **(use checklist C)** **15.1.** Could you elaborate on your choice? **16.** From the cards present, could you point learning students are involved more? **(use checklist D)** **16.1.** Could you elaborate on your choice? **17.** How collaborative work supports students learning ESD?	**How is the curriculum organized around problems?** • Understand the lecture perspective about the PBL approach and its relations with the lecture; • Outline the purposes of implementing PBL; • Assess the type of knowledge and disciplinary aimed for students **What are the process competencies developed by students?** • Overview of the impact of collaborative work on students
Synergy between PBL and ESD **19.** In which ways the learning environment change students' perspectives regarding to SD? **(Q33)**	**How do students use SD in the PBL process?** • Know SD perspectives students develop in their education

Facilitators

INTERVIEW GUIDE	RESEARCH QUESTIONS
	• Purposes
Introduction and Background information	• Collect background information about the interviewee
1. Presenting myself, my project & the choice of the programme (because has SD as core discipline)	
2. Name, field of expertise, time teaching the course, experience in PBL method	
3. In your experience as facilitator, do you observe students' relate their projects with SD (even if informal)?	**How is the curriculum organized around problems?**
Problem Based Learning (PBL)	• Understand the facilitators perspective about the PBL approach; • Outline the purposes of implementing PBL; • Understand the PBL approach in practice • Assess the type of knowledge and disciplinary developed by students;
4. Could you compare the PBL process students have with the phases I have broadly in the scheme.	
4.1. How PBL is mapped in the rest of the curriculum? Which relations with others courses, for example?	
4.2. How do lectures relate with PBL process?	
4.3. What other kind of resources and facilities are need for PBL process?	
4.4. In which ways are the problems presented to students?	
4.5. Who formulate the problems?	
4.6. How groups are formed?	
5. How, and when, are the learning objectives assessed?	
6. From the cards present, could you point out the knowledge students mobilized? **(use checklist C)**	**What are the process competencies developed by students?** • Assess the level of criticality developed by students
6.1. Could you elaborate on your choice?	
7. From the cards present, could you point learning students are involved more? **(use checklist D)**	
7.1. Could you elaborate on your choice?	
8. From the cards present, could you point what is most common students' critical thinking? **(use checklist E)**	
8.1. Could you elaborate on your choice?	• Know SD vision and definition
8.2. What is common to students reflect on when assessing the learning process? Why?	
8.3. What is common to students reflect on when doing technological assessment of the solutions? Why?	
Education for Sustainable Development (ESD)	**How do students use SD in the PBL process?** • Understand how students integrate SD in their PBL process; • Outline the main challenges; • Know SD perspectives students develop in students' education;
9. Please, select what you think is relevant to educate for sustainable development (ESD) **(use checklist A & B)**	
9.1. Why do you considered those relevant?	
9.2. What could be added to these cards? Why?	
Synergy between PBL and SD	
10. Can you relate the examples in the cards with the PBL process scheme?	
10.1. In each phases do students apply SD perspectives?	
10.2. Is it mandatory or compulsory applies analysis under a SD perspective?	
10.3. Which are the common SD areas applied by students? Why?	
10.4. What are the main challenges posed to students to integrate SD?	
10.5. As a facilitator, how can you support students in face these challenges?	

10.6. How collaborative work supports students learning?

10.7. How do students creatively solve problems and integrate SD areas?

10.8. How do PBL and ESD affect the students' motivation towards the learning process?

11. In which ways the learning environment change students' perspectives regarding to SD?

Students

Interview guide	**Research questions** • Purposes
Introduction and Background information	• Collect background information about the interviewee
1. Presenting myself, my project & the choice of the programme (because has SD as core discipline) **2.** Names, semester of study, experience of PBL method **3.** Why did you choose this programme? **4.** What are your expectations?	
Problem Based Learning (PBL)	**How is the curriculum organized around problems?**
5. Could you compare the PBL process you experience with the broadly scheme I have represented here? **5.1.** Can you give me some examples of what you do (in each phase)? **5.2.** How are the problems presented to you? **6.** From the cards present, could you point out the common activities you do? **(use checklist C)** **6.1.** Can you give examples? **7.** From the cards present, could you point similar examples with your PBL process? **(use checklist D)** **7.1.** Could you elaborate on your choice?	• Understand the facilitators perspective about the PBL approach; • Outline the purposes of implementing PBL; • Understand the PBL approach in practice • Assess the type of knowledge and disciplinary developed by students;
8. From the cards present, could you point what is most common students' critical thinking? **(use checklist E)** **8.1.** Can you give examples? **8.2.** Do you apply any of similar strategies in during the solving process? How? **8.3.** And what about the technological assessment of the solutions? How? **8.4.** Is it frequent to include sustainable development aspects in these discussions? Why? **9.** How do you relate lectures relate with your project?	**What are the process competencies developed by students?** • Assess the level of criticality developed by students
Education for Sustainable Development (ESD)	
10. Do the lectures address SD issues that you may use? **11.** Please, select what you think is relevant to learn regarding to sustainable development (SD) **(use checklist A & B)** **11.1.** Why do you considered important? **11.2.** Did you learn that? **11.3.** What do would like to learn and it is not represented here? **11.4.** How?	• Know SD vision and definition

11.5 Why?

Synergy between PBL and ESD

12. Can you relate the examples in the cards with the PBL process scheme?

12.1. In each phases do you apply (these) SD perspectives?

12.2. Is it mandatory or compulsory applies analysis under a SD perspective?

12.3. Which are the common SD areas you apply? Why?

12.4. What are the main challenges faced when discussing and use SD?

12.5. How do address these challenges?

12.6. How do you think team work supports your learning?

12.7. What do you think is the role of creativity to solve sustainable problems?

12.8. How does PBL facilitate in this process?

12.9. Do you consider that the combination of PBL and ESD affect your motivation? Why and how?

13. In which ways the learning environment change students' perspectives regarding to SD?

How do students use SD in the PBL process?

- Understand how students integrate SD in their PBL process;
- Outline the main challenges;
- Know SD perspectives students develop in their education;

Checklist as appendixes of interviews guides

Checklist A: Education for Sustainable Development

Name: **Date:**

Capable of placing engineering field in perspective with others areas of knowledge	
Develop knowledge beyond core engineering disciplines(STEM) like sociology, ethics, business, etc.	
Aware that engineering practice influences, and is influenced by, other professional practices	
Handle uncertainty by keeping open as many future options possible	
Reflect on how alternative solutions that fit with the sustainable development approach can be identified	
Accept that there are no guarantees that our solutions will be truly sustainable – we therefore must do our best with the skills, knowledge and resources we have at our disposal	
Develop alternative solutions that are locally relevant	
Develop alternative solutions that are culturally appropriate	
Seek to minimize the negative, and maximizing the positive, impacts of engineering practices both locally and globally	
Use technical engineering knowledge to solve real problems	
Involve others' perspectives and knowledge (e.g. local representatives, politicians, stakeholders, etc.) in defining and solving complex problems	
Retain the sustainability focus on the intended outcome right through the assessment and/ or implementation of the solution	
Bring social, economic and environmental experts and implications to seek a balanced decision	
Professional engineers participate in the decision making as well as in their professional roles	
Participate actively in the discussion and definition of social and economic policies to redirect society to a more sustainable development.	
Divergent thinking among peers	
Thinking "out-of-the box"	
Combining old ideas with new ideas	
Create new ideas with others	

Checklist B: Sustainable Development

Name:	**Date:**
Materials (e.g. conservation of the global resource base; efforts to reduce the material intensity and increase the efficiency of the economy; ability to use recycled input materials; and the overall costs of operations.)	
Energy (e.g. renewable, efficiency, consumption, etc.)	
Water (e.g. consumption, efficiency, etc.)	
Biodiversity (e.g. impacts on, recovering, etc.)	
Emissions, effluents and waste (e.g. reduction, management)	
Products and services (e.g. life cycle assessment, impact of, initiatives for mitigation, transportation etc.)	
Human rights (e.g. child labor, forced and compulsory labor, discriminatory behaviors, religious, etc.)	
Labor practices and decent work (e.g. employment, labor/ management relations, training and education, diversity & equal opportunity, etc.)	
Local government	
Public policy and legislation	
Local community engagement, impacts assessment and development programs	
Product responsibility (e.g. public safety and health, marketing discourse, labeling and customer privacy)	
Economic performance (e.g. direct economic impacts of the organization's activities and the economic value added by these activities on local communities)	
Market presence and interactions in specific markets (e.g. policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation)	
Indirect economic impacts (e.g. economic impacts created as a result of the organization's economic activities and transactions)	
Risk analysis (e.g. financial implications and other risks and opportunities for the organization's activities due to climate change)	
Emerging economies in low-carbon economy and growth in developing country investment	

Checklist C: Knowledge

Name: **Date:**

Knowledge about facts, elements and/ or terminology	
Knowledge of principles and generalizations	
Knowledge of theories, models and structures	
Knowledge of subject-specific skills and algorithms	
Knowledge of subject-specific techniques and methods	
Knowledge of criteria for determining when to use appropriate procedures (e.g. systematic assessment and readjustment of the solving methodology - methods, approaches to questions formulated, etc.)	
Strategic knowledge (combination of know what, know when and know how) (e.g. transfer and apply knowledge according to the situation - which methods, how to use, when to use, why it is use and related with the overall problem)	
Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (combination of know-what, know-when, know-how) (e.g. go back and look if the solving process is aligned with the problem formulated)	
Awareness of the limits of one's knowledge (self-knowledge)	
Knowledge regarding the reasons behind the *know-what*, *know-when*, *know-how* and *know-who*	
Knowledge shared and cultured (relate with knowledge production)	
Knowledge about others (actors, disciplines, communities, systems) values and attitudes (importance and challenges of others moral perspectives on issues) (e.g. other discipline members beliefs of what is right and wrong, values and behavior, etc.)	

Checklist D: Disciplinarity

Name: **Date:**

Knowledge within your engineering subfield	
Study of courses related with engineering (e.g. mathematics, physics, etc.)	
Have knowledge from different disciplines (e.g. history)	
Aware of others disciplines works	
Study of others subjects like finance, humanities, etc.	
Topic of investigation is from other area of study	
Use of techniques and tools that is commonly used by experts of other disciplines (e.g. using inter-view as method in civil engineering project)	
Combines methods and approaches from different disciplines	
Two or more disciplines which interact and combine their expertise to jointly address an area of common concern.	
Formulate new theories and methodologies from different disciplines	
Two disciplines merge to create a new one (e.g. nanotechnology, product design and technology…)	

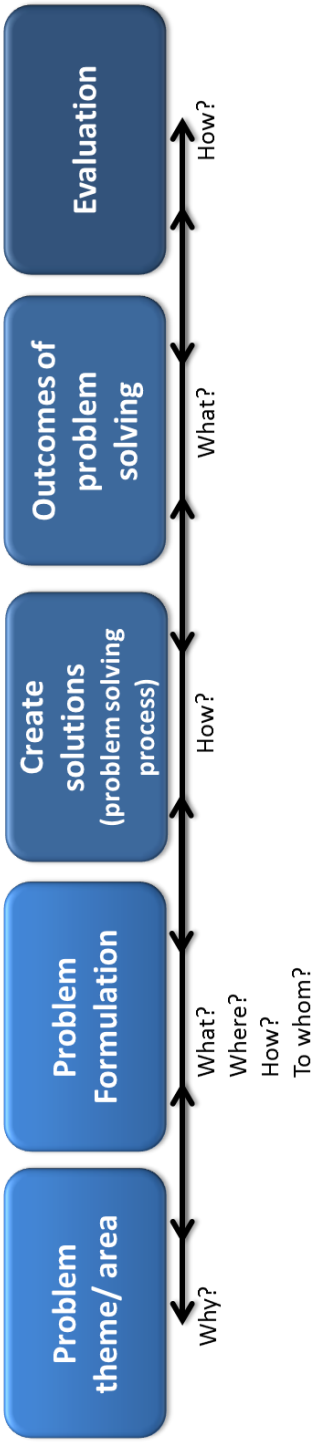
Checklist E: Criticality

Name: **Date:**

Identify factual and normative aspects of the problem	
Explain and understand and questioning the factual and normative aspects of the problem	
Analysing and assessing the factual and normative aspects of the problem in order to outline strategies	
Individual questioning and examining of the settings around problem	
Transformation of values and beliefs	
Change own points of view of existing economic, political, scientific and environmental structures and mechanisms	
Community (group) analysis as well as assess alternative possibilities and strategies	
Different points of views on each case	
Recognition that knowledge is dependent on latent interests and values	
Recognition that progress and development take place by challenging, querying, criticizing and breaking down parts of existing parts to reconstruct a new and alternative one.	
Re-built new practices without the deficiencies and errors of previous one.	
Consistent criteria of assessment to oneself and others (e.g. group is acknowledgeable of each member potentialities, skills, knowledge and opinions)	
Thinking involves emotions, feelings, intuition, and reason	
Urge to transform an intention to act in a real action to promote change	

Scheme: Problem Based Learning

Name: **Date:**



Direct observation schedules

Students' presentations (*status seminar*)

Programme:

Date:

Purpose:

Object of observation:

1. Group's identification and project's theme

Groups numbers	Identification
1	Students:
	Facilitator(s):
	Project's theme:
2	Students:
	Facilitator(s):
	Project's theme:
3	Students:
	Facilitator(s):
	Project's theme:
4	Students:
	Facilitator(s):
	Project's theme:
5	Students:
	Facilitator(s):
	Project's theme:

Remarks:

2. Sustainable development profile

	SD indicators / Time	Groups n.o ___				
Environment	Environment					
	Materials					
	Energy					
	Water					
	Biodiversity					
	Emissions, effluents, and waste					
	Products and services					
	Compliance					
	Transport					
Human rights	Human rights					
	Investment and procurement practices					
	Non-discrimination					
	Freedom of association and collective bargaining					
	Child labour					
	Forced and compulsory work					
	Security practices					
	Indigenous					
Labour practices and decent work	Employment					
	Labour/ management relations					
	Occupational health and safety					
	Training and Education					
	Diversity and equal opportunity					
	Equal remuneration for men and women					
Society	Society					
	Local community					
	Corruption					
	Public policy					
	Compliance					
Product responsibil-ity	Product responsibility					
	Costumer health and safety					
	Product and service labelling					
	Marketing and communication					
	Costumer privacy					
	Compliance					
Econom-ics	Economic performance					
	Market presence					
	Indirect economics impacts					
	Ethics and professional responsibility					

Remarks:

3. Problem based learning profile

PBL principles	Category / Time	Groups n.o _____				
Knowledge	Factual & Conceptual					
	Procedural					
	Metacognitive					
	Personal, evolutionary (know-why)					
Disciplinarity	Disciplinary					
	Cross-disciplinarity					
	Interdisciplinary					
Competencies	Lifelong learning					
	Contextual learning					
	Problem analysis & formulation					
	Problem solving					
	Creativity & innovation					
	Communication					
	Collaboration					

Remarks:

APPENDIX 7 Case Study – Data analysis criteria

Criteria and indicators for content analysis

PBL principles, criteria and indicators

PBL principles	Criteria	Example of indicators
Knowledge	Factual & conceptual (*know what*)	Knowledge about facts, models and theories, generalizations, principles, etc.
	Procedural (*know how*)	Knowledge of subject-specific skills and algorithms Knowledge of subject-specific techniques and methods Knowledge of criteria for determining when to use appropriate procedures (e.g. systematic assessment and readjustment of the solving methodology - methods, approaches to questions formulated, etc.)
	Metacognitive	Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (combination of know-what, know-when, know-how) Strategic knowledge (combination of know what, know when and know how) (e.g. transfer and apply knowledge according to the situation - which methods, how to use, when to use, why it is use and related with the over-all problem) Awareness of the limits of one's knowledge (self-knowledge)
	Personal, evolution-ary (*know-why*)	Knowledge regarding the reasons behind the know-what, know-when, know-how and know-who Knowledge shared and cultured (relate with knowledge production) Knowledge about others (actors, disciplines, communities, systems) values and attitudes (importance and challenges of others moral perspectives on issues) (e.g. other discipline members beliefs of what is right and wrong, values and behaviour, etc.)
Disciplinarity	Disciplinary	Knowledge within your engineering subfield Study of courses related with engineering (e.g. mathematics, physics, etc.)
	Cross-disciplinary	Topic of investigation is from other area of study Use of techniques and tools that is commonly used by experts of other disciplines (e.g. using interview as method in civil engineering project)
	Multidisciplinary	Have knowledge from different disciplines (e.g. history) Aware of others disciplines works Study of others subjects like finance, humanities, etc.
	Interdisciplinary	Combines methods and approaches from different disciplines Two or more disciplines which interact and combine their expertise to jointly address an area of common concern.

PBL principles	Criteria	Example of indicators
	Transdisciplinary	Formulate new theories and methodologies from different disciplines Two disciplines merge to create a new one (e.g. nanotechnology, product design and technology…)
Learning	Self-directed learning	Be able to search and self-learning new information and knowledge (self-directed learning); Be able to learn how to learn
	Contextual Learning	Learning from, and within, real and concrete situations, cases.
Competencies	Problem analysis and formulation	Be able to analyse and problematize a give situation and formulate proper and relevant problems to be solved.
	Problem solving	Be able to develop a proper a plan, strategy and methodology to solve a given problem Be able to apply plan, strategy and methodology to solve a given problem
	Critical thinking	Analysing and assessing the factual and normative aspects of the problem in order to outline strategies Individual questioning and examining of the settings around problem Transformation of values and beliefs Change own points of view of existing economic, political, scientific and environmental structures and mechanisms Different points of views on each case Recognition that knowledge is dependent on latent interests and values Etc.
	Creativity and innovation	Be able to "think out of box"; provide new solutions; combine old ideas and methods to create new approaches
	Communication	Be able to communicate with others, written and orally
	Collaboration	Be able to work with others; group work; to collaborate; in teams; etc.

Sustainable Development aspects and indicators

Aspects	A. Environmental	B. Human Rights	C. Labour practices and decent work
Indicators	Environment Materials Energy Water Biodiversity Emissions, effluents, and waste Products and services Compliance Transport	Human rights Investment and procurement practices Non-discrimination Freedom of association and collective bargaining Child labour Forced and compulsory work Security practices Indigenous	Employment Labour/ management relations Occupational health and safety Training and Education Diversity and equal opportunity Equal remuneration for men and women
Criteria	**D. Society**	**E. Product responsibility**	**F. Economic**

Indicators	Society Local community Corruption Public policy Compliance	Product responsibility Costumer health and safety Product and service labelling Marketing and communication Costumer privacy Compliance	Economic performance Market presence Indirect economics impacts

Codes for interviews' analysis

Interview guide theme	Code/ colour	Sub-codes (e.g.)	
Education for Sustainable Development	ESD (yellow)	– Drivers for ESD integration – Who integrate – Main challenges – Challenges address	– Strategies to integrate – SD learning outcomes – Assessment – Pedagogy – Who teach
Problem Based Learning	Curriculum (orange)	– Educational intention – Phases (scheme F) – Programme structure – Problem presentation	– Problem formulation – Knowledge (checklist C) – Disciplinarity (checklist D) – LO assessment
	Processes Competencies (pink)	– Criticality (checklist E) – Creativity	– Group formation – Collaboration
Synergies between PBL and ESD	Synergies (light grey)	– PBL phases & SD (scheme F) – SD content (checklist A & B) – Challenges – Students' motivation – Support to students	– Reflect on learning process – Reflection on SD – Importance of SD – Other knowledge, skills & competencies – PBL and SD perspectives
Other	Background (red)	– Projects' presentation	– Interviewees
	Other experiences (dark grey)	– Professional	– Personal histories

Checklist content analysis grids (codes and indicators)

Education for sustainable development (ESD) (checklist A)

Criteria	Indicators
A.1. Systemic & holistic	**A.1.1.** Capable of placing engineering field in perspective with others areas of knowledge
	A.1.2. Develop knowledge beyond core STEM disciplines like sociology, ethics, business, etc.
	A.1.3. Aware that engineering practice influences, and is influenced by, other professional practices
A.2. Flexibility and adaptability	**A.2.1.** Handle uncertainty by keeping open as many future options possible
	A.2.2. Reflect on how alternative solutions that fit with the sustainable development approach can be identified
	A.2.3. Accept that there are no guarantees that our solutions will be truly sustainable – we therefore must do our best with the skills, knowledge and resources we have at our disposal
A.3. Contextual	**A.3.1.** Develop alternative solutions that are locally relevant and culturally appropriate
	A.3.2. Develop alternative solutions that are culturally appropriate
	A.3.3. Seek to minimize the negative, and maximizing the positive, impacts of engineering practices both locally and globally
A.4. Problem Solvers	**A.4.1.** Use technical engineering knowledge to solve real problems
	A.4.2. Involve others' perspectives and knowledge (e.g. local representatives, politicians, stakeholders, etc.) in defining and solving complex problems
	A.4.3. Retain the sustainability focus on the intended outcome right through the assessment and/ or implementation of the solution
A.5. Participatory & decision maker	**A.5.1.** Bring social, economic and environmental experts and implications to seek a balanced decision
	A.5.2. Professional engineers participate in the decision making as well as in their professional roles
	A.5.3. Participate actively in the discussion and definition of social and economic policies to redirect society to a more sustainable development.
A.6. Creativity and innovation	**A.6.1.** Divergent thinking among peers
	A.6.2. Thinking "out-of-the box"
	A.6.3. Combining old ideas with new ideas
	A.6.4. Create new ideas with others

Sustainable development aspects (checklist B)

Aspect	Indicators
B.1. Environmental	**B.1.1.** Materials (e.g. conservation of the global resource base and efforts to reduce the material intensity and increase the efficiency of the economy; ability to use recycled input materials; conservation of the global resource base; recycled materials and the overall costs of operations.)

Aspect	Indicators
	B.1.2. Energy (renewable, efficiency, consumption, etc.)
	B.1.3. Water (e.g. consumption, efficiency, etc.)
	B.1.4. Biodiversity (e.g. impacts on, recovering, etc.)
	B.1.5. Emissions, effluents and waste (e.g. reduction, management)
	B.1.6. Products and services (e.g. life cycle assessment, impact of, initiatives for mitigation, transportation etc.)
B.2. Social	**B.2.1.** Human rights (e.g. child labor, forced and compulsory labor, discriminatory behaviours, religious, etc.)
	B.2.2. Labour practices and decent work (employment, labor/ management relations, training and education, diversity & equal opportunity, etc.)
	B.2.3. Local government
	B.2.4. Public policy and legislation
	B.2.5. Local community engagement, impacts assessment and development programs
	B2.6. Product responsibility (e.g. public safety and health, marketing discourse, labeling and customer privacy)
B.3. Business and enterprise skills	**B.3.1.** Economic performance (e.g. direct economic impacts of the organization's activities and the economic value added by these activities on local communities)
	B.3.2. Market presence and interactions in specific markets (e.g. policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation)
	B.3.3. Indirect economic impacts (e.g. economic impacts created as a result of the organization's economic activities and transactions)
	B.3.4. Risk analysis (e.g. financial implications and other risks and opportunities for the organization's activities due to climate change)
	B.3.5. Emerging economies in low-carbon economy and growth in developing country investment

Types of Knowledge (checklist C)

Type of knowledge	Indicators
C.1. Factual & conceptual (know-what)	**C.1.1.** Knowledge about facts, elements and/ or terminology
	C.1.2. Knowledge of principles and generalizations
	C.1.3. Knowledge of theories, models and structures
C.2. Procedural (know-how)	**C.2.1.** Knowledge of subject-specific skills and algorithms
	C.2.2. Knowledge of subject-specific techniques and methods
	C.2.3. Knowledge of criteria for determining when to use appropriate procedures (e.g. systematic assessment and readjustment of the solving methodology - methods, approaches to questions formulated, etc.)
C.3. Metacognitive	**C.3.1.** Strategic knowledge (combination of know what, know when and know how) (e.g. transfer and apply knowledge according to the situation - which methods, how to use, when to use, why it is use and related with the overall problem)
	C.3.2. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (combination of know-what, know-when, know-how) (e.g. go back and look if the solving process is aligned with the problem formulated)

	C.3.3. Awareness of the limits of one's knowledge (self-knowledge)
C.4. Evolutionary, or world	**C.4.1.** Knowledge regarding the reasons behind the *know-what*, *know-when*, *know-how* and *know-who*
	C.4.2. Knowledge shared and cultured (relate with knowledge production)
	C.4.3. Knowledge about others (actors, disciplines, communities, systems) values and attitudes (importance and challenges of others moral perspectives on issues) (e.g. other discipline members beliefs of what is right and wrong, values and behavior, etc.)

Disciplinarity (checklist D)

Disciplinarity	Indicators
D.1. Disciplinary	**D.1.1.** Knowledge within your engineering subfield
	D.1.2. Study of courses related with engineering (e.g. mathematics, physics, etc.)
D.2. Multidisciplinary	**D.2.1.** Have knowledge from different disciplines (e.g. history)
	D.2.2. Aware of others disciplines works
	D.2.3. Study of others subjects like finance, humanities, etc.
D.3. Cross-disciplinary	**D.3.1.** Topic of investigation is from other area of study
	D.3.2. Use of techniques and tools that is commonly used by experts of other disciplines (e.g. using interview as method in civil engineering project)
D.4. Interdisciplinary	**D.4.1.** Combines methods and approaches from different disciplines
	D.4.2. Two or more disciplines which interact and combine their expertise to jointly address an area of common concern.
D.5. Transdisciplinary	**D.5.1.** Formulate new theories and methodologies from different disciplines
	D.5.2. Two disciplines merge to create a new one (e.g. nanotechnology, product design and technology…)

Criticality (checklist E)

Perspectives on critical thinking	Indicators
E.1. Epistemological	**E.1.1.** Identify factual and normative aspects of the problem
	E.1.2. Explain and understand and questioning the factual and normative aspects of the problem
	E.1.3. Analysing and assessing the factual and normative aspects of the problem in order to outline strategies
	E.1.4. Individual questioning and examining of the settings around problem
E.2. Transformative	**E.2.1.** Transformation of values and beliefs
	E.2.2. Change own points of view of existing economic, political, scientific and environmental structures and mechanisms
	E.2.3. Community (group) analysis as well as assess alternative possibilities and strategies
E.3. Dialectical	**E.3.1.** Different points of views on each case
	E.3.2. Recognition that knowledge is dependent on latent interests and values
	E.3.3. Recognition that progress and development take place by challenging, querying, criticizing and breaking down parts of existing parts to reconstruct a new and alternative one.
	E.3.4. Re-built new practices without the deficiencies and errors of previous one.
	E.3.5. Consistent criteria of assessment to oneself and others (e.g. group is acknowledgeable of each member potentialities, skills, knowledge and opinions)
E.4. Holistic	**E.4.1.** Thinking involves emotions, feelings, intuition, and reason
	E.4.2. Urge to transform an intention to act in a real action to promote change

Projects reports: PBL criteria and indicators:

PBL criteria		Examples of indicators
I.	Background information & problem analysis	e.g. State of the art leading to formulation of questions
	Real and open situation	e.g. From where students formulate problems (case study, situation, etc.)
	Problem formulation	e.g. Research questions, and or statements that suggest something problematic and aimed to be study
II.	Solving process	e.g. Plan, or methodology, for solving the problem
III.	Possible solutions	e.g. Formulate hypothesis and assumptions which may be the answer to the problem
	Problem answered	e.g. Answer the questions formulated and why.
	Goals reached	e.g. Set methodological goals, expected outcomes, linked with plan, or methodology, of solving the problem.
IV.	Reflexive in process	e.g. Point several rival theories, methods and solutions, and point arguments why to support the different choices

APPENDIX 8 Case Study – Contact later and project's summary

Case study contact letter

<DATE>

Vestre Havnepromenade 5, 9000 Aalborg

From:

Aida Guerra

PhD fellow, Department of Development and Planning, Aalborg University

To:

<NAME OF THE INTERVIEWEE>

My name is Aida Guerra, and I am a PhD fellow at UNESCO Chair in PBL in Engineering Education and Centre for PBL in Sustainability (Department of Development and Planning, Aalborg University.

My PhD theme is integration of education for sustainable development in engineering education through PBL.

In my study I plan to address these potentialities and challenges from a curriculum design perspective; curriculum delivered perspective; and learners' perspective.

You can find a summary of my PhD project also attached.

As there is a clear indication of attention to sustainable development in the curricula, I have chosen two programmes under the study board of Civil Engineering (master and bachelor programmes in Structural and Civil engineering) and two programmes under the study board of Planning and Geography (master and bachelor programmes in Urban, Energy and Environmental Planning, with specialization in Urban Planning and Management).

Therefore, I kindly ask you if you are willing to participate in an interview session for my study as <MEMBER OF STUDY BOARD, COORDINATOR, LECTURER, OR FACILITATOR STUDENT> of the M.Sc. <NAME OF THE PROGRAMME>

I propose some dates for the interview at: <DATES SUGGESTED FOR INTERVIEW THROUGH DOODLE POOL>. If none of the dates, and hours propose, are suitable for you, please let me know when are you available for interview.

Awaiting for your reply,

Sincerely,

Aida Guerra

PhD Fellow
UNESCO Chair in PBL in Engineering Education
Department of Planning and Development
Aalborg University
Vestre Havnepromenade 5, room 2.219
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Project summary

PHD PROJECT SUMMARY

Project: Sustainability in Engineering Education and Problem-Based Learning: Challenges for 21st Century

Name: Aida Guerra

Department of Development and Planning

Doctoral Programme in Planning and Development

Supervisor (s): Jette Holgaard and Anette Kolmos

SUMMARY

The excessive consumption of natural resources in name of the social and economic development has been putting an enormous pressure on the environment. Sustainable development is an approach to development which focuses on integrating economic activity with environmental protection and social concerns. This calls for engineers to develop new processes skills and competencies and integrate a global consciousness for sustainable development with more innovative technological advances. Therefore, engineering education institutions are facing new challenges and demands to integrate new social, economic and environmental concerns into their professional education. To achieve these aims it is necessary that higher education institutions revise and, if needed, change their core values, teaching and learning environments, management and learning outcomes. This project involves engineering institutions and focuses: (i) *To what extent do EE institutions, combine PBL and ESD?* and (ii) *How does PBL support the alignment between the 21st century challenges and the institution's vision, curriculum and teaching of ESD?*. There will be used a combination of methods like interviews, questionnaires, observation, etc. to collect qualitative data. The data analysis will allow: (i) assessing the vision regarding to ESD; (ii) outline strategies used to integrate Engineering Education for Sustainable Development (EESD) at an international level using PBL approach, and (iii) strategies to change and improve practices to integrate EESD as well as the PBL scenario.

APPENDIX 9 Case study – UPM data analysis report

Content analyses grid

Aim

The aim of the analysis of the curriculum is to find out which programmes have an education for sustainable development approach. This implies the integration of knowledge, skills and competencies regarding to sustainable development and its link with the disciplinary field in the curriculum

Profile

NAME OF THE PROGRAMME: Urban, Energy and Environmental Planning (with specialization in Urban Planning and Management)

DEGREE: Master

UNIVERSITY: Aalborg University

FACULTY: Faculties of Engineering, Science and Medicine

DEPARTMENT/ SCHOOL: School of Architecture, Design and Planning (SADP)

STUDY BOARD: Planning and Geography (Studienævnet for Planlægning og Geografi)

ACCESS TO THE CURRICULUM: http://www.pgsn.aau.dk/pgsn/Studieordninger/2010/BEM-Masterstudieordning2010_UK.pdf, 16 March 2012

Content Analysis Grids

1 Overall programme qualification profile

1.1. Structure

The programme is organized in four semesters, and can be read in three specialisations:

- Master of Science (MSc) in Engineering (Urban, Energy and Environmental Planning with specialisation in Urban Planning and Management)
- Master of Science (MSc) in Engineering (Urban, Energy and Environmental Planning with specialisation in Sustainable Energy Planning and Management)
- Master of Science (MSc) in Engineering (Urban, Energy and Environmental Planning with specialisation in Environmental Management and Sustainability Science)

Figure 1 Programme's specializations and structure (self-translated from SADP, 2010, p. 6)

The modules are defined according to the specialisation with the programme. For example, there are modules only taught to students that choose the urban and planning management (U) specialisation, or environmental management and sustainable science (EM), or sustainable energy planning and management (E), and modules that are common to the three specialisations.

The called vertical analysis of the curriculum is common to the three specialisations, being the competencies profile common to the three specialisations (p. 6).

The programme is organized in four semesters, with a total of 120 ECTS. At the 1st and 2nd semester the student is entitled to construct a course of study within the objectives of the semester after previous application. The project work may here be replaced by other study activities (cf. the Framework Provisions). At the 3rd semester the

student can choose freely between carrying through the semester as 1) Project semester – with or without integrated, project-oriented internship - or 2) International or national credit or 3) Long final project (master's thesis) (cf. the project module description of the 3rd semester). In relation to option 1) the student, who has followed the 1st and 2nd semester of Urban Planning, Energy Planning or Environmental Management and Sustainability, can furthermore choose to follow a course offered at the 1st semester under another specialisation on Urban, Energy, Environmental Planning or Integrative Geography, etc. (p.8).

1.2. Overall learning strategies

"[…] a combination of professional, problem-oriented and interdisciplinary approaches and is organized on the basis of the following work and evaluation forms combining skills and professional reflection: lectures; class teaching; project work; workshops; task handling (individually and in groups); teacher feedback; professional reflection; portfolio work; pin up, etc." (p. 6).

1.3 PBL profile

Table 5 Overall qualification programme PBL profile

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
Knowledge	Factual & Conceptual	"Has knowledge within…" (p. 4); "Insight in and understanding of…" (p. 5)	x	x	x
	Procedural	"Has thorough knowledge of (…) methods in…"; "…handle the methods and tools (…) as well as general skills connected with occupation within the field(s)" (p. 4); "…using relevant scientific methods" (p. 5)	x	x	x
	Metacognitive	"…assess and choose among the theories, methods, tools and general skills (…) draw up new models of analysis and solution"; "…prepare strategies, plans and projects at different levels" (p. 4); "Able to independently prepare, structure and evaluate strategies, plans and projects" (p. 5)		x	x
	Personal, evolutionary (*know-why*)				
Disciplinarity	Disciplinary				
	Multidisciplinary				
	Cross-disciplinarity				
	Interdisciplinary	"…theories and methods in planning, administration and/or management within the public and private sector"; "Possesses insight into and understanding of the social conditions under which strategies, plans and projects within urban, energy and environmental planning are implemented"; "analyse the technical and social context (p. 4); "…be part of interdisciplinary teams…"; (p.5)	x	x	x
	Transdisciplinary				
e t e n	Lifelong learning	"Independently develop own competences and specialization" (p. 5)			x

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
	Contextual learning	"…social conditions under which strategies, plans and projects within urban, energy and environmental planning are implemented"; "…analyse the technical and social context of which strategies and plans…"; (p. 4); "…implementation of plans and strategies in Danish or international contexts" (p. 5)	x	x	x
	Problem analysis & formulation	"…discuss professional and scientific problems with both colleagues and non-specialists." (p. 4); "reflect on the knowledge and problems of the field of … and in this relation identify important social problems" (p. 5)		x	x
	Problem solving				
	Critical thinking	"…assess and choose… on a scientific basis draw up new models of analysis and solution" (p. 4); "…systematically and critically by using relevant scientific methods"; (p.5)		x	x
	Creativity & innovation	"….draw up new models of analysis and solution" (p. 4)		x	
	Communication	"…discuss professional and scientific problems with both colleagues and non-specialists. (p. 4)		x	
	Collaboration	"…involve the public and relevant actors at all levels" (p. 4); "…be part of interdisciplinary teams…" (p.5)		x	x

1.3. Sustainable development profile

Table 6 Overall qualification profile SD aspects

Aspects	Quotes	In connection with (*)	Curriculum as
A. Environmental	"Has knowledge within… **energy** and **environmental** planning";	A.1.; A.3.	Knowledge/ skills
B. Human rights			
C. Labour practices and decent work	"…theories and methods in **planning**, **administration and/or management within the public** and **private** sector";	C.2	Knowledge
	"…understanding of planning and social theory as well as competence in the structure and function of the **planning and management system** and/or the structure and function of companies"	C.2.	Competences
D. Society	"…**involve** the public and **relevant actors** at all levels"		Skills
	"…**be part of** public organizations as well as private firms, including NGOs"		Competences
	"…in this relation identify important **social** problems";	D.1	Competences
	"…plans and strategies in **Danish or international contexts**"	D.2.	Competencies
E. Product responsibility	"Can assess if **strategies, plans, projects or infrastructure systems** are expedient and feasible in technical, town planning, area planning, economic, environmental, business and social respects"	E.1., with relation with A, B, C, E & F categories	Skills
	"understanding of the technical, structural and social **conditions connected with the development and infrastructures of**		Competences

Aspects	Quotes	In connection with (*)	Curriculum as
	towns and regions"		
F. Economic			
G. Ethics and professional practice(**)	"…knowledge of the implications of research ethics"; "…reflect on ethical matters in connection with professional practice" "…reflect on **ethical** matters in connection with **professional practice**"	------	Knowledge, skills

(*) Indicators from the Global Report Initiative (GRI) - https://www.globalreporting.org/Pages/default.aspx. The GRI presents a set of indicators for the categories referred as example of good sustainable practice. The codes present in the last column is referred to a code given (see table 2.2.1, page x)

(**) Add to the indicators stated by (*)

1.4 Remarks

There is an alignment between the PBL approach and the learning strategies referred on 1.2., which allow the development of the learning outcomes stated in the competences profile of the programme. In an overall assessment, in the competence profile of the programme it is clear the presence of PBL elements.

There is no distinction between the specialisations; they all have the same competence's profile. All categories of the SD profile appear, to some extent, to present in the programme. With more focus in labour practices, and society, following by environmental. It is relevant to mention that the same sentence can be found more than one SD indicator, being one more explicit than the other, and their interrelations. E.g. "*Can assess if strategies, plans, projects or infrastructure systems* (E. Product responsibility) *are expedient and feasible in technical, town planning, area planning, economic* (F. economic)*, environmental* (A. environmental)*, business* (F. economic) *and social respects* (D. society)", therefore it is presence in 4 categories in the SD profile.

2. Courses and projects' modules qualification profile

2.1 Introduction

For each specialisation, the modules can be grouped according to their main learning strategy, lecture or project work. Each semester is composed by three modules (5 ECTS each, 15 ECTS in total), and one project module (15ECTS) (p.8). The 4th semester is composed by only one project module, designated as master's thesis (30ECTS) (p. 6-7). To each module of the master with specialization was fives a code of analysis by using the semester (1st, 2nd, 3rd, or 4th), and the main type of the instruction (lecture – L –, or Project – P) (Table 2).

Table 7 Master in Urban Planning & Management programme modules, main instruction strategy and codes of analysis

Semester	Urban planning and management specialisation's module	Main instruction type	Code
1st	The complex city	Project	1.0P
	Theories of science and research design (common module)	Lecture	1.1L
	Urban development, causes and consequences	Lecture	1.2L
	Complexity, interrelationships, synergies and conflicts	Lecture	1.3L
2nd	Power Planning	Project	2.0P
	Policy, planning and governance (common module)	Lecture	2.1L
	The deliberative practitioner	Lecture	2.2L
	Planning theory	Lecture	2.3L
3rd	Professional development (common project)	Project	3P
4th	Master's Thesis	Project	4P

The analysis process was as following: i) attribute to each module a code (table 2.1), ii) read each module competence profile (knowledge, skills and competences); ii) highlight quotes referring to the PBL elements and categories (2.2. PBL profile); iii) fill in the PBL profile as present in the Table 3.

In this process only the quotes without ambiguity of meaning were considered. The same code of analysis is used in the PBL profile and SD profile. In each semester there is a module that it is common to the other master specialisations of the programme.

2.2. PBL profile

Table 8 projects and courses PBL profile

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
Knowledge	Factual & Conceptual	1.0P	"Knowledge and understanding of direct and indirect consequences of changes in the urban land use and infrastructure"; "…use relevant scientific theories…"; (p. 9)	x		x
		1.1L	"Understanding of…"(p.8)	x	x	x
		1.2L	"Knowledge of the social, economic and environmental consequences of urban development" (p. 10)	x		
		1.3L	"Understanding of towns as complex systems..." "independently combine knowledge from different rele-	x	x	

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
			vant fields" (p. 11)			
		2.0P	"Knowledge of planning processes and their relation to questions about power in relation to specific practices…." (p. 18)	x		
		2.1L	"Knowledge of power, politics and policies…" (p. 17); "…able to use the introduced concepts…" (p. 18)	x	x	x
		2.2L	"Knowledge of the institutional contexts and power relations…" (p. 22)	x	x	
		2.3L	"Thorough knowledge of international planning theory"; "…understand the role of planning/ planner…" (p.20)	x	x	
		3P	"…have knowledge based on the highest international research" (p. 26)	x		
		4P	"Thorough knowledge of relevant theories…"; "…knowledge of the scientific-theoretical and methodical embedded-ness of the used theories and can reflect on them" (p. 28)	x	x	
	Procedural	1.0P	Have thorough knowledge of theories of science and research methods relevant for..."; "use relevant scientific theories and methods within the chosen problem" (p.9)	x		x
		1.1L	"Understanding of (…) research design and research methods…" (p. 8)	x	x	x
		1.2L	"Knowledge of theories, methods and experiences…" (p. 10)	x		
		1.3L	"…carry out simple research investigations…" (p.11)		x	x
		2.0P	"…relevant theories of science and research designs" (p.18)	x	x	
		2.1L	"…methods of analysis." (p. 17; 18)	x	x	x
		2.2L	"Can use relevant theories, concepts and methods to analyse…" (p. 19)		x	
		2.3L	"…able to analyse and evaluate the value basis of the planning theories and the planning methods" (p. 20)		x	
		3P	"Can master the scientific methods and tools…" (p. 27)		x	
		4P	"Thorough knowledge of relevant theories and methods in relation to…"; "…knowledge of the scientific-theoretical and methodical embedded-ness of the used theories and can reflect on them" (p. 28)	x	x	
	Metacognitive	1.0P	"Have thorough knowledge of the complexity of connections and effects between different changes in the land use and transport infrastructure of the towns and the behavioural, distributional, environmental and economic consequences of these changes"; "…analyse strategies within urban development in relation to their immediate…" (p. 9)	x		x
		1.1L	"Understanding of the contents and interrelation of the positions of theories of science and capability of relating critically to them"; "…complex of problems of theories of science in relation to assessment of courses and references in projects…" (p. 8)	x	x	x
		1.2L	"…reflect on the cause and consequences of …"; "…analyse and evaluate solution strategies and proposals	x	x	

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
			concerning the spatial development in towns and regions…" (p. 10)			
		1.3L	"Understanding of how urban development approaches, which aim to meet certain needs and objectives, usually also have considerable con-sequences in relation to a number of other considerations and objec-tives" (p. 11)	x		
		2.0P	"…independently and critically evaluate and develop theories, concepts and methods for analysis of power in the practices of planning" (p. 18)		x (?)	
		2.1L	"…reflecting critically on the use of the presented concepts and methods of analysis."; "…develop and introduce new concepts and methods of analysis in relation to problems relevant…" (p. 17; 18)	x (?)	x	
		2.2L	"…roles and interventions of the planner in different contexts." (p. 19)		x	
		2.3L	"…evaluate and select relevant planning theories, methods, tools and general skills and on a scientific basis improve analyses and solutions" (p.20)		x	
		3P	"…assess and choose among the scientific methods, tools and general skills of the field and draw up new models" (p. 27)	x	x	
		4P	"…describe the used theory(ies) so that the special characteristics of the theory are brought to light and in this way document understanding of the possibilities and limitations of the used theory(ies) within the concerned field of problems"; "…form a synthesis between the professional problem, theoretical and empirical investigations and make a critical assessment of the synthesis…" (p.28)	x	x	x
	Personal, evolutionary (know-why)	1.0P	"…which values/interests are positively and negatively affected by the strategies"			x (?)
		1.1L	"Capable of independently assessing the value and reliability of own science production in relation to scientific basic complexes of problems" (p. 8);		X(?)	
		2.2L	"... independently being able to understand the roles and interventions of the planner in different con-texts..."; "...design and handle the dialogues of planners and evaluate their ability to handle power, con-flicts and differences." (p. 19)		x	x
		4P	"Can point out relevant future strategies, possibilities of change and/ or solution proposals" (p. 28)		x	
Disciplinarity	Disciplinary					
	Cross-disciplinary					
	Multidisciplinary					
	Interdisciplinary	1.0P	"Have thorough knowledge of the complexity of connections and effects between different changes in the land use and transport infrastructure of the towns and the behavioural, distributional, environmental and economic consequences of these changes"; "…analyse strategies within urban development in relation to	x	x	x

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
			their immediate as well as more long-term social, environmental and economic consequences"; "professional and interdisciplinary cooperation" (p. 9)			
		1.1L	"…complex of problems of theories of science in relation to assessment of courses and references in projects…" (p. 8)		x	
		1.2L	"…in relation to spatial development in towns and regions, including the geographic localisation of enterprises, residences, service and other facilities as well as relations between mobility and localisation"; "…urban development and the social development and living con-ditions of the town."; "... the social and economic consequences of urban development" (p. 10)	x	x	
		1.3L	"Can critically analyse environmental, social and economic side effects of urban development approaches primarily starting from a certain need or a certain objective" (p. 11) "…independently combine knowledge from different relevant fields, start and carry through interdisciplinary co-operation and take a professional responsibility for interdisciplinary knowledge application when preparing solution proposals within urban planning"	x	x	x
		2.0P	"Knowledge of relevant power theories and concepts…"; "Knowledge of relevant theories of science and research designs."; "…relevant theories and concepts in relation to the analysis of power in the practices of planning"; "…interdisciplinary cooperation…" (p. 17, 18)	x	x	x
		2.1L	"Knowledge of power, politics and policies…"; "Knowledge of governance and planning…" (p. 17)	x		
		2.2L	"…handle the dialogues of planners and evaluate their ability to handle power, conflicts and differences."	x	x	x
		2.3L	"...understand the role of planning in society."; "Knowledge of the ethical questions of planning"; " and interdisciplinary cooperation" (p. 20)	x		x
		3P	"…carry through professional and interdisciplinary cooperation…(p.27)			x
		4P	"…be part of interdisciplinary discussions and development work" (p. 28)		x	x
	Transdisciplinary					
Learning	Self-directed learning	1.0P	"…take the responsibility for **own professional** development and specialisation in relation to the field of urban development"			x
		1.1L	"…**continuous professional development** through acquisition of new knowledge of the development and renewal of theories" (p. 8)			x
		2.0P	"…independently take the responsibility for **own professional** development and specialization"			x
		2.1L	"Must **independently** be able to develop and introduce **new concepts and methods** of analysis…" (p. 18) "…**professional development** through acquisition of new knowledge of policies, planning and governance (p. 18)		x	x

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
		2.2L	"…reflect on and develop **own** professional ethics and procedures" (p. 19)			x
		2.3L	"…independently take a responsibility for **own professional** development and specialisation."			x
		3P	Able to **independently** take responsibility for **own professional development** and specialization…" (p. 27)			x
		4P	"…acquire the newest knowledge in the field and are on this background capable of **continuously developing the professional skills and competences**." (p. 28)			x
	Contextual learning	1.0P	"…to identify scientific **problems in this context**" (referring to urban development); "…needs have caused the strategy or the superior plan"	x	x	x
		1.1L	"Thorough knowledge of the relation to theories of science and research designs of **own professional fields**." (p. 8)	x (?)		
		1.2L	"...understand and on a scientific basis reflect on the causes and con-sequences of urban development as well as ability to **identify scientific problems in this relation**."; "...analyze and evaluate solution strategies and proposals concerning the spatial development in towns and regions..." (p. 10)	x	x	
		1.3L	"... number of **different contexts**, structures, changes and states affect each other, and where the result of a single impact factor is conditional" (p. 11)	x		
		2.0P	"…identify questions about power in planning" (p. 18)		x	
		2.1L	"…develop and introduce new concepts and methods of analysis **in relation to problems relevant to own professional standards**" (p.18)		x (?)	x (?)
		2.2L	"…independently being able to understand the roles and interventions of the planner in **different contexts** (p.19)		x	
		2.3L	"…use international planning theory in a **practical context** and in relation to the problems of planning" (p. 20)		x	
		3P	"…scientific problems or practical problems in a **given complex context**." (p. 26)	x		
		4P	"Thorough knowledge of relevant theories and methods in relation to the **chosen problem**…" (p. 28)	X (?)	X (?)	
Process competencies	Problem analysis & formulation	1.0P	"…to **identify scientific problems**…"	x		
		1.1L	"Capable of using the basic **complex of problems** of theories of science in relation to assessment of courses and references in projects…" (p. 8)		x	
		1.2L	"…**ability to identify scientific problems** in this relation (causes and con-sequences of urban development)." (p. 10)	x		
		2.0P	"…**identify questions** about power in planning" (p. 18)		x	
		2.1L	"…**methods of analysis** in relation to **specific problems**". (p. 18)		x	

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
		2.3L	"…reflect on the planning theory and on this **basis identify scientific problems in relation**…" (p. 20)	x		
		3P	"…**identify either scientific problems** or practical problems in a given complex context." (p. 26)	x		
		4P	"Thorough knowledge of relevant theories and methods in **relation to the chosen problem** and can reflect on them"; "…form a synthesis **between the professional problem**, theoretical and empirical investigations and make a critical assessment of the synthesis…"(p. 28)	x	x	x
	Problem solving	1.0P	"…work and development situations which are complex, unpredictable and **imply new solution models**"		x (?)	
		1.3L	"…prepare solution proposals in relation to a topical urban development problem"		x	x
		2.0P	"…work and development situations that are complex, unpredictable and require new solutions"			x
		2.1L	"…use and develop the presented concepts and methods of analysis in problem-based project work" (p. 18)		x	x
		2.3L	"…use international planning theory in a practical context and in relation to the problems of planning"		x	
		3P	"Can master the scientific methods and tools of the field as well as general skills in relation to the solution of the chosen problem" (p. 27)		x	
		4P	"…point out relevant future strategies, possibilities of change and/or solution proposals"; "…form a synthesis between the professional problem, theoretical and empirical investigations and make a critical assessment of the synthesis…" (p. 28)		x	x
	Creativity & innovation	1.0P	"…manage work and development situations which are complex, unpredictable and imply new solution models" (p. 9)		x	
		1.2L	"…draw up alternative solution strategies and proposals in relation to…" (p. 10)		x	
		2.0P	"…work and development situations that are complex, unpredictable and require new solutions" (p. 18)			x
		2.3L	"…work and development situations which are complex, unpredictable and require new solutions by using planning theory" (p. 20)			x
		3P	"…manage work and development situations which are complex, unpredictable and require new solution models" (p. 27)		x	x
	Communication	1.0P	"…research-based knowledge and discuss professional and scientific problems."			x
		1.1L	"Capable of imparting knowledge of theories of science and research designs…" (p. 8)		x	
		1.2L	"…discuss professional and scientific problems with both colleagues and non-specialists." (p.10)		x	
		1.3L	"…discuss professional and scientific problems with both colleagues and non-specialists."			x
		2.0P	"…communicate research-based knowledge".		x	
		2.1L	"…impart knowledge of policies, planning and governance to both specialists and non-specialists" (p. 18)		x	

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
		2.2L	"Knowledge of communication and work with conflicts due to differences in the planning." (p. 19)	x	x	
		2.3L	"…to communicate research-based planning theory and dis-cuss professional and scientific problems…"		x	
		3P	"…discuss professional and scientific problems with both colleagues and non-specialists." (p. 27)		x	
		4P	"…impart knowledge of the problem to both professionals and non-professionals"; "…be part of interdisci-plinary discussions and development work" (p. 28)		x	x
	Critical thinking	1.0P	"…as well as ability to reflect on them."	x	x	x
		1.1L	"…capability of relating critically to them…"; "...reflect critically on project related choices of value bases, theories of science and methods" (p. 8)	x		x
		1.2L	"…understand and on a scientific basis reflect on…"; "…critically analyse and evaluate solution strategies and proposals…" (p. 10)	x	x	
		1.3L	"Can critically analyse environmental, social and economic side effects of urban development…" (p. 11)			x
		2.0P	"…independently and critically evaluate and develop theories, concepts and methods for analysis of pow-er…"		x	x
		2.1L	"Capability of reflecting critically on the use of the presented concepts and methods of analysis." (p. 17)	x		x
		2.2L	"…analyze the practice of planning and critically evaluate it"; "…independently and critically be part of complex planning processes…" (p. 19)		x	x
		2.3L	"…understand and, on a scientific basis, reflect on the planning theory and on this basis identify scientific problems" (p. 20)	x		
		3P	"…understand and relate critically to the knowledge of the field" (p. 26).	x		
		4P	"…relation to the chosen problem and can reflect on them"; "make a critical assessment of the synthesis formed and the other results of the project work" (p. 28)	x	x	x
	Collaboration	1.0P	"…independently start and carry through a professional and interdisciplinary cooperation"		x	
		1.2L	"…independently start and carry through a professional and interdisciplinary cooperation…"			x
		1.3L	"...start and carry through interdisciplinary co-operation..." (p. 11)		x	
		2.0P	"…implement subject specific and interdisciplinary cooperation…" (p. 18)			x
		2.2L	"…specific professional and interdisciplinary cooperation…" (p. 19)			x
		2.3L	"…subject specific and interdisciplinary cooperation…"(p. 20)			x
		3P	"...independently start and carry through professional and interdisciplinary cooperation..." (p. 27)			x

2.3. Sustainable development aspects

Table 9 Courses and projects SD profile

Aspect	Modules' code	Quotes	In connection with(*)	Learning outcome
A. Environmental	1.0P	"…changes in the **land** use and **transport** infrastructure of the towns and the behavioural, distributional, **environmental** and **economic** consequences of these changes"; "…analyse strategies within urban development in relation to their immediate as well as more long-term **social**, **environmental** and **economic** consequences" (p. 9)	A.1; A.9 A.1; B, C, D, F	Knowledge & Competences
	1.2L	"…**environmental** consequences of urban development"; "…analyse and evaluate solution strategies and proposals concerning the spatial development in towns and regions, especially in a perspective of sustainability and **climate**" (p. 10)	A.1; A.6	Knowledge & Skills
	1.3L	"…(for promotion of) **environmental** considerations in the urban development" "Can critically analyse **environmental** (…) side effects of urban development approaches primarily starting from a certain need or a certain objective"	A	Knowledge & Competence
B. Human rights				
C. Labour practices and decent work				
D. Society	1.0P	"…more long-term social (…) consequences"; "assess which values/interests are positively and negatively affected by the strategies"	D.1 (in relation with the impact of urban planning on society)	Knowledge & Competences
	1.2L	"…social (…) consequences of urban development". "…geographic localisation of enterprises, residences, service and other facilities…" "…spatial development in towns and regions, especially in a perspective of sustainability and climate"	D.1 (and in relation with economic growth	Knowledge & Skills
	1.3L	"…for promotion of social (…) considerations in the urban development" "Can critically analyze (…) social (…) side effects of urban development approaches primarily starting from a certain need or a certain objective"	D.1. (Impact on society)	Knowledge & Competences
	2.1L	"… power, politics and policies in relation to decision processes…"; "…governance and planning…"; "…impart knowledge of policies, planning and governance" (p. 17, 18)	D.4.	Knowledge; Skills & Competences
E. Product responsibility	1.3L	"Understanding of how urban development approaches, which aim to meet certain needs and objectives, usually also have considerable con-sequences in relation to a number of other considerations and objectives"	E.1	Knowledge (?)

Aspect	Modules' code	Quotes	In connection with(*)	Learning outcome
F. Economic	1.0P	"…**economic** consequences (of changes)…" (p. 9)	F.3. (in relation with the impact of urban planning)	Knowledge & Competences
	1.2L	"…economic (…) consequences of urban development" (p. 10) "…relation between urban development and the social development and living conditions of the town"	F.1 / F.3(impacts of economic)	Knowledge & Skills
	1.3L	"… (for promotion of) economic framework in the urban development" "Can critically analyze (…) economic side effects of urban development approaches primarily starting from a certain need or a certain objective"	F.3.	Knowledge & Competence
Ethics and professional responsibility (**)	1.0P	"…take a professional responsibility"		skills
	1.1L	"…independently **assessing the value and reliability** of own science production…"; "…reflect critically on project-related choices of **value bases**…" (p. 8)		Skills & Competences
	1.2L	"…take a professional responsibility."		Competences
	1.3L	"…take a professional responsibility."		Skills
	2.0P	"…take a professional responsibility."		Competences
	2.2L	"Knowledge of professional behaviour codes and ethical frames for the practice of the planner"; "…develop own professional ethics and procedures" (p. 19)		Knowledge & competences
	2.3.L	"Knowledge of the ethical questions of planning"; "…take a professional responsibility by using planning theory" (p. 20)		Knowledge & competences
	3P	"…take a professional responsibility…" (p. 27)		Competences

(*)Indicators from the Global Report Initiative (GRI) - https://www.globalreporting.org/Pages/default.aspx. The GRI presents a set of indicators for the categories referred as example of good sustainable practice. The codes present in the last column is referred to a code given (see table 2.2.1, page x)

3. Answering the questions from data collection strategy

In table 6 are summarize the results while addressing the specific questions of the empirical framework (in appendix 3.1.).

Table 6 Different sub-questions addressed with results from the content analysis

Questions	"Answer"
How and why is education for sustainable development integrated in the programme?	There is an explicit presence in the programme through two of the specializations. There is no explicit presence of Sustainability - standalone course or learning outcomes framed as embedded. Written for courses modules and current evaluation or active participation for project modules. Two of the programmes specializations have a strong focus for sustainability has a clear learning purpose and has part of the core discipline of the specializations. In the case of Urban Planning and Management (UPM) the learning outcomes are formulated addressing the characteristics of ESD like higher cognitive tasks, critical thinking, and interdisciplinary, contextual, problem solving and participatory through collaboration.
How is the curriculum organized around problems?	The programme is organized in 4 semesters, in each semester students have to formulate and solve problem within a context, with emphasis in collaboration and communication with others (professionals and non-professionals). As a resource, students have three courses modules (5 ECTS each) to support the project module (15 ECTS). The project modules from the two first semesters have a title like a course module, and it seems to be a relation between the projects' learning outcomes with the courses outcomes. For example, the first learning outcome formulated for the project in the first semester is: "*Knowledge and understanding of direct and indirect consequences of changes in the urban land use and infrastructures*", and the learning outcome of the course "Urban development causes and consequences" is: "*knowledge of the social, economic and environmental consequences of urban development*". It is clear the link between one and other learning outcome, being the first one more concrete in "*land use and infrastructures*" consequences, while the course is broader, addressing "*social, economic and environmental consequences*". Learning outcomes formulated related with process competencies such as communication, collaboration, problem formulation and solving, interdisciplinarity, is present in all modules of the programme and not exclusive of the project modules. The content analysis provides more insights to a "what" question rather than a "how" like it is formulated. In this sense this answer address better "what is the relation between the PBL process and the overall structure of the programme?" This is related with examination; interviews will allow answering more accurately to this question. May knowledge type is metacognitive, with strong possibility for evolutionary knowledge It is considered an interdisciplinary programme. and the problems can be characterized by being real; unstructured, conceptual. The problems are characterized based on problem catalogue is suggestions of problems presented to students by staff, where they need to choose. This process is also related with group formation. Also students have the possibility to present themselves themes where they want to work on. Notice that these situations, problems proposals, are is concrete and out of real contexts.

Interviews

1. Interviewees and interviews summaries

In the following it will be present the interviewees and their interviews' summaries. To full fill the anonymity of the interviewees, their names are substitute by a code, the ID code, formulated by given the initials of the groups he, or she, belongs, and number, and the initials for programme. Example interviewee **SB1**$_{UPM}$ means: SB - member of study board; 1 - first being interviewed; UPM - Urban Planning and Management specialization.

Following the interviewees and interviews characterization is given a brief summary of the interviews. The interview summaries are made by group (study board, lecturers, and facilitators). Each interview's summary is composed by the following themes:

- Background
- Education for Sustainable Development (concerning the first cluster question from the empirical framework)
- Problem Based learning process and curriculum organization (concerning the second cluster question of the empirical framework)
- Process competencies (concerning the third cluster question of the empirical framework)
- Synergies between PBL and ESD (concerning the last cluster question of the empirical framework)
- Other experiences

In each clustering themes are putted most relevant quotes from interview analysis. Following the interview summaries are the checklists, and comments grid, fill by the interviewees during the interview session.

Start by characterizing the different target groups interviewed.

Table 10 Interviewees characterization

Group	**Master programme in UPM**		
	Interviewee(s) ID	**Interview's duration**	
Study Board	**SB1**$_{UPM}$	1:38:52,7	
	Interviewee(s) ID	**Interview's duration**	**Course**
Lecturers	**L1**$_{UPM}$	1:39:22,3	Policy, Planning and Governance
	Interviewee(s) ID	**Interview's duration**	**Students**
Facilitators	**F1**$_{UPM}$	01h 58m 31s	**S1**$_{UPM}$ **S2**$_{UPM}$, **S3**$_{UPM}$, **S4**$_{UPM}$
	F2$_{UPM}$	01h 43m 07s	**S5**$_{UPM}$
	F3$_{UPM}$	00h 58m 45s (+) 00h 11m 06s	**S6**$_{UPM}$
	F4$_{UPM}$	01h 37m 31s	NOT INTERVIEWED
	Interviewee(s) ID	**Interview's duration**	
Students	**S1**$_{UPM}$	01h 14m 29s (+) 00h 05m 18s	Individual
	S2$_{UPM}$, **S3**$_{UPM}$, **S4**$_{UPM}$	01h 57m 27s	Group
	S5$_{UPM}$	01h 43m 09s	Individual
	S6$_{UPM}$	03h 17m 15s	Individual

Study Board

Interviewee $SB1_{UPM}$

Background

SB1$_{UPM}$ was educated in Aalborg University in Civil Engineering, has master degree in Urban Planning and traffic, and a PhD degree in sociology of mobility. It has been working within the field for many years, including air mobility.

SB1$_{UPM}$ considered civil engineering education very traditional while his master and PhD education is more social oriented.

Education for sustainable Development (ESD)

In the UPM programme, sustainability can be integrated in 1st semester, but also cross all semester by using themes, and on both project modules and courses:

> "*I would put it* [ref. to sustainability] *in the first semester actually because it already covers a number of sustainability issues. Maybe it could be phrased more directly, and also with some of key issues you have shown me here* [ref. to checklist B], *I think it would be of good inspiration for the people that are working with program.*
>
> *So I would say the first semester, but it should be a theme that crosses all the semesters. I think the 1st semester is quite obvious because that works with complex cities. I mean, that's much relate with sustainability. You would be a complete ignorant if you just work with complex cities with any kind of environment perspectives.*
>
> *I will put on both project and course. I would take one of courses and frame it much more in relation with sustainability, and also run it together with other disciplines. I would also frame the project of complex cities much more directly in relation to sustainability, and I think it could be frame, or included more practical elements, how to carry out. So it could be something that relates with strategies for urban cities."*

In this way, sustainability themes would be worked at a concrete and contextual level.

Problem Based Learning (PBL) process and curriculum organization

UPM can be characterized as open and interdisciplinary programme giving to students the possibility several options within the urban planning education. However while some programmes were design taking into consideration the object of profession (e.g. what is expected from them as future planners) UPM to some extent lost that connection. According to **SB1**$_{UPM}$, when students finish their education they will be very good in making analysis and point what can be or cannot be done, however may be missing the providing a possible solution to a concrete problem:

> *"UPM it's too contextual and there is, if I can be very rude, there is not core of the profession. It started out as what you call a professional education. You say 'you have some planners out in the real world that should plan something - energy systems, road systems, good urban areas to live in and so on. And then you have more and more people analysed the processes around the city, e.g. power relations. But what have happened with UPM, as*

I can see it, that you totally lost the object - what is the object"

It is also the focus in analysing the processes around the city that may explain the variety of themes encountered in students' projects. Students in their education get involved in an environment where they have to deal with several systems, and forces that not always are clearly defined.

> *"Power is a good example, I would say that if the object if your profession is invisible and you know all about processes (and I think we should move away from this very technical approach)… When you are working in planning, the object is slightly different from the traditional engineer because you are also work with humans, and human interaction with a physical object. The field is different so you cannot copy what you do in a straight technical discipline but, I can see that there is a bit after 15 years here, many people go in and out, and shift, and when we end up with a situation that students know everything about power relations and they don't know much about the object of the planners - what a planner actually do, when go out to plan a city? What should they do if you want to make a sustainable city? How to calculate that one solution is better than the other. How do you distinguish scenario A from scenario B, but you can say everything about processes and discourses, and everything. But then you are getting very weak in terms of producing solutions but very strong in analysing."* […]
>
> *"If you discuss with citizens and with professional people, and so on, if you criticize something, they will expect than you to facilitate or come up with some solution about what to do. If you say B, and you should not do A, then you should be able to tell why but also what to do instead, or what you can't do. It is not perfect but it is what can do now. And if you are cannot do then business people, politicians, public authorities, are get a bit angry, because they are saying 'you some here and criticize, and that's ok, but what should I do and you can tell that's a big problem."*

Also the type of problems students work with reflect the characteristics of the programme, as being broad (vs. specialized); interdisciplinary (vs. disciplinary) and reflective, which may lead to more theoretical discussion rather than point a pragmatic solution to a given problem:

> *"Yeah. I think you are touching something crucial. Because I think it is also how the problem is formulated and how they solve it. I think you are right about that, that they go in more… the overall frame of the field is going in a more theoretical way with a weak link what to do."*

Due to his background, **SB1**$_{UPM}$ is able to compare SCE and UPM programmes in their characteristics. And for example taking the link to the professional practice, which may be a strong link towards professional identity and in UPM weaker. Also the broader and holistic perspective in which students are educated in UPM programme seems to be less in the SCE programme:

> *"But you can actually say that these are two poles. I come from a field myself, having a very technical and traditional with a lot of difficulties about reflecting about your own knowledge production. And the other pole saying it is the only thing you do (put a bit strong), this is our main core where I want to go somewhere in between, and say that you should have both competencies. You can be technical, you can solve things but you can also be able to… In general if you take all traditional engineering education there a huge deficit on reflecting in our own practice, your knowledge production - thinking about why I do this at all, not because the teacher told me to, or the university tell me is important, but*

why it is important"

Process competencies

SB1$_{UPM}$ considered that the reflexive component of a PBL process are less and less visible in what it has been practicing in university, in particularly in technical education where it can be characterized as very technical and focus on detailed aspects of technical fields:

> *"Limit of how PBL has been practiced at AAU. There is much focus in solving every day's problems, or technical problems, or huge problems that this reflective part kind of has disappeared"* […]
>
> *"Technical fields are very detailed, and, if you are working in a laboratory, then you just start out with something detailed and get more and more detailed throughout your education."*

Synergies between PBL & ESD

SB1$_{UPM}$ considers that there is a contradiction between how AAU technical students are educated through PBL and what sustainability principles require. As mentioned before there are limitations of students' abilities to reflect on their own production of knowledge, and its consequences, and the in the construction of the self (as in German nominated as "*bildung*"). In education for sustainable development literature Sterling refers to it as "mind, hands, spirit and heart" dimensions of learning:

> *"If you are a technician and you want to world with sustainability and don't know how that... - as you say you should not be selfish - than it have a huge impact on everyday life. Not necessarily much but have some impacts in a way or another. You should instead of just saying that is dangerous, I think, to people… this is the way it should be done. Than you should know why… what sort of value, for example, your assumptions are based on. And that's value I support but you should be aware of that are values that you base your assumptions and that the on so that the output also depends on, and if you though totally different than you have other outputs. That's a reflexive academic should be able to do, to explain people 'ok there is some values, there is some technological knowledge of course. I mean, if you take climate change, there is something you can calculate, you can see maybe that the ice is changing but it is a social construction. I mean environment from my perspective is out there but doesn't have its own voice. When society is saying this is important, this is something we need to do about because it is integrated in society. WE don't have nature and then society because is totally combined. Nature is something we give a voice to as human beings, so… I think it is very important. You should be aware, I don't know how to phrase it, and society has a big interest in saving nature because we are part of it."* […]
>
> *"If you start out, and have that as a goal I see a contradiction with to sustainability. If you start work with PBL, and then you have such a strong focus on solving concrete problems, you take on all the, what I call, the process of formation* [ref. to bildung]. *If you go back in history then it will be totally natural that a person, writers with physics Nobel prizes winners, and also huge talks where they meet, sitting around the table and discuss. And people can came from all different kinds of places, humanities, social sciences, science of nature, literature, etc. and talk about difficult stuff. And they are able because they are on*

top of the profession, they can see. But if you go down and say you should not worry about, you should solve a technical problem, that's for clever people, or whatsoever. You should just be able to work problems based with all the people from the people and you should this problem. And afterwards people wondering why that people cannot reflect on theory of science, sustainability and all that. I can tell you because you take all that part out from the education. That part, and says that you should be very focus on this, and then afterwards say 'oh! Why I do this and not…'. That I will say is some of problem, not UPM we don't have, but with some of… for the very technical disciplines. You have totally allowed being, to ignore very society contextual knowledge. You can just specialise and that and just work problem based learning. And that's why I say from the beginning you start very detailed and then you can get even more detailed. Even if in paper it may even look like they work very broad, they are also very detailed and some of the technical core disciplines".

Other experiences

SB1$_{UPM}$ consider the shift from a technical education to a more social oriented education, and not all engineers, or engineering students, may be able to make. Some of such difficulties is related with government and context view of what is an engineer:

"In the Danish context one of the problems is to work across things, interdisciplinarity. That is because you have some restrict regulations, guidelines coming from the government. If you take the UK context, for example, than it is much more to the individual, each university to decide what pedagogical perspective they want, what forms of grade, learning goals you want to develop. Here, in the Danish context, you can say is also but it is some sort of in a box you can say. If you are working in a technical field than it is very difficult. They will say this is interdisciplinary that's fine but then you can place it in social sciences. And it is very difficult.

We have a board in Denmark that evaluate each education. From time to time, each education should be accepted through this evaluation system, which is based at national level. Each 4, or 5 years, and in that system they have a paradigm very much based in a conventional, traditional way of think. For example, what is a civil engineering, and that is very much…

I just moved to the department of Architecture and Media Technology and they are going through this process in all their educations because it is very design oriented, and the government is saying this is not technical enough.

There is a huge debate of what technical stuff is and why something is more technical. I can see why physics is more technical but I cannot see why designing urban spaces are less technical than traffic planning."

Lecturers

Interviewee $L1_{UPM}$

Education for sustainable Development (ESD)

$L1_{UPM}$ points several possibilities for integration of SD in the programme, faculty and even university level, from elective courses, definition of sustainability aligned with specific discipline; etc.:

> "*I am also chair of the University environmental committee and we have a quite strong focus on how to make the educational, and candidates, more sustainable, to have a sustainability elements, virtually in any student coming out. And there is a discussion and how to do this. I know that the PBL centre has the idea that in the technical faculty, the window of opportunity is to use the second semester projects. And to have a... Because there have you already established a structure that is suitable for teaching and creating learning processes that will put sustainability in the heads of engineering students. And I think that is quite viable. Monday I had a meeting with the board of the rectors and we discuss this issue as well, and rector have the idea that will be suitable to create cross university course, kind at middle level, that should be extra curricula, meaning that should not compete with the specific educations. Personally...*"

But there is limitations and constraints that should be taken into consideration, like for example, the difficulty to engage students in free study activities:

> "*We have had that but that would be something which will give you ECTs and would compete with the educations. And obviously we can be proud of having very targeted, goal oriented students which means that everything that is extra curricula and pushes something out will not be chosen. Or very likely not to be chosen. I think we have to work on a multiple strategy, obviously if you have places where you can integrate than we don't have to fight for the space. For example the PV course in first semester bachelor. In the long run we have to create platforms and definitions of sustainability integrated with specifics studies, and we have to have it integrated in the projects. So that it's something, you actually said earlier, so you make something that give a tone in the projects. I think a lot of projects are doing that, but we cannot see it's hidden. I think one thing is quite important, when I have the environmental committee perspective on it, is extremely important that we become visible and able to measure it because, for two reasons: partly we want to brand ourselves from it, and form the more brand it will grow more. And I would also like to be able to follow how it moves. And then the other thing is that we should work on making specific definitions of sustainability that fits with the different studies. And it is very important that we don't have a situation where everything goes, and in the other hand it is very import that we don't push generic sustainability concepts down. But there is a problem, sustainability is very flexible in its interpretation, and it is not straight forward easy to, because you can go out and have everything sustainable. I would be able to argue that almost anything can be sustainable just by having the sustainability concept widen enough, and that is not a problem. So we have to be... and it is an interesting process.*"

L1$_{UPM}$ lectures in the course Policy, Planning and Governance. The course is the only course taught for the three specializations in the 2nd semester of master programme: Urban Planning and Management (UPM); Environmental Management and Sustainability Sciences (EMSS), and Sustainable Energy Planning and Management (SEPM). At the moment lectures and responsible are looking into the lay out of the course and tried to organize it better so it could better address the students' needs regarding their projects.

One of the learning objectives of the courses is to enable students to think critically about a theory and use to solve specific problems:

> "*It is problems that related with policy making, planning, and governance. You could say problems that involve both environmental, social types of problems. It is on the mixture. I think one of the basics ideas is that if you have a very traditional approach to planning you tend to say 'ok we have a certain problem, we will do certain things to mitigate it, and we implement that and then we will see what happens'. And that approach to planning may have some kind of repercussions, it is kind of naive. It has tendency not to look at the power at play, not to look at the kind of institutional types of barriers and possibilities. So the course is very much focus on students to understand these more, I would say more social contextual factors that you need to have an idea about, when you want to make things change. So it's about making them more competent change agents, and also be able to analyse the situation, make better plans, make better understandings of why things happen or don't happen. So that's the idea. And obviously when you do that in this kind of 'not easy digestible topics' we are working with, it is also important that this course covers students from UPM, energy management and environmental management. So it also covers a broad range of entrance competences, people starts from very different points. The idea is to make then understand, and when have these "unattractive" type of problems, you typically need to combine different theoretical frameworks, and then it is quite important that you have the idea on how to use that, to be able to put some other angles on what is going on. You can also say it has some quite, in my eyes, clear lines back to theory of science. Because it is very much about ontological types of assumptions behind the analytical frameworks and the theories you use, or construct. So you could say that the critical reflection should both be on the theories and methodologies that you use and on the topics areas, cases you are looking at."*

According the **L1**$_{UPM}$ the relation between the projects and the course differs, depending on the type of problems students are working on an also the specialization:

> "*I think... My feeling is that it's differs. Some problems have a nature, or basic problem formulations you could say, type of problems where the theories that we use in the course and lot of learning objectives of the course are quite fitting. That is my impression, and we haven't looked into the projects, but we are planning to do so. There is quite of projects that taps into varies aspects they learn in the course. Tendency is a lot of discourse theories are reflected, especially in UPM. I think of the institutional theories are in a lot of the different projects, but maybe in more Energy and Environment parts that this is reflected. My feeling is that... Back in time this course had a pre-cursor which had a large of the same content or to some extent a lot of the same content at least. It was called policy institution and discourse, more and less the same. At that time courses were divided in two types, some were part of a project (like PV courses), and others were kind of extra general knowledge. And that course was in the extra general part but my feeling is that it was*

more used in the project than some of the project oriented courses were. So I think it is quite used. But I have any quantitative measurements of that."

Summing up, the students learn through cycles such: move from abstract and generalizations of theories, reflect critically on that, and then bring, and use it in the contextual situation provided by the problem/ or project, they are working on.

There is always the "stigma" of the overcrowded curricula, when asked about it, **L1**$_{UPM}$ points that there is always relevant and that students should learn. Normally the courses introduce to students theories, in a superficial way, and it is their job to "dig" deeper in that theories along the project work:

"*They are introduced to different approaches and then they have to dig deeper in whatever they choose to use in their projects, guided by their supervisors.*"

When comparing the both programme UPM and SCE, the interviewee thinks they are two different educations, being UPM much more generalist and SCE much more specialized, and that is reflected in the programmes:

"I think UPM students and SCE students they are very different in that sense. Because SCE has a traditional core of technical courses. You don't have... SCE is much more specialist education and UPM is much more generalist type of education. So you can really set them aside so I actually would think a lot of these questions have a starting point in SCE for instance "develop knowledge beyond core engineering disciplines". In UPM you have a little bit of both, but if I may be little bit rude, you don't have a real core in the traditional technical sense. Of course you have some basic about statistic, math, physics, and maybe chemistry, I don't remember, and that makes them engineers but they still generalist type of education."

Perspectives towards the PBL practice, which means that not everything may be problem oriented in the principles and conceptualization of what learning through PBL means:

"*There are two levels. you can say when you develop a new way of teaching is innovative but the idea in PBL, and in my head the idea is that students have a problem based learning orientation and that they have to reflect concretely on how the problem should be conceive, how they can be possible solve that have to be innovative. So in my head, PBL is not PBL if doesn't have an innovative aspect in itself in the process of doing it. Of course it may not be innovative in creating the framework because you can't continue to innovate it. Otherwise it is no PBL.*

I was educated as engineer in DTU, starting with environmental engineering with a little of chemical engineering. DTU is known as traditional and old school and we had problems in laboratory, but it is well defined problems. And I don't see any different between what is taking place in a lot of the technical departments here and what we did back in the university. The difference might be the projects, but not necessarily because quite often the projects.. the difference is that you have a problem but it is kind of - of course you won't say to students 'here is a problem and there is unlimited ways to solve it', you have to limited yourself somehow - but at some point you make the problem formulation so well defined and limited that there is not space for the students to do anything but the same thing they did in the last semester. If you look in to different years, year one, two, three and four, and they produce exactly the same type of problem, there is no problem orientation. They had

not reflection but reflecting what they did last year. It is a mechanical process."

Process competencies

One of the main points in the relation between course content and project work is students to development a critical thinking and reflective analysis of their work and learning. Same is also aimed when questioned about if some of the learning outcomes to be assessed in the project module are related with course:

"*We don't have a single formulation of the LO of the projects, because that is defined in cooperation between the students and the supervisors. But in my mind, yes of course. Because I think it's so important for our students to be able to reflect critically about how to define problems. And this course is giving them some very useful tools and approaches to understand why certain things have been problematized and certain things aren't. And the fact that you have divided things between being more or less problematized is not necessarily equality to those problems being problems, or not being problems, it is rather the question of how they are being constructed in society. Which depend on institutional discursive structures and power balances, and etc. etc. So I would say that it is extremely important for students to have an idea about this, both in their projects and formation as candidates.*"

Synergies between PBL & ESD

There is already some sustainability aspects integrated in the programmes; however they are hidden (as it was already mentioned above). There are also some aspects that are strong in Aalborg university such as social responsibility. Also the interviewee thinks that there may be praxis that supports the integration of sustainability then it is a matter of making it visible and explicit, which can also be challenging:

"*When it comes to social responsibility we are quite good; when it come to the perceptions of the university we are quite ok, and when it comes to the ability to work on energy and our ability to work with sustainability is very bad*"

"*I am so much a social constructivist that I would say that this is what matters. If you are right that it should be so difficult to change. If you actually have a* praxis *that supports the sustainability* praxis *than it would be about making it visible and that's more difficult. If the perception reflects a situation which is bad then we need to do a lot of work in the sense in improving how our educations are being constructed.*

This is only a problem if you want to compare how sustainable we are with another university, or another place in the world, and then you have to translate this somehow. There is a lot of sustainability factors, and a lot of studies are strongly related with sustainability by the types of technologies being developed for energy production, for water savings and treatment, etc. but that may not have an ethos *of sustainability embedded, it has been kind of stiffen. You a have general culture of doing sustainability stuff but the individuals kind of forgotten, because this stiffen tradition of doing this things, and it comes at another earlier stage when their minds start to grow. And obviously it's pointed as a problem, because if you want to have this to continue, having this type of praxis to continue than you need to make the mind sets to change in that direction as well. And I hope you come*

with good suggestions on how to do that. You shouldn't do brain wash. I just recently saw a, article in journal from a PhD in Aarhus University about cynicism among Chinese students. And he has this point that you also have this among Danish young people, they would say they are totally along with the lines of what you describe 'Hey CO2 gas emission is bad, it is important but and we assume anyone is doing anything about so we don't do as well'. So what you see a kind of cynicism approach to sustainability. They know it is important, they find it's important but they find it is hard to create sustainability praxis*. One of the things we are trying to do in the environmental committee is to create a basis that will allow us to have a basic sustainability to 'walk the talk', and you need to do that.*

[..]

"It is not difficult; it is about tuning the right cases and put a little bit extra curricula but not a lot. One of the problems in a lot of technical department is that PBL is not really problem based, it is narrow well defined problems."

Facilitators

Interviewee $F1_{UPM}$

Background

$F1_{UPM}$ also lectures other courses, in other programmes".

Education for sustainable Development (ESD)

Integration of sustainability moves form several options, but some also present constraints such as the administrative issues:

I can see the different courses or themes that you putted up here. My guess is that you could find courses in other educations, in AAU, where students in this programme can sit in. And be part of. Energy planning, environmental planning maybe something about international relations, within terms of human rights, both technical and social sciences, and humanities and so on. I think that may be possible but there is also, I suppose, the risk that the structure of the programme would be a bit fragmented because they take completely different courses where just sit in.[ref. optional courses beside the 5 ECTS courses]

I think that would make sense, that would have a core course in each semester and then you can decide to take one course in the technical, some kind of technical engineering education, or take a course in sociology, or something like that, and then select your own profile... I think that sounds a quite interesting idea because than you could also shape you own profile.

But whether you just do that... I mean you could think you could just select but then you will be also running into administrative stuff. You could say that you could select packages of courses within this school, where we are located in, or within this department. Because there are different programmes here, right!? I like the idea actually that you could take different modules in different programmes, but in terms of economy having courses in all these… that's impossible so it has to be that the students are sitting in on courses run in other programmes. But would help them to understand different educational backgrounds and disciplines and so on.

[ref. if integration of SD should be mandatory in a course, or in the project in order to apply and learn knowledge and competences for ESD]

There is also something about that the students that select this education, let's call it SD, or let's say its call [ref. name in Danish], *then they will have a natural interest in sustainable development, environmental issues, and so on. And in the courses you are teaching something Urban Planning, Environment Planning, Energy Planning, and so on, and all of this has to be with sustainable development. So Sustainable Development is there but maybe a bit like "unspoken", underlying everything so you don't have necessarily to specify that the aim of the project is to come with new ways for sustainable urban development, for example. I think, at least, if the semester project is more, let's say 'this semester about power' so that is where we focus on. This semester could be for example about traffic planning, next semester about land planning or climate change, and then you would sort of different perspectives."*

Problem Based Learning (PBL) process and curriculum organization

According to **F1**$_{UPM}$ one of the potentialities of PBL is the use of theoretical knowledge learning in real situations like solving problems, and be able to develop critical and reflexive thinking:

"Instead of just learning a theory and what is about, it is more about to enable them to choose between different theories, which are one, is more appropriate to this setting, or situation. And then, also go be able to go beyond the theories, and be able to think critically about 'oh right, this is just a theory and in practice we may have to do different things or combine different theories in new ways. And I think, at least from my perspective is where problem based learning (PBL) and, especially project work, is very helpful because they learn how to use theories, and take even small pieces of each and put them together."

However there also some limitations of the learning environment such as make a single traditional lecture problem oriented:

"I just take my own experiences. I think there are some challenges in making the ordinary lecture problem based. If we want to say that everything is supposed to be problem based then each lecture itself should be problem based. And that can be challenge I think with sort of the things students also need to know somehow. You want to introduce to students a theory in this lecture, and if you would have to do problem based than you would start out with a problem, a case, and then find your way back to the theory. Often it is much easy to start out by introducing the theory and then afterwards give some examples of how to contextualize how that theory might be used, what are the limitations of that theory in practice. But I suppose it is very much the other way around, you should start with a problem and find your way to the theory. At least in UPM, and I suppose in others programmes, it is not how we do teaching at the moment."

"*What I was also trying to say is that if you take one single lecture, and that also has to be problem based, then a single lecturer should start with a problem before you can introduce the theory. The way it is structure at the moment, at least in the course I run, we introduce a theory each lecture, and they get to know the theory and then they can take this theories and use them in their projects project. It is more like a resource, and obviously, and also we create this new thing, in the end of the course we do workshop where the students 'play' with the different theories and apply them to a different case. But as it is now, I suppose*

the lectures are more as resources to be used by the students in their project work."

Normally it is in the problem formulation that students use theoretical elements for problem analysis and formulation. To some extent, such be observed in the students projects' reports:

"*It is up here, and obviously in the end, students use the theory to create the problem formulation, their research question phrased in a way where it contains theoretical concepts. Typically, students project would be introduction and problem formulation, and it would be some kind of theory chapter that goes through the helpful theories, hopefully that ends out with a kind of analytical framework that students can use to finalize their case study. It may also be some methodology as well but then they jump to their case study and start to analyse that. And they finalize with some discussion about what they have found and what could be changed, kind of small solutions. They always go back and always towards the end they discussion the analysis results and the implications for the theory. I suppose, in this semester, it is about these theories to planning practice and how to do that, so it is theory in the beginning of the project.*"

There are some constraints of what, and how, students mobilize knowledge (from previous semester, or just from the semester they are in) to the project work. Some of these are related with time allocated to project as a consequence of the PBL model:

"*I think the good students can't help to use what they have learned before but on the other hand there are limitations of how much can the students do. They are doing these three big courses, and have to make the project aside - and I know the project in terms of ECTS is 15 instead of 27, or 25 - but the students are still doing the same project more and less. So it is ... I mean we could say that they shouldn't do this long projects and I think we are trying to tell them that, but they also want to do, they want to write. It is difficult to write a project in 40 pages.*"

Process competencies

Once more one of the most relevant process competencies is students' ability to think critically but also new ways to purpose solutions:

"*I think how far they get in their project. I suppose for us the most important thing is that they became about to think critical whether... they kind of select a case and what they are doing in that case weather is good or right, whether that is a good way of doing planning, and they sort of the language and able to use the theoretical concepts to critique, or at least analyse in a critical way, what's going on. And then how far they go in their solutions phase, or to propose alternatives, that's more independent and how good the group is, how ambitions they are. Some groups do fine in proposing new ways how to do planning, and another group just end with something a little bit vaguer. It is actually not something that they have some training discourse; it is more one of the other semesters where they are doing more about planning. Now they are analysing more the planning processes. The UPM, 1st semester, they have to analyse a plan and make a purpose for a new plan. So this semester is more about planning process.*"

Interviewee $F2_{UPM}$

Education for sustainable Development (ESD)

$F2_{UPM}$ has the opinion that SD could be integrated both in courses and in projects, both strategies complement each other:

> "*I think in both* [ref. to courses and projects] *and it cannot be in one way. I think the lecture cannot be alone. During a project students are really focused in some kind of practice oriented thing, and we are looking at the problems with their own frame, with their own eyes. I find important in both, for the lecture have a framework*"

Also agrees that it is like to move from the theory to the practice, and not only have an idea, or theory about it, but also bring, and use in, to the real action:

> "*For me as planner, it is essential to move from theory to practice and then back to theory again*"

When questioned about where it should integrate the sustainability in a problem oriented learning approach, the answer was in the problem formulation. Sustainability is a complex problem, and it is not one way to solve it. There is a tendency to create solutions, but it is also need to forecast, and back cast, to solve problems in a sustainable way:

> "*In the problem formulation. For me, yes. Because it is a complex problem, it is not one way, it is not one problem. And, technical universities, and technical engineers and students, they always create solutions. Or they forecast, or they try to, they are able to do so.* [...]
>
> *Of course, then I think, coming back, the created solutions, I think the outcomes of the problem solving can also be re-frame in the sense that not having one problem of sustainable development. I think this creation of solutions it can be some kind of prove tested much wiser. I think if I have to add something to this scheme* [ref. PBL scheme F attached to interview guide], *maybe one here in between, that is learning: what we can learn with the creation of solution here. If not just in terms of outcomes, it can be outcome learning.* [...]
>
> *I think it is just not predicting but it is… well... it is just not predicting but what we can learn from creating from this kind of solutions from this kind of problems.*"

Problem Based Learning (PBL) process and curriculum organization

$F2_{UPM}$ was not educated under Aalborg PBL model, and become in involving in teaching trough PLB when become part of the academic staff member in AAU. He thinks that PBL constitutes an important part of students preparation for profession:

> "*Not really, not really before I came here. The first lecture I gave here I asked around to colleagues how was this different and they said to me: "Oh well you have to think about not just to give a lecture but also to give some questions and some statement in which they can really elaborate from their idea of the lecture, together in groups, and so on. So I started to do that, now I really understand a little bit better what it is, how can am, because I am also doing this pedagogical course... I was a little bit always; I had a personal*

attitude probably to have this PBL myself even if... it is not really very difficult maybe to engage with this. […]

It is I think, potentially is. But I think what planners need to do is to learn, to learn from their experience, and to learn what they can get in the future oriented experience, to plan the future. Actually, I think it is potential, so I cannot really say for sure it is as in now. But I mean in the experience and the ideas that it is, potentially is very close to practice. I think also working group together as the students do, I think it is also very close to the practice. We are practitioners doing that all the time."

F2$_{UPM}$ has the opinion that the educational model can always improve and there are some practical challenges that he faces as facilitator. For example, engineers are very good creating solutions but not always are good formulating and understanding what the problem is. In the area in which he is teaching and working it is very important to know how to formulate problems:

"*I find it for technical engineer, in the field I am working and teaching is... we have to put a lot of effort in this problem formulation. And while we are very good in creating the solutions, the problematizing I something, I find this... sometimes you have really fill them with questions. So this I think is the main obstacle I can see. Well... I think they are very good in the other things.*"

Process competencies

Beside facilitating groups, **F2**$_{UPM}$ also teaches some lectures, and try to make students critical in lecture based activity:

"*I think in a lecture I try always even sometimes not succeeding but what I am trying to do is presenting some kind of problem that is in some way considered in a different way.*" […]

"*Well... I have to say in my experience until now, I didn't make complete courses. I give some lectures and I think in some way, in the work I am following, they brought some these concepts. Something that I present to them were much more concerned what... means to engage with local community. Sometimes they are very oriented to collaborative planning, but what it is the base of the collaborative planning!? So I try to bring them the idea of democratic governance, so I explain to them some king of democratic theory as well. What is the base of this? I think maybe this is difficult and maybe they try to escape. In some ways there are also concepts like transitions that I try to explore with them and I see that they are using this vocabulary in the groups.*"

The interviewee considers that the critical ability, called as criticism, is fundamental in students. However students not always like to be questioned as a mean to develop critical thinking, as well as struggle in several moments in the project work:

"*I think it is linked with this problem formulation, maybe they have... May be they start with exploring something and then we see 'ok this kind of problem' and move to hypothesis... there is some criticism... I think they come back more and more to this in the process. I think they also a little bit afraid of not understanding completely what we are doing so, I they can back on this. So they don't move on criticism immediately. Also there is this technical student want have this in a more objective way, so they have to feel that we grasp everything and so they can move to some criticism... Work with political scientist before is*

very different because we move criticism and go to verify. But in engineers are more careful in this, they are searching for objectivity. Move around with criticism means to be involved and play you in something, and that's something difficult. I see this in the lectures as well. I even sometimes put my research in place to challenge, but I think is a step forward for them because they don't feel that we have grasped it... they haven't the clear idea... sometimes it happens but I think they have to put effort. On this criticism to move around. They didn't have this out of the box thinking, I think it is very important but they want to have boxes"

Synergies between PBL & ESD

Some of the SD aspects pointed in checklist B (see below) are already present in the programme. And interviewee considers that planners can easily link sustainability with their professional role and practice. Also it seems that, whenever one or more sustainability dimensions are present in students' projects, it is more related with solving process:

"*In the solving process, and a sort of evaluation they do very often at the end. I think we do this much more, but sometimes they take this green policies, green mobility and it is a part of the discourse they want to analyse. Maybe then it is more part of the beginning.*"

Interviewee $F3_{UPM}$

Education for sustainable Development (ESD)

$F3_{UPM}$ thinks SD should be integrating in the projects because what projects encloses: solving problems within real contexts. However some theoretical support should be given through courses for example.

Problem Based Learning (PBL) process and curriculum organization

$F3_{UPM}$ points structural and functional challenges in educating engineers through the current PBL model:

There are a couple of ones. Some that are procedural and some that are structural. The procedural ones are for example: it is very to form cross functional process groups. From the time you get in at AAU, from day one until you finish your bachelor, you are in environmental, energy and urban, it is the same study. When it comes to the master it splits. So what happens is, is that you get is shared classes that they take but when it comes to projects group formation - urban stays with urban, environment stays with environment and energy stays with energy. What that means is if there is a group in urban planning which is focus on sustainable mobility or something like this, they look at it with their particularly lens. So they see it from the way an urban planner would see it which is very different in the way someone does energy planning would see it, or someone works with environmental stuff sees it. I personally tried to structure a group like that last semester and the students don't like it.

This may lead to think that students may not like to get out the comfort zone, however the interviewee points examples of the contrary:

But it was two groups and both want to work with climate change adaptation with large cities. One in London and one in Copenhagen. My suggestion was 'well you guys can pull your data into a comparative case study. This group does this; this group does that and creates a common data pool. And then you can still pull out. Because party the problem is the structural problem as well, is the study board guidelines are very explicit about what the delivery of the project should be. And that is not negotiable, so when students deliver a project they have a series of goals, and if those goals are not consistent between the environments, energy and urban, so the projects groups are responsible for delivering because is their 15 ECTS for that. So they are responsible and they will be evaluating based on these criteria. Actually the structure here is interesting enough in a PBL environment; make it almost impossible to create cross functional project groups.

The interviewee thinks that this may be cause by the rigid and fix structure of the PBL model:

And works against creating these transactions between these different lines. And moreover you can't even go outside. If you find somebody in Medialogy, or you found somebody in cognitive psychology, or you found somebody in business that are actually interesting in doing something like this, you couldn't make a project group out of that. You can't do it, which I think interesting. And sustainability is about what!? Systems thinking, integrative approaches, holistic. Great idea and then bring it in to an institution that still 400 years old in its thinking.

It is very difficult [ref. to integration of education as sustainability in higher education]. *Something similar happens when you see research groups that have natural sciences and social sciences; they haven't had a lot of experience in look into each other worlds. They simply don't understand each other. At a fundamental level, what which constitutes an empirical fact from a natural science perspective is often as perceived as possible explanatory cause from a social scientist, and vice versa. So here natural scientist and here social science presenting a so called evidence, ant they go 'huff that is not evidence, that is you describe something'. That cultural gap in engineering programme is interesting because that is one of the tensions I find quite fascinating here. When you think about engineering as a hard core discipline, you would expect to see significant amount of math, chemistry, physics, and these sorts of backgrounds. And those are here to some extent, they are elements of that, we have people that came from math, we have some people that came from civil engineering - by far the dominant bon on students and research side - in social sciences.*

According to **F3**$_{UPM}$ this "400" years old of thinking which may constitute a barrier to integrate ESD in higher education. To some extent such reflects a problem of communication between different disciplines and areas, which makes a barrier in collaborating in cross functional groups, department and/ or programmes.

To some extent such model has repercussions trough the procedural challenges mentioned above:

Yeah... Maybe it is more about the timing of things. For example, if you want students - and maybe it also relates also with the structure - is that the way that this master is putted together is you have... these different modules, 3 modules of 5 ECTS [ref. to courses] *and the project group. So the way that the modules of 5 ECTS work is typically there is course responsible for that. And they have quite bit of autonomy to decide how that's going to go and there is a semester coordinator. The semester coordinator primary job is to make sure*

that everything functions. There is no programme responsible, and in the absence of that what that means is there is not overarching themes that emerge from this. If we think about the sustainable urban development, what are the primary drivers, what are the primary barriers, what sort of solutions, those kinds of things are not there. Maybe they embedded some pieces... but I think from an educational stand point there is a challenge that make a little bit - I don't know if ironic is the right word - but there is a lot of criticism directed towards planning authorities that they silo planning. Those architectures do land use planning, transport engineers do transport planning and environmental engineers do the sector planning. But that is the exact replication they do here.

On the other hand, PBL model presents potentialities however it is not may be grasping in its full potential by the institution, and its actors.

Process competencies

There is a need to develop the ability to students to work in multidisciplinary teams, as future engineers that is something that will happen in real life, however in the educational systems they still close in their own department, programme, etc.:

Civil engineers are taught in a specific ways of thinking, which is he need to have double, triple failures. So he need to do exact calculations of what the exact workloads are and then o triple them, because you are personal responsible if something happens, the building collapse or the dam collapses. So safety and risk avoidance are the two primarily factors, environmental engineering is not exactly brought up in that exact same terms. They are not thinking of my design fails I am going to jail and that's different. For example transport engineers are brought up about safety, accessibility and speed. That what happens in practice, and I don't know which reflects which, but it's definitely replicated inside the training for new engineers. It's reducing congestion, making sure the soft travel, making sure that there are few accidents as possible. So there is a series of sequential decisions fall over from that.

They don't have a choice, they have to. They don't have any other options; there is no optional courses, no extra courses. You don't get a menu card when you come to the master and you could take 'humm, one, two, three, and four...' you pick three out of these ten offerings. No, you take this one and you take this one, and you take this one and then you do your projects. It is extremely difficult. The structure itself it makes almost impossible to reach outside of your discipline, to reach outside for.. if you want to know something about systems science, if you are interested in energy planning but you have a strong environmental background.

Interviewee F4$_{UPM}$

Education for sustainable Development (ESD)

Integration of SD in the programme:

> "*I don't know if in a project, because is up to students to define the nature of the project, and for me to push them along the lines of sustainability, some other topic probably that's could be promoted by myself for sure if I am acquainted with the topic. Sometimes supervisors are very much relying on their own research. So probably in a course they will be able to judge from the beginning where is going to be use or not in the performance of their project. Probably course work as an example.*" […]
>
> *Probably already in the formulation, that means that you are going to use it in all the evaluation of... I mean in the analysis of the all project. Thereby you have to be... setting your theory, your case as well. I think always in those terms.*"

Problem Based Learning (PBL) process and curriculum organization

Differences between PBL approach in AAU and the one experienced by the interviewee at British Columbia, Canada:

> "*I learned about PBL there, and I worked in groups together with others in coming up with projects. Although it was a little different, I mean we determined the problem together; we worked in different sessions together, always with a supervisor in situ, not like here. They are left alone and you gather with them in the meetings. Over there the supervisor was always there... I mean not to orient but also to vigilante... Tutoring... probably tutoring. You are not entirely allowed to ask directly to the supervisor what to... They were there just… sort of moderate...*"
>
> "*I think it was more guided. In my experience as PBL, I mean there was a course using PBL, I felt, I mean we all felt, much more guided. Probably over here that's a chock for international students. Who never been in this system, they were not taught how to deal with this... that's a big of a challenge*."

The interviewee considers that are some challenges arising in the system:

> "*I think there are so many challenges arising. For instance, if I take the example of this group, this semester, you know them probably already. What I see is that they may be case of very different cultural backgrounds. And educational backgrounds. So these two different things: the country where they come from, the way they grow up; and also the educational, the planning education is different depending on the country they are coming from. Where is in Germany tend to be more technical, and Norway, probably it's more related to here but still there is massive differences, and then in UK is another tradition of planning. These different planning traditions merging to work in a specific problem, in this case was about public participation, collaboration in planning. And the challenge was that people have different ideas, they come up with different perspectives and the one that that has the strongest personality has probably more leadership knowledge and sub taking over the others. And the others find quite difficult to develop arguments to create a space within a group to put forward their ideas. That was one of the core things I saw in this group, and I have seen it in other groups in the past as well. So these two factors are cru-*

cial for me - cultural and the educational. And then the outcome that is produced in the project, the written outcome, can be extremely different from the way they perform in the examination, the oral examination, because it's two different ways of evaluated. We are supposed to evaluate the oral, not the written, and yet that's also can be remarkable different, totally unexpected actually. So that's been a challenge because, of course, you sort of stigmatize students already from the beginning, you sort of... towards the end you know what the outcome is going to be but particularly this time I was extremely surprise that my stigma was totally downgraded, and I was happy about that because I learn about the fact that..."

PBL process allows students to develop ownership in their projects, and research, which reflects to some extent in their motivation and engagement in solving process:

"*I think that's also links more to ownership than empowerment. I don't know... if they develop from the very beginning, or early stages in their projects, they develop some sort of ownership already towards wherever that is they are researching. That's why sort of sometimes try to engage them in a early pile of interviews for instance, to go out to the field, to really get a sense of what is this all about. Then they start to develop more interest, more ownership to their projects. And that can even help them socially wise, if they go together but of course that is to relative but still. So I can see that this is a case of ownership probably... I mean I am not entirely sure... I haven't really sensed it as a case of empowerment.*"

PBL potentialities:

"*So probably that would be some of the strengths, or even opportunities that they end up... at the end by having done this sort of project. I think... I mean, through engagement on working with a tangible problem like PBL theory says, they end up really opening up some specifics topics or, or really making something out of them. Both individually and in collaboration with others. So if there is appropriate group dynamics, and by appropriate I say lot of really enriching discussions and when they really getting engaged discussion and open up ideas without... I mean living behind their stubbornness or their personal issues. I think they end up learning far more than in the typical traditional way of lecturing just because of the fact that they exercise it. They are not just reading it and reflecting upon it in a written expression, which is extremely valuable as well, it is another way of... another sort of challenge like it was I remembering in Canada. It was about pretty much about individual work and your performance in a written expression, over here it also the oral part, which I think it is crucial. But the oral part to perform positively in the examination, you have to have very good dynamics and very good interactions all together.*"

Process competencies

According to the interviewee, students find difficult to transfer knowledge from the courses to apply in the solving process, which reflects in the outcome of the project, like for example, very soft and superficial analysis of data collected for solving the problem:

"*In 90% of the cases they don't know how to do it. In my experience it is ah... they don't know how to use theory and, many of them, don't know what theory is there for. They just think that they just need to talk about theory so they can analyse the case and they need*

to handle theory because it is required by the programme in question, or the education in question. But when you actually explain them how to use theory, what for they need a theory, and the relevance of theory, and usefulness of theory, and they grasp that, I think then they star to understand to be able to use of it in their analysis. But for that you need supervisors that know how to do that. And there are so many cases... I mean that you can tell a lot of students, for instance 1st year PhD students, possibly even some professors sometimes, do way they tend to explain that it is not the really best fit for students at that stage. So you need to be extremely eloquent, extremely specific and trying to.. I mean if you are going to be successful in transmitting that sort of knowledge then that's really giving then a lot of tools to work with that. And I think, of course, students need to be very engage, they have their responsibility but the supervisor has an even larger responsibility making them understand the way to use theory in analysis." […]

"*I had experiences where it was so hard for them actually even to develop a specific methodological approach to carry out the project. So there are cases where they never end up knowing what the problem is all about. I have seen several actually. And usually with international students because they are not used to it. The Danish have been working with this from the first semester [from the bachelor level] so that's very common that they move smoothly in this timeline but in another cases I find that they sort of purpose something that they want to learn about without problematizing, and they move towards some theories that could probably match that problem but again they are moving from phase to phase without being certain about the previous phase. They don't wrap it up.*"

"*Even the analysis sometimes is extremely soft, it is to narrow, to fluffy because they didn't problematize well, because they didn't follow a methodological approach that really sounds right to be able to analyse better and then they don't know how to integrate the theory probably they chose the wrong theories because they never know what the problem was all about. So many cases are like that. They jump from one to another without knowing because they are desperate and probably they are not even working in between they are just go to the next presentation they sort of grab everything hop in the last few days and go the supervision presentation.*" […]

Synergies between PBL & ESD

The UPM programme already have some aspects/ semester addressing sustainability with connection with practice/ profession:

"*I think it is in the 7th semester* [ref. 1st semester of master programme]*... well what I like about here it depends, probably someone will answer you differently. But definitely in UPM 1 and 2, 1st one the complex city, you definitely address it. Students come in with all these ideals about sustainability and how to create a sustainable city and so forth. It is somehow embedded in there.* [...] *In the first semester is probably better embedded than in the second, which is about Power and Planning issues, also looking the dark side of planning and not focusing on a lot of sustainability, but more about these courses of interaction of actors, about what happens out in the reality, more government politically based. So, it is there.*"

"*They think is that the ways the programmes are promoted in this department, the 5 master programmes, what they are advertise. They advertise sustainability programmes as many others universities because that's been a trigger word for a lot of students to go for*

those sort of educations, to track students by using that. But from my perspective implicitly I hate to use that term of sustainability, I mean... it's... for me a political discourse in many ways. I have used but only from a discourse perspective to say what people mean but that and the power that is embedded. But I think... a lot of students get here and in the 7th semester they tend to focus their project using this approach by sustainability and then in the 8th they sort of start really getting more down to earth and getting into another things. But I think it is there, the component is there, at least the way it's advertise, the way they were teaching it as well, to some extent in the 7th semester is there. In the 8th probably not as much but you can find it there for sure."

Students

Interviewee $S1_{UPM}$

Background

S1$_{UPM}$ got a bachelor degree from Aalborg University in Urban, Energy and Environment Energy, and is in the second semester of master programme with the same name within specialization of UPM.

Education for sustainable Development (ESD)

Definition of sustainability:

"I don't think the social aspect so much as sustainable even though I know it is there. Bu when I talked about it in general it is not I would define sustainable. Sometimes I think probably more about nature than I think in society. But then society is link to nature and it is another discussion..."

Agree with the integration of sustainability in the project, and pointed specific moments where sustainability can come in PBL process:

"Everywhere, I think definitely in the evaluation, at the end. But you also need from the beginning otherwise you will not be able to be evaluated in the best way. so if you don't have it with you from the beginning than..."

There is need for specific measurements to connect sustainability with real life practice:

I think we need to see the city developing; they would need the more concrete examples of what it is. Because that what you see in general, everything is sustainable development, every commune, every municipality suddenly is sustainable. But they don't really define what it really is, they just say economics. I think it is important in that we need some specific measurements for the government, for the state, even for the public to understand what is going on. If you out it in the higher level that you sit in the university, then you may can use a theory and connect to here m but if you are look to real life it is really important, it is in this level. Otherwise you will never see any results, and people would not understand.

You have the Brutland about the definitions, and even though it has the three definitions people claim that's the definition of sustainability. If you take one of these things out, you

would like in human rights, you would not have the economic perspective as much as you will have. And it can also be defined in so many different ways.

Problem Based Learning (PBL) process and curriculum organization

Perspectives towards PBL learning process – challenges, difficulties and gains:

"In some ways is to cooperate I would say. Find this balance between who is the leader, do we have a leader. How do we cooperate, how can we divide work equally, it is even possible. And that people are engage in the same amount in the project. I think that is some of the main challenges, to create really good fellow in a group, what is really needed when you do this PBL because it's a fundamental for creating good projects. And if you have good fundamentals you almost can write a good project about the most boring thing in the world."

"Depends if you see the international context, multicultural environment or if it is your own culture. I experience the jump from being only Danish people, where you focus, or you thought it was hard, or people were not as good as you, or had difficulties in understanding what was going on, or didn't do the amount of work it was supposed to do. In the master programme you have cultural differences, it is just the language barriers sometimes, and expectations and cultures of how you work and how you think. It is definitely a challenge but you also learn something, but that's hard."

"I think... sometimes it is the feeling, when you are done, that you create some new knowledge which hasn't been produced before. It is just from other perspective, that you know that you didn't only learn something, that didn't only read books, and then you went for a examination about that books, but actually be able to do by yourself, to produce knowledge. There is no better feeling when your supervisor afterwards says 'it is really good what you find out and I've even told some of your results to my colleagues'. That's a really good, nice feeling, to be independent and produce your knowledge."

Process competencies

Ability to deal with complex systems such as a real social context:

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 is a knowing when to apply knowledge that you get from theory.

Do you think is a more reflect of the process? Three clusters as problem formulation, problem solving and assessment of solution. Where do you think you become more aware of the strategic knowledge?

I think the first one is when you starting creating it, but you start reflecting about it in the second one, when you gather the knowledge and information, when you are actually sitting with the case you are working.

Because that's where you have to be aware of lack of knowledge and you have to be aware of theories that have to connect together with case, as well as with different actors and systems. That's where you start reflecting even though you still you still have the last

part, which obviously would be the one you do it [ref. to reflecting]. *But I think you start doing it* [ref. to reflecting] *in the second phase, and then, in the third phase, you use our reflections on the third phase and produce there.*

You think it is somehow difficult to jump back and forth and keep a clear image of this process?

You will never do just in a logical way, theories are never 100% and you find out, when you do empirical work, that you miss something which lack, limits ones knowledge. But suddenly pops up and say I was not aware of that, or theories haven't been aware of that. It is actually an interesting area here.

About double loop learning, and ability to reflect in process and limitations:

It a hard part but it happens no matter what. I think the challenging part is to remember to criticizing all the time, in the process you are right now, breaking down into parts and say "where are we actually now; why are we here and why we didn't end in the other corner instead?" I think that is something we learn in the 3 first years [in bachelor] and something that takes even more time to know with students that never tried before [PBL method]. But I think it can be kind of hard. But that's the whole thing with project as well. I don't even know if you can give the PBL the medal of it, because I think it a general when you start learning. […]

You think is because you work with real cases, in a context?

I think that helps me to come further but I think it is. I won't be able to answer that. Maybe is because I am so much into this that I think is obviously that you will transform that, your values may change afterwards but probably help when you work with specific cases because you get… it is not a theory read about or history, but actually people you talk to or analysing something really you see.

But you work with a group as well, how much of these transformations happen in group dynamic?

I think many discussions are based on feelings and reasons why

What motivates you to make a change? Do you think there are feelings behind?

I think in many situations there is a feeling behind it. In my case it's a mixture of rational thinking saying how it should be because it's best for everyone and, of course, depends on the case. There are also feelings involved.

Synergies between PBL & ESD

Not always the choice of integrating sustainability elements, or look with sustainable perspective in mind drives the project. To some extent, the context call for such:

I do think that start reflecting by ourselves, why is like that? I don't think we thought it was more sustainable, I think we thought it was interesting subject that it was aware that cities just only focus on the "right citizens", and that's more and less we have been made projects about in the last semesters. The sustainability in some ways has been introduced but not this social perspective of sustainability. I don't think... Probably was unconscious from our side, you know!? It was not something directly though 'oh it's sustainable that's why

we have to do it'.

Other experiences

Perspectives towards UPM education and its link with creating sustainable cities and ways of living:

> *When I've started this education mainly focus in Urban Planning, more about designing like creating the cities. But now I found out that there is so much else behind, the buildings that needs to work and mechanisms that are important to be aware of. And of course that is also something... especially after we started in the bachelor, or this education, that is the awareness of the environment and the sustainability. Of course there is something this education, or this institute, is filled with professors who make living for sustainability in different levels and in different definitions. So of course somehow it will get into you. Of course there is some kind of level and interest in creating better cities and more environmental friendly societies. This can be on the social level, where you look into people and how they can have a better live and create a better live but maybe sometimes at a more technical perspective, how the cities can be create so there is more sustainable.*

Interviewee $S2_{UPM,}$ $S3_{UPM}$ & $S4_{UPM}$

Background

$S2_{UPM}$; **$S3_{UPM}$** had their bachelor education in Urban, Energy and Environmental Planning, and more to the master programme for the specialization of Urban Planning and Management

$S4_{UPM}$ did her bachelor in UK, where she is from, and had a second semester in Aalborg as part of exchange programme and to finish the master education.

Education for sustainable Development (ESD)

Integration of SD:

> *I don't think you have to do something to the curriculum but maybe somehow... I don't know, maybe it is just to me but I never been that into what the curriculum actually says.* (**S2**)

Problem Based Learning (PBL) process and curriculum organization

Perspectives for improve the educational programme:

> *I think in this semester because it is about power. I wouldn't think it was that relevant but I think we have kind of been raised to the years always to have it in mind and always sort of pop ups. I think this is the first semester it is not really a big deal. But…* (**S2**)
>
> *I think somehow I've seen this as is; I got a lot of skills and knowledge about Sustainable Development (SD) 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 and still knowledge that we have so many different*

powers out there, economic powers, political powers, that will really block us in ours pursuits, in our mission to make everything right (**S3**)

I guess you can say that has been very normative so far but this semester has been quite blur. You will have to deal with this and this as well (**S2**)

Just preparing us, I feel like that what has been happening. Actually, I think it is fine this semester has nothing to do with environment, or anything. I feel like they done a pretty good job teaching us that until now. And so I am ready just to learn how to be an actual planner now. (**S3**)

One of the challenges of the learning environment is concern the intercultural environment, which also as some positive points as follow:

Tacit knowledge that we become experts in doing it [referring to 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 wash I've been. It is not that I don't like it or anything is other ways of looking into it.* (**S3**)

Challenges for a foreigner student:

I have done group work back home but not as intense as now. Before, it is a lot more like... you can give more time to your own and decide if you don't every day at 9 o'clock, you can put more hours at end. When you are in group you want to be there more and want to be part of the group more. Like from the start, you don't have your only expectations, but you have others people as well so have got to make sure that you pull away from the start. To prove yourself but to others as well. [...]

No difficult adaptation, but it is not so as it is here. (**S4**)

Process competencies

Skills and competencies developed through the programme:

I think we have a little of everything for skills. I've learn 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. (**S3**)

Synergies between PBL & ESD

Interviewees do not consider that a sustainable perspective integrated in the project report, even the answer was given by **S2**$_{UPM}$:

I think it depends on the definition of sustainability, because we do have some... it is somehow link with to social sustainability and also kind of... if we don't really watch the role of the planner or watch what actually is going on, what will happen to the environmental and economic sustainability. But we have not really been thinking about sustainable development. Of it is in there somehow because it is there somehow if you want to re-

late it. But we didn't.(**S2**)

Interviewee S5$_{UPM}$

Background

Has the bachelor in the same education as the master programme.

Education for sustainable Development (ESD)

Definition of ESD:

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, use a lot of time describing on 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.

Problem Based Learning (PBL) process and curriculum organization

Challenges of being educated through PBL:

I have been able to go into depth with whatever subject I found interesting. Ok, you always have to kind of find... You are in a group of 4, 5 6 7 people, and you have to find something that you all find interesting. But I think I have been very luck, always been a group where willing to give and take a bit. All members of the groups have always found something interesting in whatever we were doing. Because we can go into much into details.

I think in most cases we have had an idea of what the results may be and a good idea often. But I am not saying that you can predict the results always. One thing I like about this is that you are not just doing an assignment. You are trying to solve a problem that nobody before you know about. I have had a sensor who - when he saw the project - apparently he had done something similar. But we didn't know that and we couldn't contact him because we knew he was our sensor. But he hadn't used that particular method so he hadn't seen other possibilities of what we were trying to do so he found that very interesting. We suddenly created something new, and I think that is interesting I must say. I don't think we really do [ref. the changes from the bachelor to the master]. *One think changes, and that is the theoretical background, we need to emphasize in that when we come to the master but I am not sure I find the projects we have been doing in the master more complex. They maybe be a bit harder to work out because... for instance this semester is about power issues and can't measure a power issue. So that's a different between this semester and other semester where I have been doing, to higher extent, can go out and calculate something. But still I don't really find it.*

No in the first year. The first year is quite simple I must say. And they may not be carrying out as thoroughly as are they are now but that's one think. But perhaps the last year of the

bachelor that were some quite complex problems we had there. But at least we made them complex. It might be because I was in a group that was quite ambitious about what they are doing. It could be a different here concerning the group. [Ref. to complexity in relation with projects' themes underlying the semester]

Synergies between PBL & ESD

SD intentions for the project work:

> *Not sustainability. There are few elements of it, we are not discussing sustainability, saying what it is and describing the theory behind, we are not doing that. But we have something about some climate issues, or something but we are not describing it because they talk about green transportation but only has an excuse for something. We are not saying what it is because that is the point about the approach we take this semester. That people have different perceptions of things, they interpreted differently so would not make any sense to say what is this actually. Because we are dealing with politicians here can they use us as positive word and just to say this is a positive thing that is linked to something of this? That's enough because that is what they use, they are not going to detail and it wouldn't make any sense if we did because then we would just say 'they don't have any idea of what they are talking about'. No they don't but they still have power.*

Even if it not an aim of the semester, the interviewee can makes a relation between his project theme and how it may be related with ESD:

> *I think that is quite familiar with have been doing this semester, what you just said. That's ok. I think was we did this semester was initiated by some development that we thought were wrong perhaps. But in the end we are not being the judge of that, we are not saying that anything is wrong but rather what it is. But that in itself is interesting as well because that you can actually have power and who is powerful and powerless.*

Interviewee S6$_{UPM}$

Background

S6$_{UPM}$ is Lebanese and has a bachelor in structure and civil engineering from AAU, and is doing the master in the UPM programme.

S6$_{UPM}$ participated in projects of Engineers Without Boarders, and has a high interest in collaborate with NGOs, inside and outside Denmark.

Education for sustainable Development (ESD)

Perspectives and definition of ESD:

> *It depends if we are talking about sustainability as the big brand shoes like the new shoes. I think it's my education makes me aware about things being sustainable but it depends in how it is defined because sustainability differs in my opinion. What is sustainability in the*

3rd world countries compared to here? I don't think is the same? What I like is that this education, in formal sense, teaches to me, gives me some tools, gives a knowledge that I can use. And of course, aiming and making everything sustainable. And what I talk about when I do my work as NGOs is because I am seeking sustainability and equality. And if equality is part of sustainability then yes. That's why I am trying to make my life sustainable by educating myself, getting a better living standard from where I come from. Because from where I came from a ghetto where we were 6 children in a small apartment, where my parents. So I am trying to sustain my own life but also being aware that other people's lives are not sustainable and therefor I try to apply the sustainability I gain through life as well.

I would define sustainability as balance.

According with interviewee there is space in technical programmes to integrate ESD, however there are several limitations being one the narrow design of the curriculum and type of problems worked by students, as mentioned bellow.

Integration of ESD:

I think it should be at... depends... That is a difficult one. I don't think it should be up to the students to create sustainability. We should be able to do this when we are educated. And done. We are still learning. How I see it is it is nice that is given the freedom to us to shape our project as we want to but we still have supervisors to direct us, so I think it is important to see the connection between the courses and the project. so therefore the sustainability should be

Mostly... like that should be a good concreteness and abstractedness of how... This is the tools; this is how we apply the tools in a course. Because wren the study board or the lecturers have done this, they have given us a good foundation a good foundation to build up our project on. And of course what we learn in the courses is something also should apply into our projects. So even we can decide not to write about the delivery part us still being asked question to the exam about the exam. So it is up to us to create sustainability between the different courses and then apply it to this. But I think it is also important to the courses that they can link with each other. Of course tells a lot about the students of they can do it by themselves and also grade them. But it is implied that the courses are connected or it is just up to the students to see the connection and applied to the project? I think it is a really big question because, of course we shouldn't be handed every answer we should know who to find the answer and we should know how to connect things and should know how to reflect about things in the project and by ourselves. Of course and have always 'ahhh' effect at the end, 'ahh so this what they have been talking this is how it is used', but give it again the time constraint and that life happens you know, and can affect the project, like in our case, I think it is important that all the lectures. I like what they do here in UPM - that we have one or two months with all the lectures - but also... because then they create time and space for us to play with what we learn in the end. I think again we have the concreteness, if that is the lectures together, and then we have the abstractedness of it like how we apply it into a given abstract problem, anchor this problem and define this problem I like that, that we have the space at the end of the project without thinking about exams, or going to lectures. We have the lecturers in the beginning and time to slowly incorporate and define the problem for the project.

Gains from PBL education:

> *I think I've gained more confidence, I've learn so much. I've learn 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 I am sitting here, I've learn how to reflect, I've learn how to use tools. And that is something I didn't get from my bachelor maybe if I was interested in looking into steel beams I would see it but it is not applicable for the person I am.*

Limitations of technical education:

> *The bachelor is no way near balance, because it is relying in only one thing, which is technical solutions and improvements. I think yes. I think what I have missed in my bachelor was the balance of what I am being taught and how I can use it. What they mostly did was to fire way with all the theories but what we were, many times me and my group member as we work together for 6 semesters in 6 projects, so we know each other really good. What we were looking at was how, why don't you explain, like 'tell me a story about why it is important to look at steel beams. How can I use for here, why it is important.' It was too to clinical and to* close [as detailed/ narrow], *and it is good because it is part of the balance that I am looking at but I need to know how I can take this and apply it to the real house.*
>
> *We didn't real understand it. The problem with Esbjerg compared to Aalborg is that one of the supervisors we had there has worked there for 30 years, so he is just used to. He is just riding in the method. He is brilliant supervisor but he was to narrow down to this, he had explained for students 60 at least because he had each semester going for 30 years.*
>
> *A lot of things that we were told like if we had difficulty in some equation, or anything, understanding something or how we could connected it to reality, how we could reflect on it, was this is you learn on the 3rd grade in school. Because they only told us about who made this equation and what it's dependent on in terms of variables. Like in units, not in real life. Like saying 'this bridge the steel beam depends on the temperature, the force, materials to put on, so on.' You know, you are taking up to the level where it's explain clinical, clean close systems in comparison to the real level. It could be more open.*
>
> *What I think is you have mathematics, physics, chemistry, etc., it is not based in the real world but... I think I have read in my dynamics books is 'if you have a problem and you can solve the problem as it is then try to simplified it the problem and try to solve it them. Make a close system and them you say these are my units; these are my variables these is how my equation is, depending on this outcome. And then you can take this, small problem that you solved, make it bigger, add more variable to it. At this is what we needed, why we need to know Newton's three laws, because we need to calculate the falls and so on. This is how you can say it but people don't really understand. You get an explanation in primary school that goes... we have gravity so we don't go out flying to the moon but what we can use gravity, we can calculate different things, make building rise. But it is missing a balance towards explaining what you can use this for, and not just how you use it. This connection is left up to you.*
>
> [A connection to society for example] *That's what I think. Just to give a simple example. When a lecturer was standing there in the first week telling us that was needed to build a*

new bridge because the capacity of cars is rising. My thought as technical engineer was as ' ok maybe the solution is to knock the bridge and build a bigger one, or build another bridge'. And my complex problems were steel, beams, concrete and bla bla. While other people that's comes from different background were thinking in different ways but I never thought that could be a different solution then just building a new bridge. Then he said [ref. to lecturer] *maybe we could reduce the private cars, and enhance the public transport. Or we could do some changes in one side of the city. Maybe it is a social problem, maybe we have to much people in one side, or because there is more work in this side so maybe we could create more work... And this is has maybe a better effect because if we create more work here, we can build more houses, we give a boost to the economy and so on. I think the balance with sustainability in my bachelor was really missing because a lot of the creative...*

When we talk about PBL we hear say that some people are really good at listening, some are good at seeing. But if you every day only see chalk on the black board and equations and not connected with pictures, with stories or whatever. Then it is difficult to understand. In this master I was given the opportunity to connect, especially in a course where it was always given an example, he always would end by saying this is a planning theory this is how you can use, here is a case where it has been used, and we have to present ourselves and reflect about and connect to a certain problem, or area or whatever.

Process competencies

Collaboration within PBL learning environment and relation with assessment:

Collaboration is a tool. I think as being a student, at some point you need to know what you do and you thought. I know the exams say a lot of things and you can get good critique and good feedback. But sometimes... Last semester I did the a lot of the work load, a lot, and this is where the Aalborg model doesn't connect together - it is the ability to gain new knowledge that is being tested at the exam and not so much the work you have done. And this is really frustrating for students that work a lot and this actually broke me after the exam last semester. I see the exam room as a clean laboratory, you know, it is clinical, it is clean, there is no relation between me and my supervisor, there is no relation between me and the sensor and it shouldn't be any relation between the two, but this is the system I am talking about but the system it is not the real world. What I mean is... I am more trying to direct on how to formulate you as a student, as a supervisor and as a sensor. And this was something I wasn't actually so satisfied with. After that I've decided that I am going to be a free rider at the project next semester because this is the problem because the people that don't do so much work can just sit down, read the project and reflect on it. These kinds of people, always, they have to pretend, to keep this calm face in the exam room when people that actually done a lot work and done a lot of things have used...

I think there is a define line in going to an exam and your knowledge still knew because then you go and explain it. But if a sudden your knowledge becomes old knowledge than you just assume and go a step further up. And that's what just happen to me by the explaining all my thoughts. I was able to sum up the project in five minutes and the main problems but in the rest 30 minutes I was talking about all other topics - what is adaptation and what it us needed to do - but not really link it to the project. It was 5 minutes of what I know and the 30 minutes about reflection. I understand that should be a define line, and this is why I actually to be a free rider this semester but didn't happen because the

kind of person I am.

Other experiences

Engineers without boarders – project in Palestine:

Actually within my 3rd year of studying. In my case what I am trying to bring to engineers without boarders, when I go out and talk with different students, educated people, what I try to do is tell my story.. Like my professional story, my hobbies, the way I see life. This is actually what I could use from what I've learned through project work, as just... Was not that must in these connection, because it was so technical, structural what I've learned but how to manage time, what things should be in order before you can do other things. I've also could use, but I could mainly could use was my calmness in stress situations. Like I can pressure myself to this it also comes from project work, having a high work load and still keeps the overview and work towards the goals. I could use my cultural understand, my religion understanding, and the third this. I could speak Arabic. And also I was that I was understood I can kind of pitch myself and say: "I know you man, engineers are down there don't have access to the women, and I have never learn this in my bachelor but I know for a fact that this kind of cultured the man are the lazy ones, and the one doing the hard work in theses villages are the women, so if they want to map down realistic interested need and value it would be defined by the women and not by the man. [...].

This was not really the map down with the same way it was only by the man. The man would just say we want this, and this, and make tea, you know normal conversation and more talking about the dangerous of leaving there than actually say what… Where the women would say even if there is a fight we need to get sheeps out so they could have food, after three or four days of war, if our sheeps get ill we cannot survive further. They need cleaning water to get the whole village running and to some point even to create economic market presence. [...]

That was not the mapping down the needs, and it was the previously engineers problem, the problem was that they could not get access to the women, and this were I say the technical engineers are very good at a lot things but what they are not good at, they need to seek help from others like: communication, cultural understandings, religious understandings, traditions by religion and culture. And they would have known that we can't really work in this area unless we have one or two females, that at least one understand the cultural religions and traditions, and a person that can communicate in this language and the sayings and like that. [...]

I think that the difference here everything is manage through the planning systems, like how do we zone, how we do this, we have an area of problems this is how we approach it. We have access to this knowledge here, but what engineers and a lot of NGO's forget, that how many was successful implemented but when we implement it did we actually made maintenance budgets for that., where is poor areas they hardly to make money to life. You need the maintenance budget... they go a work in a project implemented the system that they need and then they leave it. They don't go back and check how it is going. If still maintain, is still work and a lot of times they down to this area and found out that actually that pipelines form 10 years ago, from other NGO's. It is important to get money for the system, the system will cost probably 1/5 of the maintenance budget and here is where do you need to incorporate people leaving in this area, that make a board like how do you

maintenance this, how much each family may contribute, etc. You put a kind of responsibility in yourself, when you do this kind of help you should also be aware that you cannot just put the system and walk away.

2. Checklists and comments

Checklist A

		Programme	*Urban Planning and Management*									
		ID code	**SB1**	**L1**	**F1(*)**	**F2**	**F3**	**F4**	**S1**	**S2 S3 S4**	**S5**	**S6**
		Group	*Study board*	*Lecturers*		*Supervisors*				*Students*		
A.1.Systemic & holistic	A.1.1. Capable of placing engineering field in perspective with others areas of knowledge											
	A.1.2. Develop knowledge beyond core STEM disciplines like sociology, ethics, business, etc.		**X**		**X**				X			
	A.1.3. Aware that engineering practice influences, and is influenced by, other professional practices		**X**	**X**				**X**	**X**	**X**		**X**
A.2.Flexibility and adaptability	A.2.1. Handle uncertainty by keeping open as many future options possible				**X**							
	A.2.2. Reflect on how alternative solutions that fit with the sustainable development approach can be identified					**X**					X	
	A.2.3. Accept that there are no guarantees that our solutions will be truly sustainable – we therefore must do our best with the skills, knowledge and resources we have at our disposal				**X**		**X**		**X**	**X**	**X**	**X**
A.3.Contextual	A.3.1. Develop alternative solutions that are locally relevant						**X**	**X**				X
	A.3.2. Develop alternative solutions that are culturally appropriate											X
	A.3.3. Seek to minimize the negative, and maximizing the positive, impacts of engineering practices both locally and globally									X		
A.4.Problem Solvers	A.4.1. Use technical engineering knowledge to solve real problems						**X**	**X**			**X**	
	A.4.2. Involve others' perspectives and knowledge (e.g. local representatives, politicians, stakeholders, etc.) in defining and solving complex problems		**X**		**X**	**X**	**X**		**X**	**X**	**X**	**X**
	A.4.3. Retain the sustainability focus on the intended outcome right through the assessment and/ or implementation of the solution											
A.5.Participatory & decision maker	A.5.1. Bring social, economic and environmental experts and implications to seek a balanced decision		**X**			**X**				X		
	A.5.2. Professional engineers participate in the decision making as well as in their professional roles											
	A.5.3. Participate actively in the discussion and definition of social and economic policies to redirect society to a more sustainable development.		**X**	**X**	**X**					X		
A.6.Creativity and innovation	A.6.1. Divergent thinking among peers			**X**								
	A.6.2. Thinking "out-of-the box"			**X**		**X**	**X**		X			
	A.6.3. Combining old ideas with new ideas											
	A.6.4. Create new ideas with others					**X**					X	
(*)ADDED A SUGGESTION: LEARN TO REFLECTIVE AND CRITICALLY (NAVIGATE COMPLEXITY)												

Checklist B

		Programme	Urban Planning and Management									
		ID code	SB1	L1(*)	F1	F2	F3	F4	S1	S2 S3 S4	S5	S6
		Group	Study board	Lecturers		Supervisors				Students		
B.1.Environmental	B.1.1.Materials (e.g. conservation of the global resource base and efforts to reduce the material intensity and increase the efficiency of the economy; ability to use recycled input materials; conservation of the global resource base; recycled materials and the overall costs of operations.)		X			X						
	B.1.2.Energy (renewable, efficiency, consumption, etc.)								X		X	
	B.1.3.Water (e.g. consumption, efficiency, etc.)								**X**		**X**	**X**
	B.1.4.Biodiversity (e.g. impacts on, recovering, etc.)				X							
	B.1.5.Emissions, effluents and waste (e.g. reduction, management)						X		X		X	
	B.1.6.Products and services (e.g. life cycle assessment, impact of, initiatives for mitigation, transportation etc.)								X		X	
B.2.Social	B.2.1.Human rights (e.g. child labor, forced and compulsory labor, discriminatory		X		X				X			
	B.2.2.Labor practices and decent work (employment, labor/ management relations, training and education, diversity & equal opportunity, etc.)								X			
	B.2.3.Local government		**X**		**X**	**X**	**X**	**X**	**X**	**X**		**X**
	B.2.4.Public policy and legislation		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	B.2.5.Local community engagement, impacts assessment and development programs		**X**		**X**	**X**		**X**	**X**	**X**		**X**
	B.2.6.Product responsibility (e.g. public safety and health, marketing discourse, labeling and customer privacy)											
B.3.Economic	B.3.1.Economic performance (e.g. direct economic impacts of the organization's activities and the economic value added by these activities on local communities)								X			
	B.3.2.Market presence and interactions in specific markets (e.g. policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation)								X	X		
	B.3.3.Indirect economic impacts (e.g. economic impacts created as a result of the organization's economic activities and transactions)								X		X	
	B.3.4.Risk analysis (e.g. financial implications and other risks and opportunities for the organization's activities due to climate change)						X		X			X
	B.3.5.Emerging economies in low-carbon economy and growth in developing country investment					X			X			

Checklist C

		Programme	Urban Planning and Management									
		ID code	SB1	L1	F1	F2	F3	F4	S1	S2 S3 S4	S5	S6
		Group	Study board	Lecturers		Supervisors				Students		
C.1.Factual & conceptual (know-what)	C.1.1. Knowledge about facts, elements and/ or terminology						X	X				
	C.1.2. Knowledge of principles and generalizations		X				X					X
	C.1.3. Knowledge of theories, models and structures		**X**	**X**			**X**	**X**	**X**	**X**	**X**	
C.2.Procedural (know-how)	C.2.1. Knowledge of subject-specific skills and algorithms						X					
	C.2.2. Knowledge of subject-specific techniques and methods						X					
	C.2.3. Knowledge of criteria for determining when to use appropriate procedures (e.g. systematic assessment and readjustment of the solving methodology - methods, approaches to questions formulated, etc.)		X		X	X				X		
C.3.Metacognitive	C.3.1. Strategic knowledge (combination of know what, know when and know how) (e.g. transfer and apply knowledge according to the situation - which methods, how to use, when to use, why it is use and related with the overall problem)			X	X	X			**X**	**X**	**X**	**X**
	C.3.2. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (combination of know-what, know-when, know-how) (e.g. go back and look if the solving process is aligned with the problem formulated)			X	X (?)					**X**	**X**	**X**
	C.3.3. Awareness of the limits of one's knowledge (self-knowledge)		**X**		**X**	**X**		**X**	X		X	
C.4.Evolutionary, or world	C.4.1. Knowledge regarding the reasons behind the know-what, know-when, know-how and know-who		**X**	**X**	**(X)**			**X**				
	C.4.2. Knowledge shared and cultured (relate with knowledge production)						X					X
	C.4.3. Knowledge about others (actors, disciplines, communities, systems) values and attitudes (importance and challenges of others moral perspectives on issues) (e.g. other discipline members beliefs of what is right and wrong, values and behavior, etc.)			**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**

Checklist D

		Programme	Urban Planning and Management									
		ID code	SB1	L1	F1	F2	F3	F4	S1	S2 S3 S4	S5	S6
		Group	Study board	Lecturers		Supervisors				Students		
D.1.Disciplinary	D.1.1. Knowledge within your engineering subfield										X	
	D.1.2. Study of courses related with engineering (e.g. mathematics, physics, etc.)					X						
D.2.Multidisciplinary	D.2.1. Have knowledge from different disciplines (e.g. history)	**X**	**X**	**X**		**X**		X	X			
	D.2.2. Aware of others disciplines works		X			X	X		X			
	D.2.3. Study of others subjects like finance, humanities, etc.	X	X					X				X
D.3.Cross-Disciplinary	D.3.1. Topic of investigation is from other area of study			X		X	X	X			X	
	D.3.2. Use of techniques and tools that is commonly used by experts of other disciplines (e.g. using interview as method in civil engineering project)		X	X	X			X				X
D.4.Interdisciplinary	D.4.1. Combines methods and approaches from different disciplines	**X**	**X**	**X**		**X**		X			X	
	D.4.2. Two or more disciplines which interact and combine their expertise to jointly address an area of common concern.	**X**	**X**		**X**		**X**		X			X
D.5.Transdisciplinary	D.5.1. Formulate new theories and methodologies from different disciplines	X	X (?)			X					X	X
	D.5.2. Two disciplines merge to create a new one (e.g. nanotechnology, product design and technology…)								X			X

Checklist E

		Programme	Urban Planning and Management								
		ID code	SB1	F1	F2	F3	F4	S1	S2 S3 S4	S5	S6
		Group	Study board		Supervisors				Students		
E.1.Epistemological	E.1.1. Identify factual and normative aspects of the problem		X		X	X	X				
	E.1.2. Explain and understand and questioning the factual and normative aspects of the problem		X	X							
	E.1.3. Analyzing and assessing the factual and normative aspects of the problem in order to outline strategies		X		X	X					
	E.1.4. Individual questioning and examining of the settings around problem		X	X	X			X		X	
E.2.Transformative	E.2.1. Transformation of values and beliefs			X				**X**		**X**	**X**
	E.2.2. Change own points of view of existing economic, political, scientific and environmental structures and mechanisms							X			
	E.2.3. Community (group) analysis as well as assess alternative possibilities and strategies				X					X	
E.3.Dialectical	E.3.1. Different points of views on each case					X	X	X			
	E.3.2. Recognition that knowledge is dependent on latent interests and values			X	X				X		X
	E.3.3. Recognition that progress and development take place by challenging, querying, criticizing and breaking down parts of existing parts to reconstruct a new and alternative one.			X			X	**X**	**X**		**X**
	E.3.4. Re-built new practices without the deficiencies and errors of previous one.										X
	E.3.5. Consistent criteria of assessment to oneself and others (e.g. group is acknowledgeable of each member potentialities, skills, knowledge and opinions)					X		X	X		
E.4.Holistic	E.4.1. Thinking involves emotions, feelings, intuition, and reason		X			X	X		X		
	E.4.2. Urge to transform an intention to act in a real action to promote change									X	X

3. Answering the questions from data collection strategy

Not all the questions from the interview guides were addressed. The interview is semi-structured, where allow formulating questions based in, and exploring, answers of the interviewees. Also not all the questions were addressed. The results are presented according to the groups of interviews: study board, lecturers, facilitators and students.

These interviews are relevant because they constitute evidence on perceptions and needs of ESD presence in the specific programmes studied, for example.

The first part of the results is related with the research questions, and sub-questions, presented in the empirical framework (see appendix 3.1). In the following table (Table 11) it is answered the questions formulated but, due to the considerable number of questions aiming to collect data through interviews, and targeting different data sources, it is only presented in the main questions that worked as themes for coding (called clustering questions). The sub questions are sub-codes and are part of the answer to the main question. Therefore answering the sub questions it is answering the main question.

Table 11 Different research question answer the interviews' analysis

Questions	Analytical framework sub questions' answers
How, and why, is education for sustainable development integrated in the programme?	The interviewees are mainly involved in the second semester of the master programme specialization. The second semester does not have an explicit strategy for sustainability. For ESD the main vision regarding it is its integration through the projects, giving some support through courses. For example interview SB1 and L1 proposed good ideas of what could be done, not only at a programme level but also a faculty level. The lecturer L1 (course common to the three specializations) has a background in environmental management, but the course is about police, planning and governance.
How is the curriculum organized around problems?	The mainly advantages pointed by the interviewees of being educated by PBL is, for example: 1. Possibility to produce your knowledge 2. Solve real problems 3. Contextualize theories, principles and concepts through applying it to solve a real problem 4. Be able to think critically Some positive points are also pointed regarding the PBL learning approach. for example: 1. Solving approach is very focus on analysis of process taken place in planning 2. Very structured and fix where students are kept "inside" the programme without the possibilities to explore and make cross programmes groups, for example. 3. Multicultural and international environment One of the challenges in the educational systems is the challenge to make a lecture also problem oriented. The courses provided in each semester are directly related with the

Questions	Analytical framework sub questions' answers
	semester themes for problem formulation and project work. The problems are formulated by students, there are some proposals/ suggestions from the academic staff but students also have the freedom to bring in suggestions and problems they find worth solve. According with the checklists C (type of knowledge) and D (disciplinarity), the learning process encloses mainly metacognitive knowledge and interdisciplinarity, respectively. However there are some indicators pointing for higher cognitive tasks like evolutionary and world knowledge. There are also some indicators for transdisciplinary in the programme. The learning outcomes are assessed through oral examinations (for projects' modules) and individual written examinations (for courses).
What are the process competencies developed by students?	The level, or more correctly, what is emphasised in terms of critical thinking it is pointed through the checklist E. Students and facilitators filled in this checklist. Curiously the two groups seem not to emphasise the same. Facilitators point more for an epistemological critical thinking which encloses, for example, reflection and analysis of normative and factual aspects of a problem, while students emphasise the dialectical critical thinking. There is no questions directly regarding of creativity or innovation in solving problems, however the interviewee S5 pointed as one of the advantages of PBL is the possibility of doing something new and producing your own knowledge. The groups are formed by the students, in the beginning of the semester.
How do students use SD in the PBL process? How SD can be integrated in a PBL environment?]	The interview encloses two checklists where principles of ESD are stated (checklist A) and possible aspects that may work as SD themes (checklist B). It is asked to interviewees to fill them based on the activities carried out along the semester (checklist A) and key words are related with concepts present in the programme and courses (checklist B). For checklist A (ESD principles) the interviewees considered problem solvers, followed by systemic and holist, flexibility and adaptability as part of the education environment and learning process. Regarding the SD aspects/ themes (checklist B) it is pointed: social (local government, public policy and legislation, local community engagement, impacts assessment and development programs). There are also some indicators that fall in the environmental and economic aspects.
Ethics and professional responsibility	According with the SB1, there are some guidelines in the school/ study board webpage. Regarding the rest of the interviewees there is not unanimous definitions, being difficult to point a definition, but that is very link with frame of values and what is right and wrong. But there is no formally approach, or intended learning outcomes concerning ethics and professional responsibility.

Observations

1. Groups identification

Table 12 provides the group identification in relation with facilitators and students interviewed.

Table 12 Groups identification

Group No.	Group formation	Facilitator	Project's themes
1	**S2**$_{UPM}$, **S3**$_{UPM}$, **S4**$_{UPM}$	**F1**$_{UPM}$	Collective planner
2	Four students (not interviewed)	**F4**$_{UPM}$	Public participation and collaborative planning
3	Three students plus **S1**$_{UPM}$	**F1**$_{UPM}$	Group movements and its influence in planning.
4	Four students plus **S5**$_{UPM}$	**F2**$_{UPM}$	Transportation mobility and planning in the city
5	Two students plus **S6**$_{UPM}$	**F3**$_{UPM}$	Climate change adaptation (in relation with house holding association, stakeholders and negotiation with municipality)

2. Observation: Status Seminar

Each group presentation has a duration of 10 minutes, followed by 10 minutes discussion and feedback form other groups and facilitators present. The chair of status seminar is the semester coordinator.

The following figures (Figure 2 and Figure 3) presents the main SD aspects and PBL elements observed during the status seminar, both during presentation and discussion.

Presentations were mainly focus on presenting the theme of project and brief background for problems formulated and methodologies for solving (which included data collection strategies and analysis). Such indicators are considered in the PBL elements observed and pointed in Figure 3

The followed discussion of each group presentation was mainly focus on giving feedback but also posing questions for clarification – like for example, what are the units of analysis will you use? It was an open discussion, with questions coming from students and facilitators, or even other guests researchers invited.

It reveals very constructive for students but also reflective on their own progression in project work and solving process.

2.1. Sustainable Development aspects

The Figure 2 presents the SD aspects observed during the status seminar (held on the 2nd of May of 2012). The presentations showed a variety of themes worked by students, and related with profession of an urban planner (see for example the project titles in Table 12, p. 119).

	Group No.	1		2		3		4		5	
	SD indicators	*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*
Environment	Environment			X							X
	Materials										
	Energy										
	Water										
	Biodiversity				X						
	Emissions, effluents, and waste									X	X
	Products and services				X						
	Compliance										
	Transport							X	X		
Human rights	Human rights						X				
	Investment and procurement practices				X	X	X				
	Non-discrimination				X	X	X				
	Freedom of association and collective bargaining						X				
	Child labour										
	Forced and compulsory work										
	Security practices										
	Indigenous										
Labour practices and decent work	Employment										
	Labour/ management relations										
	Occupational health and safety										
	Training and Education										
	Diversity and equal opportunity										
	Equal remuneration for men and women										
Society	Society	X				X				X	
	Local community	X		X		X	X	X		X	
	Corruption						X				X
	Public policy	X		X		X	X				
	Compliance						X				
Product responsibility	Product responsibility										
	Costumer health and safety										
	Product and service labelling										
	Marketing and communication					X	X	X			
	Costumer privacy										
	Compliance										
Economics	Economic performance			X							
	Market presence			X				X			
	Indirect economics impacts			X					X		X
others	Ethics and professional responsibility			X		X		X		X	X
	Comments	There is not much integration of SD indicators considered		The discussion main focus is on project theme with no explicit relation with SD indicators used for observation.		Ethics more related with the problem analysis. Mentioned of "relocate" people and bring the "right" people for living in certain urban areas.		Ethics more related with problem analysis. Relation between the economic growth and creation of jobs. In the discussion is mentioned cost and benefits assessment (CBA)		Local community in relation with housholders and stakeholders. Ethics and professional responsability related with problem formulation and analysis.	

Figure 2 Main sustainable development themes observed during status seminar (groups presentations and followed discussion)

Society is the main theme that can be related with sustainable development considered for analysis. Group one had its main focus in societal aspects, however the other four groups link their project themes

and problem with other themes that are not only social but also economic and environment. This points for a multi system and interdisciplinary understand from groups 2, 3, 4 and 5. For example, group 3 (focus on civil movements), 4 (focus on mobility and transport systems) and 5 (focus on climate change adaptation) presents and discuss about the interconnections about the different systems (environmental, social and economic) that a planner has to foresee and deal with. Labour practices and decent work, like for example employment and generation of jobs, it was not mentioned during presentations and discussions.

2.2. Problem based learning elements

The following figure is pointed the PBL principles and elements observed above. As it can be observed, and in relation with the discussed above regarding the multi themes and interconnection between social, environmental and economic links students make in their presentation, it can be considered that students learn in interdisciplinary environment and carry out cognitive tasks during solving process that enclose metacognitive and personal/ evolutionary knowledge.

	Group No.	1		2		3		4		5	
PBL principles		*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*	*Presentation*	*Discussion*
Knowledge	Factual & Conceptual	X		X		X		X		X	
	Procedural	X		X	X	X		X		X	
	Metacognitive		X			X		X			X(?)
	Personal, evolutionary (know-why)					X					
Disciplinarity	Disciplinary										
	Cross-disciplinarity										
	Interdisciplinary			X	X	X		X		X	X
Competencies	Lifelong learning										
	Contextual learning	X		X		X		X		X	
	Problem analysis & formulation	X		X		X		X		X	X
	Problem solving	X		X		X		X		X	
	Creativity & innovation										
	Communication	X	X		X			X			
	Collaboration	X		X							
	Comments	concept of hybrid planner - one with many roles; Discussion between observation od what is practiced and theory. Communication centralized in one element of the group		Discussion encloses reflection regarding project - critical thinking. More clear and structure presentation.		Main discussion and discussion around, how different social groups influences the citu planning, who and where comes the power. Neo liberal theories. Discussion encloses reflection regarding project - critical thinking.		Discussion encloses reflection regarding project - critical thinking.		Discussion encloses reflection regarding project - critical thinking.	

Figure 3 PBL elements observed in status seminar (groups' presentations and followed discussion)

Regarding the competencies, all competencies considered in this study and used in other data collection instruments for other data sources, are also considered here with exception of critical thinking. It is important to point that some of the criteria considered are not so easy to tick in the observation grid (e.g. it is being really observed or not, for example) like creativity and innovation and lifelong learning. Whenever there was a doubt of it was or not being observed in the observation grid it was thick an X followed by a (?), like it is pointed for group 5 in the metacognitive knowledge.

On the other hand, critical thinking was not considered as something to be observed, however almost all discussion revealed itself to be critical for students and also reflexive with questions like: why you do this? How to analyse?

3. Answering the questions from data collection strategy

In Table 13 presents the clustering questions and answers based on the interpretation of the results.

Table 13 Research questions from the empirical framework answered

Questions	"Answer"
What are the process competencies developed by students?	Some of the questions are quite difficult to answer once only observations were carried out in status seminar. In this seminar all groups presented in 10 minutes their project (mainly brief background, research questions, research methodology). After each presentation students have a session of 10 minutes for questions and answers. The questions were posed by the audience (researchers, other groups, and facilitators). The questions posed were reflective as push for students to answer why the methods, why the approach, and also how you will analyse the data and through each theoretical frames. Such questions lead students to reflect and argue for their choices regarding the solving process. It is considered that mainly students reflect on process of how to do, following by the why. With the exception of one project (project regarding climate change adaptation, group 6), no other project presented an explicit strategy or was targeting sustainability aspects. However the real contexts from where problems seem to bring attached some issues that touch upon sustainability issues. Such appear more evidence in the discussion when one or other group was questioned about the situation of the problems (to whom and why it is a problem) and/ or what are implications of the solutions proposed. Collaboration is not so visible in such presentations; however the work/ presentation time is divided by the different members of the group. However when it came to answering questions after presentation some students seems to be more dominants than others.
How do students use SD in the PBL process?	From the observations it was possible to point the aspects that can relate, and used for discussion towards sustainable development. The variety of projects reflects not only the complexity of a planner work (which includes environmental, technical and infrastructural aspects of a city but also its social, economic and political dimensions) but also its multisystem nature. This is also evidenciate by almost all the key words that compose the observation grids of the SD aspects were thick off during the status seminar. Some projects embrace more aspects than others. It is not possible to link the PBL phases which students go through in a semester by only observing one status seminar. However most of the SD aspects emerged when students discuss their projects, and when they have to link with real situation form where the problem was for-

	mulated.

Also the answers given in the above table is a sum up of the results obtained from the observations.

Students' projects: SD aspects

Following is the main results from the content analysis of the students' projects reports. The results are presented by the group number, and order of presentations in the status seminar.

Group 1: One role to rule them all? A case study of the Hybrid role of collaborative planners in Skive Municipality

Project information

TITLE: One role to rule them all? A case study of the Hybrid role of collaborative planners in Skive Municipality

NO. PAGES: 87

AUTHORS: **S2**$_{UPM}$; **S3**$_{UPM}$; **S4**$_{UPM}$

SUMMARY: This report answers the research question: *What conditions are Danish collaborative planners working under today, how do planners deal with this and how desirable is this role for the planner and society?* In order to answer this, the theoretical part of the report contains a review of the development of the environment in which planners work including the eras characterised by rational, strategic, neoliberal and collaborative planning theories. The collaborative planning theory is elaborated for use in the further analysis. It is argued that planning practice today is a mix of the theories mentioned above. The review moves forward with a study of Sehested's hybrid planner theory which addresses the complexity of planning and the role of planners by arguing that planners today take on and balance four different roles; the professional strategist, the manager, the market planner and the process planner. The empirical part of the analysis is based on a case study of Skive Municipality, where collaborative planning approaches are applied. Their collaborative approach is analysed through a literature review and interviews conducted with three planners from Skive, and shows that the process is close to the collaborative planning theory, however the planners use a professional strategist role to influence the projects. The second part of the empirical data analyses the role of the collaborative planners in Skive's general planning and conclude that the planners are in fact hybrid planners. Finally the discussion concerns the usability of the hybrid planner role to planners in practice and planning theory. It is concluded that the approach can be used by theorists as another way of thinking about planning theory as pragmatic rather than normative. To planners the theory can be used as a tool of reflection however the analysis shows that planners balance the roles unconsciously. Following this, a discussion of the favourability of the actual hybrid planner role for planners and society is undertaken. It is argued that planners need to be hybrid planners in order to be professional and able to fulfil the tasks they are given. Finally it is concluded that society benefits from planners who are able to think holistically and have knowledge, skills and competences within all four roles.

PBL profile

	Exemp. PBL indicator	Presence	Remarks	Page(s)

I.	Background information & problem analysis	Yes☒ No☐		5-6
	Real and open situation	Yes☒ No☐	From where data collection and municipality is taken under analysis	14
	Problem formulation	Yes☒ No☐		6
II.	Solving process	Yes☒ No☐		23-72
III.	Possible solutions	Yes☒ No☐	Conclusions from end of each part the report is divided	41, 65 & 79
	Problem answered	Yes☒ No☐		
	Goals reached	Yes☒ No☐		
IV.	Reflexive in process	Yes☒ No☐		

Projects' analysis on SD aspects

	Quotes from the project	Word freq.
A. Environment	*"The planner and other governmental professionals thus believe that their task was to take the lead and steer society in the right direction using their expert knowledge to work towards a political goal or objective. Although today rational planning may be considered outdated, some characteristics such as obtaining quantitative data are still evident in planning practice today, for example* ***Environmental Impact Assessments*** *are still considered important in making planning decisions."* [p. 30] *"All four examined planning trends (rational, strategic, neo-liberal and collaborative planning) are to some extent still influencing the way Danish planning is done today. The rational approach can for example be seen in the use of* ***assessments of environmental impacts of projects (EIA)*** *or the use of traffic models to forecast growth in road traffic and* ***need for new roads.*** *In that sense, there is still a rationale present today stating that planners have expert knowledge and skills that give them special authority to decide what is good and bad decisions."* [p. 38] "*Finally, the state established seven* ***Environmental Centres*** *responsible for the* ***development and maintenance of the EU habitat and bird protection areas****. The reform thus meant a decentralization of planning management, giving each of the 98 municipalities a greater responsibility for the development and the land use of their particular area, while the state was also given the role as more of an overseeing body, securing the overall planning considerations. (Ministry of the Environment 2007b)."* [p. 51]	71 instances (not all related with environment but rather professional environment)
B. Human rights	"*The communicative idea was actually not a new thing in planning when people like Forester and Healey started promoting this planning theory. In America during the 1970's citizens felt powerless and began to lose trust in the state, believing "the government is corrupt, aloof, power-ridden, insensitive to human needs and inequitable in its benefits" (Friedmann, Nisbet & Herbert 1973)."* [p. 33]	1 instance

	Quotes from the project	Word freq.
C. Labour practices and decent work	"*The political aspect of planning is as such more present in this role than the traditional rational planner role, but the professional strategist still strives for* ***equality between politics and professionalism***. (Sehested 2003)" [p. 41] "*However, they were very aware of themselves as being part of the political organ, always having to clear ideas with the politicians and the administration and having to understand the rules of the bureaucratic system to comply with the hierarchical structure of the place of* ***employment****."* [p. 81]	2 instances
D. Society	*"What is the role of the planner of today? How does she work in her daily life and manage the different tasks she is* ***given in a complex society*** *while staying true to her professional and personal values? Trying to give answer to these questions is essentially the aim of this report."* [p. 11] "***Society*** *has changed radically over the past few decades. We are now in what can be labelled the Information Age, which includes a* ***new order of economy and society****. New technologies have enabled us to live electronical lives, handle enormous amounts of information quickly and easily, and communicate over great distances."* [p. 29] *"Consequently the concept of planning* ***for public good*** *which required high levels of* ***community participation*** *emerged. In this context community participation is defined as 'gaining voice in and having influence over the allocation and uses of power in processes of governances but also the wealth of the community' (Friedmann, Nisbet & Herbert 1973)."* [p. 33] "*The mentioned change from the more comprehensive planning styles (primarily rational and strategic) towards more project based planning came to Denmark in the 1980's, and since then planning and other* ***public policy arenas*** *have been increasingly characterized by cooperation with actors from the market and civil society in the past 15-20 years."* [p. 38] *"In the former chapter it was stated that the planner of today is working in a* ***complex environment of the network society*** *and "governance in the shadow of hierarchy"."* [p. 40] "*This section has provided a description and an analysis of the collaborative process in order to understand how the method is carried* ***out by the community*** *and not least the planners involved in the process.*" [p. 60]	69 instances (for society, most for complex society) 17 instances for community (local and professional) 8 instances (for policy)
E. Product responsibility		
F. Economics	"***A market planner*** *prefers to think of herself as a project manager* ***responsible of the dynamics and economic health*** *of the city rather than a government officer, and functions as a sort of coordinator between different public and private actors and creates close relations between them from the very initial phases of the local development projects. (Sehested 2003)*" [p. 42] *"…the politicians* ***ultimately strive for economic growth****, whilst then planners have to work within different networks and try and balance political considerations with other social values using their professional knowledge."* [p. 67]	38 instances (economic) 63 instances (market)

Group 2: Bridging Gaps through Community Collaboration – A Case Study from the Regeneration of Groruddalen, Oslo

Project information

TITLE: Bridging Gaps through Community Collaboration – A Case Study from the Regeneration of Groruddalen, Oslo

NO. PAGES: 55

AUTHORS: Four students (not interviewed)

SUMMARY: Planning practice has notably changed in recent years in Norway. Due to the change from government to governance and since planning is a form of governance, collaborative planning emerged as a way to enhance the effectiveness of governance processes in a network to address issues in urban planning realms. Collaborative planning and communicative planning theory are claiming to make planning processes more democratic. Three different variables can be identified, which depict conditions that are directly related to the effectiveness of network power: diversity, interdependence and authentic dialogue.

This report looks closer into empowerment through a collaborative planning process in a diverse community in Norway. A case study was chosen to analyse how actors from the planning authorities attempt to empower the community in the area-based regeneration project in Groruddalen, Oslo, through network governance. Together with a literature review, five interviews were conducted in Oslo with representative people working within the programme to get a broad overview and a deeper understanding of the planning system, and the methods that were used to increase participation and include a diverse group of Groruddalen's residents in the planning process.

The regeneration programme itself cannot be evaluated as a success or failure, but it became clear that Groruddalssatsingen managed to include quite a diverse group in terms of ethnicity of citizens into the planning process, especially in the focus area of Furuset. Considering age, adults and seniors are found to be out of the focus, with the youth taking priority. Communication between the planning authority and the City Districts was improved in the process, but interdependency among horizontal departments and residents is still lacking to a great extent. This may partly be related to the Norwegian planning system, regulated by a new Planning Act from 2008, which leaves the process open in a way that makes the system dependent on individual actors in the Planning Agency or in the community, to challenge current hierarchical structures through the use of more communicative methods to achieve a more collaborative process. To change this factor of dependence, Norwegian planning may need to be modified in a way that genuinely empowers and therefore engages a diverse group of residents.

PBL profile

	Exemp. PBL indicator	Presence	Remarks	Page(s)
I.	Background information & problem analysis	Yes☒ No☐		1
	Real and open situation	Yes☒ No☐	Two chapters regarding specific planning system in Norway	1 17-32
	Problem formulation	Yes☒ No☐		1-2 14
II.	Solving process	Yes☒ No☐	Methodology chapter	12-17
III.	Possible solutions	Yes☒ No☐	Last chapter	50-52

	Problem answered	Yes☒ No☐	Last chapter	50-52
	Goals reached	Yes☐ No☒	There are no goals explicitly formulated aligned with research methodology	
IV.	Reflexive in process	Yes☒ No☐		

Projects' analysis on SD aspects

	Quotes from the project	Word freq.
A. Environment	*A strong focus on these novel aspects can be related to what Lorange and Myhre (Lorange, Myhre 1991)highlight as a previous planning practice in Norway; the implementation of short-term solutions* ***without taking environmental aspects into account*** *and rare co-operation and co-ordination between horizontal and vertical planning authorities.* [p. 19] *In addition, some important physical challenges are also found such as dilapidated* ***outdoor facilities, noise, air and soil pollution*** *(often associated with the valley's large share of infrastructure) and poor accessibility for pedestrians*. [p. 24] *Structural changes such as improvement of roads etc. were not affected. However, according to Hindhammer and Skalstad, these small changes still increase the local empowerment feeling and contribute to a subjectively* ***more positive living environment for the residents***. [p. 46]	21 instances (environm.[(1)]) 4 instances (for pollution)
B. Human rights	"*public participation as part of a representative democracy gives citizens a right to justice, but a regulative justice (legal rights) instead of a communicative justice based on the discursive ethic of communicative practice". This implies that the Norwegain planning system first of all is designed to "…****regulate conflicts or prevent illegimate practices or suppression of legal rights***" [p. 21]	3 instances (for rights)
C. Labour practices and decent work	*According to Fraser (Andersen, Van Kempen 2003), structures in the welfare state have to be changed in order to address* ***inequalities***. [p. 10] *For classical living condition parameters like* ***health, education, employment and income****, despite large internal variations, Groruddalen has an overall lower score on socio-economical parameters in comparison to the rest of the City.* [p. 27] ***Diversity*** *has been divided into three categories in the analysis:* ***age, culture/ethnicity and access to resources***. [p. 34] *In summary, the power can be seen to have been spread* ***more equally among the actors*** *which is significant to networks governance*. [p. 51]	5 instances (for employment) 39 instances (for diversity) 10 instances for equality
D. Society	*In conclusion,* ***community*** *participation in planning will be examined.* [p. 3] *However reality seems different as new discourses have become dominant in the upcoming planning arena and have laid the foundation for* ***cultural dominances****, producing new unequal power relations in society rather* ***than intercultural communication as the basis for a more democratic society*** *(Healey 1997).*[p. 12] *Furuset, how different groups from the* ***civil society are participating*** *or not in the area-based strategy and what is done to change this picture*. [p. 16] *After the* ***initial round of community*** *participation, the more official part of planning process started. In 2010 a draft for the new local land use plan was submitted for public hearing*. [p. 34]	28 instances for society 194 instances for community 148 instances for public

	Quotes from the project	Word freq.
E. Product responsibility		
F. Economics	*In addition, an increasing amount of* ***public services have been transferred to the market*** *in accordance with more neo-liberal ideas*. [p. 18] *Today, several of the local centres which originally were designed to be the vital hub of each suburb area in Groruddalen, located next to the metro systems, are found to be depleted with few* ***social and economic activities***. [p. 26]	20 instances for economic 8 instances for market

Remarks

(1) Not directly related with environment, but rather physical surrounding conditions like for example, work environment.

Group 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

Project information

TITLE: A Fight for the Right to the City The Case Study of an Urban Social Movement and the Fight against Neoliberal Planning in Wilhelmsburg

NO. PAGES: 79

AUTHORS: Two students plus **S1**$_{UPM}$

SUMMARY: Due to the current political economic system that society operates within today, right to the city movements are increasingly re-emerging in global cities and can be seen as a reaction to the prevalence of neoliberalism. Before an understanding of a specific right to the city movement can be examined, a review of literature regarding neoliberalism and right to the city will be provided. In doing this, the main features of neoliberal planning will be provided and the three, key characteristics of right to the city will be presented. The redevelopment of Wilhelmsburg has been chosen as a case study since within the quarter, there exist two conflicting groups. Firstly, the International Building Exhibition Hamburg (IBA Hamburg), which is a company founded by the municipality, is responsible for the redevelopment. Secondly, the "Arbeitskreis Umstrukturierung Wilhelmsburg" (Working Group on Restructuring) (AKU), which is an opposing initiative that comes under the global right to the city movement, also exists in the quarter. The characteristics that were found in the theory chapter were used to understand the redevelopment of Wilhelmsburg as a case of neoliberal planning. Based on interviews, document analysis and a fieldtrip, an analysis of the AKUs core goals and how they work has been undertaken. This is followed by an analysis of how their efforts are perceived by the IBA Hamburg and the municipality. Based on this, a number of contradictions of the AKU have been established. Finally, it can be concluded that right to the city movements do not directly influence the planning of cities, however, their beliefs and goals can be recognised as an increasing need for change in how urban development is implemented in cities today

PBL profile

	Exemp. PBL indicator	Presence	Remarks	Page(s)
I.	Background information & problem analysis	Yes☒ No☐	Introduction	1
	Real and open situation	Yes☒ No☐	Subchapter 3.1 Chapter 4	19 29
	Problem formulation	Yes☒ No☐	Main research question, followed by four sub questions	1
II.	Solving process	Yes☒ No☐	Documentary analysis (chapter 2) Methodology chapter	9-14 19-28
III.	Possible solutions	Yes☒ No☐		15
	Problem answered	Yes☒ No☐		43; 64;71
	Goals reached	Yes☐ No☐		
IV.	Reflexive in process	Yes☒ No☐		

Projects' analysis on SD aspects

	Quotes from the project	Word freq.
A. Environment	*"The state being concerned only with the integration of money, and military, defence, police and juridical functions, ensures private property rights, and supports freely functioning markets. State intervention must only occur in areas such as education, health care,* ***social security*** *and* ***environmental pollution****, in order to create markets. Once these* ***markets are created****, the state should not intervene."* [p. 4] "*The* ***social function of the city*** *and of urban property, with the collective good prevailing over ind****ividual property rights****, involving a socially just and environmentally sustainable use of urban space. (Mathivet, 2010, p24)*" [p. 26] *"Regardless of this, planning has been traditionally concerned with management of the use of space and ensuring that valued spaces are created that take* ***into consideration social, economic and environmental factors****. With this in mind, it can be stated that planning is now undertaken in a neoliberal context, therefore, social and environmental issues have been put to one side, whilst the economy has become paramount. This shift in discourse has led to the widening of* ***the development gap, social inequality, segregation and polarisation, and de-democratisation****."* [p. 70]	6 instances (out of 18)

	Quotes from the project	Word freq.
B. Human rights	"*The two core themes found in this chapter that the AKU is working with;* ***right to public involvement and right to centrality****, will be the basic elements in the forthcoming analysis. The analysis has the aim of creating an understanding why the AKU and the RaS network are fighting for the right to public involvement and the right to centrality, and which methods and approaches they use to try to achieve this*." [p. 56] "*As previously noted,* ***they only want to address and cooperate with the "right" people****; therefore, they try to cooperate with residents and other initiatives or associations, who have the same view. However, the AKU Wilhelmsburg maintains that they do not work against other initiatives on the Elbe Islands, but they are also not cooperating with them, unless they share the same point of view*." [p. 67] "*In summary of the first chapter, the AKU believes that, with regards to redevelopment in Wilhelmsburg, every citizen should have the right to be involved in the decision making process, this is what they are fighting for."* [p. 77]	214 instances (only word right, and with repeated context in which appears)
C. Labour practices and decent work	"*Neoliberal discourse manifests in such a way that presents itself as being the only option, that in striving for perfectly balanced markets, society will eventually because a place where there is constant circulation of capital, high rates of employment and social well-being, due to a trickle-down effect.*" [p. 21] "*Hamburg's Spatial Vision is underpinned by the phrase "Metropolis Hamburg - Growing City"; this concept characterizes all of Hamburg's urban development. In 2001 the Senate of Hamburg introduced this concept with the following aims: to increase the population, to achieve an above-average economic and employment growth and to create the international appeal and increase quality of life in Hamburg (City of Hamburg, 2007).*" [p. 47]	3 instances (for employment)
D. Society	"*The aim of this sub question is to examine what the RaS is actually fighting for, and to establish whether or not* ***urban social movements can influence society.***" [p. 36] "*It is difficult to suggest what role the* ***planner can take in meeting the needs of society*** *since their position within the planning system is minor, therefore, they do not have the ability to bring about major changes.*" [p. 83] "***Public policy*** *is based on "social contracts," expanding social welfare and the right to* ***collective bargaining***." [p. 16]	35 instances (society) 2 instances (public policy) 5 instances (community)
E. Product responsibility	"*Other negative points draw upon how neoliberalism* ***undermines the production of public goods, degrades social and environmental resources*** *and constrains/weakens socially progressive alternatives to market liberalisms (Peck & Tickell, 2002*)."[p.17]	6 instances (related with products)
F. Economics	"*Harvey (2007) clearly defines neoliberalism as being a* ***political-economic practice*** *which proposes that human well-being can best be advanced by the maximisation of entrepreneurial freedoms within an institutional framework characterised* ***by private property rights, individual liberty, markets and free trade***." [p. 15]	58 instances (related with market)

Remarks:

Can find elements from all aspects considered, including one that actually can be link with sustainability. Only some quotes are used as example.

The examples here pointed will be compared with student interviewed and the status seminar observations.

Group 4: Keeping the discourse on track - An analysis of the light rail project in Aarhus

Projects' information

TITLE: Keeping the discourse on track - An analysis of the light rail project in Aarhus

NO. PAGES: 114 (incl. appendixes)

AUTHORS: Two other students plus **S5**$_{UPM}$

SUMMARY: Public transport planning is a discipline that deals with developing public transport systems, and from a technical point of view it involves two aspects, namely transport engineering and traditional urban planning. However, in reality, the process of planning involves many different actors with different interests. This report looks at how discourses and the involvement of different actors can influence a planning process. The project examines the hypothesis regarding the area of Greater Aarhus that is experiencing a necessity to develop and implement the light rail project in order to respond to societal changes and maintain economic growth. The research begins by reviewing theories concerning discourse, stakeholders and the case study. It then applies a discourse analytical approach to examine the hypothesis. The concluding part explains why the planning process of the light rail in Greater Aarhus developed the way it has, i.e. which actors' rationalities dominated the planning process and how other actors were embraced in the planning process of the light rail in Aarhus.

PBL profile

	Exemp. PBL indicator	Presence	Remarks	Page(s)
I.	Background information & problem analysis	Yes☒ No☐	Introduction chapter	1-7
	Real and open situation	Yes☒ No☐	Chapter 4	29-34
	Problem formulation	Yes☒ No☐	Introduction	7
II.	Solving process	Yes☒ No☐	Methodology chapter and analysis chapter	pp.19-29
III.	Possible solutions	Yes☒ No☐	Discussion chapter	65-71
	Problem answered	Yes☒ No☐	Conclusion	73-76
	Goals reached	Yes☐ No☐		
IV.	Reflexive in process	Yes☒ No☐		

Projects' analysis on SD aspects

	Quotes from the project	Word freq.
A. Environment	"*Many of the above topics are sensitive and are contributing towards labelling the current* ***transport*** *tendency concerning an increase in commuting distances as being* ***environmentally hostile****. But however hostile it may be, it is none the less necessary to maintain transportation because it is a vital part in* ***sustaining economic growth*** *and thus forcing* ***the society to impose a more sustainable way of increasing our mobility*** *through e.g. "green"* ***transportation*** *(Leisner and Klüver 2009)."* [p. 5] *"Where possible, there should be considerations about a high class,* ***public transport system*** *– especially rail-based. The light rail can take market share from* ***the private car use and reduce energy consumption and CO2 emissions****. This is especially true where a high correlation between the rail system and areas with high concentration of jobs is created." (Aarhus Municipality 2009, p 12)"* [p. 6] "*We also take a look at how the light rail is perceived from different sources such as official documents (master plans,* ***environmental impact assessments****, maps, bills etc.), archival records, newspaper articles, and reports to assess what has developed based on these different perceptions*." [p. 13] "*During the conducted interview, Anne Bach several times refers to the light rail as a* ***green mode of transportation****, sustainable or an* ***environmental friendly solution***." [p. 55]	41 instances (environ.) 8 instances (energy) 6 instances (emissions) 1 instance (biodiver.) 40 instances (transport.)
B. Human rights	"*However, later on Peter Thyssen admits that besides solving commuting problems and presenting the light rail as the best* ***solution to the traffic issues****, there was a hidden agenda* ***behind this particular investment in the public transport infrastructure.****"* [p. 48] *Most people, in Denmark at least, have one or is about to get one, even though there is a large group of uneducated people. Simplified, the reason for people not to have a job could be one of the storylines of education, e.g. "one must have an* ***education in order to get a job****", but if these persons* ***already have a job****, they have reached the goal of education without having one and thus there is no reason for uneducated people to get an education (except when looking at* ***job security*** *etc.). Another storyline could be "one must have an education in order to earn more money" or even "... in order to get* ***socially accepted****".* [p. 20]	19 instances (invest.) 1 instance (security)
C. Labour practices and decent work	"*The above statement clearly shows how mobility and (public) transport are indisputably connected to a number of important issues including* ***economic growth****. One important indicator of this is the close* ***link between transport and jobs employment*** *which the above quote highlights*." [p. 5] "*An example could be of a specialised educational institution, or specialised* ***healthcare providing services to the residents as well as employees*** *within the region. These kinds of institutions may well have the legitimacy attribute that is needed to form a coalition*." [p. 68]	3 instances (empl.) 3 instances (health)
D. Society	*"The structural reform in 2007 was aimed at improving the overall planning in Denmark; in addition it takes into* ***account society's interests****, respect to land use while contributing and protecting the countries* ***nature and environment.****"* [p. 42] *"In the introduction chapter of this report, it has been clarified what may be obvious to many:* ***society, policy-making and planning*** *is influenced by many different interests, even conflicting interests."* [p. 73]	27 instances (society)
E. Product responsibility		
F. Economics	"*The main tendency, from the western industrialisation and since then, has been to move from rural areas into the cities that provided greater opportunities in terms of work as the productivity rose which meant new markets for e.g. the service area and trading etc."* [p. 1] *"In this case, we interpret* ***economic growth*** *as something that is influenced by a number of different aspects that can all contribute to an increase or decrease in the economy. These aspects play a key role in the everyday life of the* ***society where human behaviour****, structures and global economies and relationships, just to mention a few, can determine the state of the economy."* [p. 3] "*Economic growth is therefore understood as a two-way process that can either shape the city or be shaped by the city. Hence in order for the economic incentive to be increased, good facilities have to be provided – a good infrastructure that will enable the residents to live their lives and create the mobility needed to maintain*	65 instances (economic) 3 instances (market)

	Quotes from the project	Word freq.
	economic growth." [p. 4]	

Remarks:
The main themes focus is economic and social enclosing some environmental aspects.

Group 5: Collaboration in climate change adaptation: A case study of Copenhagen

Projects' information

TITLE: Collaboration in climate change adaptation: A case study of Copenhagen

NO. PAGES: 68

AUTHORS: Two students plus **S6**$_{UPM}$

SUMMARY: This report deals with the question; to what extent the absence of legal and regulatory powers in climate change adaptation encourage municipalities in collaborative planning. The report is based on a single case study conducted in the capital of Denmark, Copenhagen. Through two interviews with three representatives from the city of Copenhagen and several strategic documents produced from the Ministry of Environment, the Municipality, pilot project and an Urban Renewal project on climate change adaptation, collaboration and legislative matters, an analysis is carried out.

The report shows different indicators on both collaborative and non-collaborative methods along with a change of both legislations and frames in different sectors, to enable adaptation measures on the necessary sectors and levels. The report will discuss to what extent it is necessary to use collaborative planning to empower citizens in a local area or; to what extent it is necessary to gather local knowledge because different issues calls for different processes and solutions.

We conclude that in the sense of collaboration between different governmental actors; it is necessary to collaborate given the stage that adaptation planning is at in Denmark. In the sense of collaboration with non-governmental actors; it is necessary to gain local knowledge and information that can support the newly emerged and future necessary legal and regulatory frames to integrate climate change adaptation in Danish climate policy along with empowering and educating citizens.

PBL profile

	Exemp. PBL indicator	Presence	Remarks	Page(s)
I.	Background information & problem analysis	Yes☒ No☐	Introduction chapter	1-2
	Real and open situa-	Yes☒ No☐	Chapter 5	23

	tion			
	Problem formulation	Yes☒ No☐	In introduction chapter and chapter 4	1; 16
II.	Solving process	Yes☒ No☐	Methodological chapter (case study)	14
III.	Possible solutions	Yes☒ No☐	Chapter 6 (analysis and interpretation Chapter 7	33 45
	Problem answered	Yes☒ No☐	Conclusion	53
	Goals reached	Yes☐ No☐		
IV.	Reflexive in process	Yes☒ No☐	Chapter 8 Discussion and reflection	50

Projects' analysis on SD aspects

	Quotes from the project	Word freq.
A. Environment	"[…] *sometimes promoting and accommodating economic activity, and other times as regulating it to safeguard other values such as the conversation about* ***the environment or social justice****. Looking at the environmental part of her view, she further adds that local environment and institutional qualities have a key role in the competitiveness of urban areas in relation to the present globalised ordering of economic life (Healey 2006)."* [p. 17] "[…] *definition of spatial planning explains why it is handled in spatial planning as it is an* ***environmental issue***." [p. 17] "*Williams (1999) argues in her paper that to bring* ***justice and equity*** *in to* ***environmental policy-processes*** *can partly be done by* ***stakeholder participation***." [p. 20] "[…] *the question about whether or not collaboration is the right way of* ***dealing with environmental issues*** *within planning is a question* […] *then he draws on the* ***critique pointed at environmental policies****, thus there has been an increasing recognition that* ***participatory processes*** *are inherently problematic*." [p. 22] "*Instead of building single house units, apartment buildings are preferred for floor space and* ***energy consumption***." [p. 38] "*Besides of this, they are trying hard to implement regulatory measures – fees on* ***water directed to sewage system****, as well as they are making effort to show the national government (through Skt. Kjelds pilot project) the necessity of new legislations which will* ***regulate who is responsible for financing adaptation***" [p. 61]	77 instances (environ.) 23 instances (energy) 111 instances (water & rainwater) 1 instance (waste)
B. Human rights		

	Quotes from the project	Word freq.
C. Labour practices and decent work	"[…] *public institutions focus on economic growth and employment increase aiming policies, so there is a little place left for climate change oriented ones. As can be noticed from interviews, this is not valid for Copenhagen municipality*." [p. 57] "*On the other hand* ***diversity can also be race, gender, geographic roots and other factors*** *depending on the case at hand. Interdependency exists in that the agents must be in a situation where their abilities to fulfill their own interest depends on each other's action*." [p. 21]	4 instances (employ.) 7 instances (diversity)
D. Society	"[…] *regulatory agencies handling issues such as funding of the National Health Service and disposal of nuclear* ***waste****, in the UK, which led to a greater use of* ***consultation and stakeholder participation in public decisions*** *(Bayley 2008)*" [p. 19] "*The area consists of seven large apartments like* ***society housing****, Copenhagen blocks, business and institutional area*" [p. 40] "*Because unless the collaboration among the residents, private and public actors, it is not possible to solve the complex problems of the* ***society like climate change adaptation***." [p. 58]	17 instances (society) 7 instances (pub. particip.)
E. Product responsibility		
F. Economics	"[…] *second article highlights the importance of adaptation to ensure adaptation strategies within* ***food production****,* ***ecosystem****,* ***health*** *and* ***economic development*** *(United Nations Framework on Climate Change 2011)*." [p. 14] "[…] *to the fact that all* ***effects, risks and economic consequences*** *caused by climate change are still unknown to safeguard our city* […]" [p. 37] "*It has the potential to explore funding opportunities and* ***assessing market potentials and strengths***" [p. 38]	11 instances (economic) 7 instances (market)

Remarks:

Category A. Environment, using keyword environment, several of the instances pointed are related with "ministry of Environment", and build physical, urban environment for climate adaptation.

Answering the questions from data collection strategy

Table 14 addresses the questions formulated in the empirical framework for the projects' content analysis.

Table 14 Research question from empirical framework answered

Questions	"Answer"
How is the curriculum organized around problems?	The answer to this question encloses sub questions regarding to type of problems, knowledge, and disciplinarity. The content analysis of the projects' turn to go into such detailed as it is shown through the documentary analysis. However the PBL structure is well seen through in the structure of the project. The projects show a qualitative research approach, with case study as research strategy. Projects show a variety of problems underlying the core theme of the semester – "Power in Planning".

How do students use SD in the PBL process?	The SD aspects used by students are very much related with the theme of the problem – citizen movements, climate change or mobility.

The projects' analysis complements the students' interview. To some extent the analysis focus on have an overview of how the PBL process in terms of problems analysis, formulation, solving dimensions reflected in the project and the SD themes/ aspects also used and that may be used as integrator themes.

APPENDIX 10 Case Study – SCE data analysis report

Content analysis grid

Aim

The aim of the analysis of the curriculum is to find out which programmes have an education for sustainable development approach. This implies the integration of knowledge, skills and competencies regarding to sustainable development and its link with the disciplinary field in the curriculum

NAME OF THE PROGRAMME: Structural and Civil engineering

DEGREE: Master

UNIVERSITY: Aalborg University

FACULTY: Faculties of Engineering, Science and Medicine

DEPARTMENT/ SCHOOL: School of Engineering and Science (SES)

STUDY BOARD: Civil Engineering

ACCESS TO THE CURRICULUM: http://www.ses.aau.dk/digitalAssets/14/14964_msc_k_250610.pdf, 16 March 2012

Content Analysis Grids

1. Overall programme qualification profile

1.1. Structure

The programme is organized in 4 semesters, with a total of 120 ECTS. Optional choices are given on the 2nd an 3rd semester; some course modules can be selected. The projects on the 3rd and 4th semester can be selected freely within the field of structural and civil engineering and the students have the choice of making a long master's thesis comprising both semesters (p.8).

1.2. Overall learning strategies

"[…] combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection: project work; lectures; classroom instructions; study groups; workshop; exercises; laboratory tests; measurements and testing in the field; portfolio work; independent study" (p. 6-7).

1.3 PBL profile

Table 15 PBL profile from vertical analysis

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
Knowledge	Factual & Conceptual	"Has scientifically based knowledge"; "Has knowledge about…" (p.5)	x	x	x
	Procedural	"Has an understanding of […] based on scientific methods"; "Must understand analytical, numerical and experimental methods for analysis and design of engineering structures" (p.5) "Excels in the scientific methods and tools as well as general skills related to employment within civil and structural engineering." (p. 6) "Can select and apply appropriate methods for…" (p.6)	x	x	x
	Metacognitive	"…judge the quality of results…" (p. 6)		x	x
	Personal, evolutionary (*know-why*)	----------	----------	--------	----------
Disciplinarity	Disciplinary	----------	----------	--------	----------
	Cross-disciplinarity	----------	----------	--------	----------
	Multidisciplinary	"…loads, geometry, material properties, structural response and computational models"; "Has knowledge in one or more subject areas that is based on the highest international research within the fields of civil and structural engineering" (p.6)	x		
	Interdisciplinary	"…implement (…) interdisciplinary cooperation" (p.6)			x
	Transdisciplinary				
Competencies	Lifelong learning	"…take responsibility for own professional development and specialization." (p.6)			x
	Contextual learning	"Can apply appropriate methods of analysis for investigating […] in civil engineering structures…"; "Can assess loads on civil engineering structures…" (p.6); "select and apply proper scientific theories, methods and tools for their solution" (p.6)		x	x
	Problem analysis & formulation	"…identify scientific problems" (p.6)			x
	Problem solving	"…solving a given problem" (p.6)			x

PBL variables	Criteria	Quotes	Learning outcomes		
			Knowledge	Skills	Competencies
	Critical thinking	"…judge the quality of results." (p.6)		x	x
	Creativity & innovation	"…develop and advance new analyses and solutions…" (p.6) "…work-related situations that are complex and unpredictable, and which require new solutions" (p.6)			x
	Communication	"Can communicate research-based knowledge and discuss professional and scientific problems with peers as well as non-specialists, using the correct terminology in civil engineering" (p.6)		x	
	Collaboration	"…implement discipline-specific as well as interdisciplinary cooperation" (p.6)			x

1.4. Sustainable development (SD) aspects

Table 16 SD aspects profile from vertical analysis

Aspects (*)	Quotes	In connection with (*)	Curriculum as
A. Environmental	"especially **environmental (loads** like wind and wave loads)" (p.5)		Knowledge; skills
B. Human rights	----------	----------	----------
C. Labour practices and decent work	----------	----------	----------
D. Society	----------	----------	----------
E. Product responsibility	"**risk and reliability** (in engineering including uncertainties of)" (p. 5)	(E.1.)(E.2.)	Knowledge
F. Economic	----------	----------	----------
G. Ethics and professional responsibility **	"…assume professional responsibility." (p.6)	----	Competencies

(*) The indicators are from the Global Report Initiative (GRI) - https://www.globalreporting.org/Pages/default.aspx. The GRI presents a set of indicators for the categories referred as example of good sustainable practice. The codes present in the last column is referred to a code given (see table 2.2.1 of curriculum content analysis grid)

(**) Add to the indicators mentioned above resulting from its presence as learning outcome

1.5. Remarks

There is an alignment between the PBL approach and the learning strategies referred on 1.2., which allow the development of the learning outcomes stated in the competences profile of the programme. In an overall assessment, in the competence profile of the programme it is clear the presence of PBL elements.

In this analysis, it is not compared the number of sentences a given word (for example, communication, risk, etc.) appear programme. However it is pertinent to referred that some focus is given to certain kind of knowledge, skills and competencies that put emphasis on knowing, selecting and using the proper methods and theories in specific area of civil engineering. On the other hand, communication, collaboration and ethics appear only in one sentence in the entire profile. If we compare with the number of sentences the word methods, this last appear in more than one sentence and regarding to knowledge, skills and competencies.

Regarding to SD profile, the main focus is in the technological knowledge, with only one reference to the risk and reliability of the outcomes of the engineering practice. However this risk and reliability is direct link to specific knowledge domain in structural and civil engineering. It is not explicit the present of SD content out of the technical knowledge required and developed by the students.

2. Courses and projects' qualification profile

2.1. Introduction

The modules can be grouped according to their main learning strategy, lecture or project work. Each semester is composed by three modules (5 ECTS each, 15 ECTS in total), and one project module (15ECTS) (p.8). The 4th semester is composed by only one project module, designated as master's thesis (30ECTS).

To each module of the master with specialization was fives a code of analysis by using the semester (1st, 2nd, 3rd, or 4th), and the main type of the instruction (lecture – L –, or Project – P) (Table 17).

Table 17 Master in civil engineering programme modules, main instruction strategy and codes of analysis

Semester	Module	Main instruction type	Code
1st	Analysis and Design of Load-Bearing Structures	Project work (P)	1.0P
	Structural Mechanics and Dynamics	Lecture (L)	1.1L
	Material Modelling in Civil Engineering	Lecture (L)	1.2L
	Fluid and Water Wave Dynamics	Lecture (L)	1.3L
2nd	The Excitation and Foundation of Marine Structures	Project work (P)	2.0P

		Coastal, Offshore and Port Engineering	Lecture (L)	2.1L
		Advanced Soil Mechanics[1)]	Lecture (L)	2.2L
		Risk and Reliability in Engineering	Lecture (L)	2.3L
		Advanced Structural Engineering[1)]	Lecture (L)	2.4L
3rd	A	Analysis and solution of an Advanced Civil and/or Structural Engineering Problem	Project work (P)	3.0P
		Renewable Energy Structures: Wind Turbines and Wave Energy Devices[2)]	Lecture (L)	3.1L
		Wind Loads on Structures[2)]	Lecture (L)	3.2L
		Advanced Geotechnical Engineering[2)]	Lecture (L)	3.3L
		Fracture Mechanics and Fatigue[2)]	Lecture (L)	3.4L
	B	Traineeship at an Engineering Company[3)]	Project work (P)	3.5P
	C	Study at Other University	-----	----
	D	Long Master's Thesis	Project work (P)	4.0P
4th		Master's Thesis		
All semesters(*)		Problem-based learning (PBL) and students responsibility at Aalborg University	Lectures (L)	PBL

1) The student must choose one of the course modules.

2) The student must choose three out of the four course modules.

3) The study board must approve on the content of the Traineeship, before it is commenced.

(*) For students not acquainted with the Aalborg PBL model

The analysis process was as following: i) attribute to each module a code (table 2.1), ii) read each module competence profile (knowledge, skills and competences); ii) highlight quotes referring to the PBL elements and categories; iii) fill in the PBL profile (Table 18).

In this process only the quotes without ambiguity of meaning were considered. The same code of analysis is used in the PBL and SD profile.

Regarding to lectures modules, on the 2nd semester students have to choose one of two courses modules ("*Advanced Soil Mechanics*" and "*Advanced Structural Engineering*"). On 3rd semester A, students have to should three of four modules ("*Renewable Energy Structures: Wind Turbines and Wave Energy Devices*"; "*Wind Loads on Structures*"; "*Advanced Geotechnical Engineering*", and "*Fracture Mechanics and Fatigue*") (p. 8).

Three project modules descriptions: "*Analysis and Design of Load-Bearing Structures*" (1st semester); "*The Excitation and Foundation of Marine Structures*" (2nd semester); "*Analysis and solution of an Advanced Civil and/or Structural Engineering Problem*" (3rd semester A). In the 3rd semester, there is also the possibility of students study in

other university (C); have a traineeship in a company (B); or comprise the semester with the 4th semester for a long master thesis (D). Only B and D are described in the curriculum as comprise project work, and present learning outcomes (knowledge, skills and competencies) (p.8).

2.2. PBL profile

Table 18 PBL profile from horizontal analysis

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
Knowledge	Factual & Conceptual	1.0P	"Know fundamental theories […] for analysis of structures subject to static loads." (p.14)	x	x	
		1.1L	"Know fundamental theories…"; "use correct terminology…" (p. 22)	x	x	x
		1.2L	"Understand fundamental properties…" (p.19)	x		
		1.3L	"Must have knowledge about…" (p.16) "…calculate of kinematics and dynamics of regular linear waves on deep and shallow water." (p.17)	x	x	
		2.0P	"Must have knowledge about design rules for marine structures…" (p. 23)	x		
		2.1L	"Must have knowledge about…" (p.15)	x		
		2.2L	"Must know CSSM model to interpret…"; "Must describe…"(p.12)	x	x	
		2.3L	"Understand the concepts…"; (…) …"Understand basic concepts of stochastic processes…" (p.21)	x	x	
		2.4L	"Should have basic knowledge about…"; "Should have sufficient background to choose…" (p.13)	x	x	
		3.1L	"Understanding basic functioning of…" (p.20)	x		
		3.2L	"Understand the nature of wind…"; "Understand stochastic processes, stochastic dynamics and wind actions on structures" (p. 25)	x	x	
		3.3L	"…have knowledge…"; "fine-element analysis…"; "understand.."(p.11)	x		
		3.4L	"Should have basic knowledge about…" (p.17) "Should understand the stress and strain variations near a crack tip." (p. 17)	x	x	
		4.0P	"Have knowledge…" (p. 18)	x		
	Procedural	1.0P	"Know fundamental […] methods…"; "Be able to apply […]; to develop and implement […]; to plan and set up a test for…" (p. 14)	x	x	x
		1.1L	"Know fundamental theories and methods for…"; "Develop and implement a…"; "…plan and set up a test for…" (p. 22)	x	x	x
		1.2L	"Understand fundamental theories and methods…" (p.19) "…able to plan and set up tests to…" (p. 20)	x	x	x
		1.3L	"…be able to apply analytical and semi-empirical methods…"(p. 17).		x	
		2.0P	"…methods for…" (p. 23)	x	x	
		2.1L	"…have knowledge about methods…" (p. 15)	x	x	

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
			"…able to make a conceptual calculation of characteristic wave..." (p. 16)			
		2.2.L	" Must be able to manipulate"; […] "quantify" "structure…"…(p.12)	x	x	
		2.3L	"…know methods…"; (…) "…and time variant reliability methods…"; (…) …	x	x	
		2.4L	"Should be able to… formulate models….; estimate (p.13)		x	
		3.0P	"…have knowledge about analytical, numerical and experimental methods for investigation of the chosen problem." (p.15)	x	x	
		3.1L	"…know methods…" (..); "be able to apply methods…"	x	x	
		3.2L	"…able to calculate static and dynamic wind loads on buildings"; "…able to assess wind loads…" (p. 25)	x	x	x
		3.3L	"…understand and use numerical methods"; "…design complex structural structures"(p.11)	x	x	
		3.4L	"…in order to establish criteria for crack initiation and crack growth"(p. 17) "…be able to use…"; "use methods for analysis of stress variations" (p. 18)	x	x	x
		3.5P	"…have (& apply) knowledge about analytical, numerical and/or experimental methods for…" (p. 24)	x	x	
		4.0P	"…to apply a wide range of engineering methods…" (p.18)	x	x	
	Metacognitive	1.0P	"Be able to compare results obtained from different analysis methods and..."; "evaluate methods" (p. 14)…			x
		1.1L	"Be able to quantify errors associated with different types of analysis and evaluate the methods regarding assumptions and simplifications" (p. 22)		x	x
		1.2L	"Be able to compare results obtained by different constitutive models" "judge the quality of results" (p.20)		x	x
		1.3L	"…describe assumptions and limitations of mathematical models for different types of flows" (p. 17)		x	
		2.0P	"…compare and evaluate limitations and uncertainties related to simple and advanced methods for…" (p. 23)		x	
		3.0P	"…able to compare and evaluate limitations and uncertainties related to the methods used for… (p. 15)		x	
		3.5P	"…able to compare and evaluate limitations and uncertainties related to the methods used for solving…(p. 24)		x	
		4.0P	"…able to evaluate the progress of the project independently and select and include additional literature…"		x	x
	Personal, evolutionary (*know-why*)	----	----------	----	---	-----
ci- pli nar .	Disciplinary	----	----------	----	---	-----

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
	Cross-disciplinarity	----	----------	----	---	-----
	Multidisciplinary	1.0P	"… determining basic material properties"; "…test for finding the strength and stiffness of a given structure; "…apply statistical methods for assessment of test results … (p.14)	x	x	
		1.1L	"Based on general continuum mechanics, be able to formulate a model for a given structural problem, and based on the assumed kinematics, to establish a finite element formulation with the aid of the principle of virtual work." (p. 22)		x	
		1.2L	"…fundamental properties of construction materials in civil engineering with emphasis on their mechanical response." (p.19) "…select and apply appropriate material models for the analysis of structural behaviour under different load conditions" (p. 20)	x	x	x
		1.3L	"…about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations…; "…describe wind generated waves…"; "kinematics and dynamics of regular linear waves on deep and shallow water" (p. 16 & 17).	x	x	
		2.1L	"…have knowledge about currents and water level variations in the coastal zone; "about sediment transport, scour and scour protection." (p.16)	x		
		2.2L	"Basis of a more advanced knowledge in soil strength and deformation characteristics to explain and to use mathematical models describing elastic, elasto-plastic, and purely plastic behaviour of soil." (p.12)	x	x	
		2.4L	"…knowledge about non-linear effects in structural response…"; "modeling joints in structures linear as well as non-linear."; "…formulate geometrically non-linear models for thin-walled structures involving buckling, postbuckling and imperfection sensitivity" (p.13)	x	x	
		3.3L	"…wave propagation from earthquake [...]; liquefaction of soil […]; numerical methods, etc." (p.11) (mainly)	x	x	
		3.4L	"…crack growth and influence of loading sequences…"; "…crack driving force based on energy analysis…" (p. 17)	x	x	
		4.0P	"…the use of advanced mathematics, scientific and technological knowledge." (p.19) "include additional literature, experiments or data when needed in order to maintain a scientific basis for the project" (p. 19)	x	x	x
	Interdisciplinary	2.0P	"…design rules for marine structures…"; "…investigation of marine and geotechnical problems…"; "…marine and geotechnical site assessment…"; "advanced methods for estimation of environmental load as well as geotechnical bearing capacity and deformations." (p. 23)	x	x	x

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
		2.1L	"…non-linear waves, including 2nd and 5th order and stream function theory"; "…methods for extreme climate analysis…"; "…water level variations in the coastal zone…"; "…sediment transport, scour and scour protection…"; … (p. 15 & 16)	x	x	x
		2.3L	"…concepts risk, uncertainty, reliability and safety; "…modeling physical, model, statistical and measurement uncertainties"; "use failure rates and hazard functions to model failures in systems reliability for non-structural components" (p. 21)	x	x	
		3.1L	"…assess wave energy resources…"; (…) "…assess wind energy resources…" (…); "assess loads…"…		x	
		3.2L	"...nature of wind: wind profile, mean wind, extreme wind, turbulence, turbulence field – for applications for structures such as buildings, bridges and wind turbines."	x	x	x
	Transdisciplinary					
Competencies	Lifelong learning	----	----------	----	---	-----
	Contextual learning	1.0P	"…for a given structural problem, including analytical, numerical and experimental analysis methods"; "…plan and set up a test for finding the strength and stiffness of a given structure." (p.14)		x	x
		2.0P	"…for investigation of marine and geotechnical problems." (p.23)	x		
		2.2L	"…and to a certain extent be able to do the experiments, interpretate the results and use them in practice." (p.12)		x	
		3.0P	"…for investigation of the chosen problem…" (p. 15)	x	x	
		3.3L	"…for selected geotechnical structures"(p.11)	x		
		3.5P	"…of advanced problems within the company's field." (p. 24)	x	x	x
		4.0P	"knowledge and identify new scientific problems within the field of the specialization" ; "explain choice of scientific theoretical and/or experimental methods"; "ndependently with a project on a specific problem within the field of the specialization" (p. 18 & 19)	x	x	x
	Problem analysis & formulation	1.1L	"…be able to formulate a model for a given structural problem…" (p. 22)	x	x	
		4.0P	"…identify new scientific problems within the field of the specialization." (p.18) "…define and analyse scientific problems…" (p.19)	x		x
	Problem solving	2.0P	"…knowledge about analytical, numerical and experimental methods for investigation of marine and geotechnical problems." (p. 23)	x		
		3.0P	"…the methods used for solving the chosen problem." (p.15)	x	x	
		3.3L	"… to solve deformation and failure problems" (p. 11)		x	
		3.5P	"…investigation of advanced problems within the company's field." (p. 24)	x		x

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
		4.0P	"…solve new and complicated technical problems…" (p.19)			x
	Creativity & innovation	4.0P	"…be able to develop new solutions…" (p.19)			x
	Communication	1.0P	"…be able to communicate the results of the project work in a project report." (p. 14)			x
		1.3L	"…apply proper terminology in oral, written and graphical communication…" (p.17)			x
		2.0P	"…able to communicate the results of the project work in a project report." (p. 24)			x
		2.1L	"…apply proper terminology in oral, written and graphical communication". (p.16)			x
		2.2L	"…structure and present test data in data report…" (p. 12) "Application of proper terminology in oral, written and graphical communication and documentation within Soil Mechanics." (p. 12)	x		x
		2.3L	"…participate in a dialog…"; "…communicate risk analysis…" (p. 22)			x
		2.4L	"…participate in a dialog on structural modifications..." (p.13)			x
		3.0P	"…be able to communicate the results of the project work in a project report." (p.15)			x
		3.1L	"…able to understand and communicate…" (p. 21)			x
		3.2L	"…and communicate wind loads…" (p.25)			x
		3.3L	"Application of proper terminology in oral, written and graphical communication and documentation…"(p.11)			x
		3.4L	"…communicate fatigue analysis of welded structures and participate in a dialog of fatigue analysis…" (p. 18)			x
		3.5P	"…proper terminology in oral, written and graphical communication and documentation…" (p. 24)			x
		4.0P	"…communicate relevant scientific and professional aspects…" (p.19)		x	x
	Critical thinking	1.0P	"Be able to compare results obtained from different analysis methods and be able to judge the quality of the results."; "…evaluate the methods regarding assumptions and simplifications." (p.14)			x
		1.1L	"…be able to judge the quality of the results..." (p. 23)			x
		1.2L	"…to compare results obtained by different constitutive models and be able to judge the quality of the results (p.20)			x
		2.0P	"…compare and evaluate limitations and uncertainties related to simple and advanced methods for…" (p. 23)		x	
		3.0P	"…compare and evaluate limitations and uncertainties related to the methods used…" (p.15)		x	
		3.5P	"…able to compare and evaluate limitations and uncertainties related to the methods used…" (p. 24)		x	
		4.0P	"…critically evaluate knowledge…"(p.18)	x	x	x

PBL variables	Criteria	Modules codes	Quotes	Learning outcomes		
				Knowledge	Skills	competencies
			"During the project and when finalising it make an independent and critical estimation of…"(p.18)			
	Collaboration	1.0P	"…contribute successfully to teamwork within the problem area and make a common presentation of the result…" (p. 14)			x
		2.0P	"…contribute successfully to teamwork within the problem area…" (p. 24)			x
		3.0P	"…contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work." (p.15)			x

2.3. Sustainable development (SD) aspects

Table 19 SD aspects profile from horizontal analysis

Aspects (*)	Modules code	Quotes	In connection with(*)	Learning outcome
A. Environmental	1.2L	"…properties of construction materials…" (…); "…behaviour and modelling of construction materials"; (…) "analyse the behaviour of construction materials" (p 19 & 20)	A.2	Knowledge, skills and competences
	2.1L	"…currents and water level variations in the coastal zone." (p. 16) "…environmental loads on coastal, offshore and port structures including ice, wave, current and wind loads." "…sediment transport, scour and scour protection"	A.4 A.1 A.1	Knowledge
	3.1L	"…assess wind energy resources…"; "…assess wave energy recourses…."; "structural elements in wave energy devices…" (p. 20)	A.3	Knowledge and skills
B. Human rights	------	----------	--------	--------
C. Labour practices and decent work	------	----------	--------	--------
D. Society	------	----------	--------	--------
E. Product responsibility	2.0P	"…able to evaluate the safety by application of probabilistic methods for assessment of loads and bearing capacity of marine structures." (p.23)	E.1.	Skills
	2.3L	"…concepts risk, uncertainty, reliability and safety."; "…assessment of reliability of structural systems…"; "…apply of risk & reliability methods for probabilistic design of engineering structures such as buildings, bridges, offshore structures, costal structures, wind turbines etc." (p.21)	E.1 E.2	Knowledge, skills and competences

Aspects (*)	Modules code	Quotes	In connection with(*)	Learning outcome
	3.1L	"…sufficient reliability of wind turbines" (p. 20)	E.1	
	3.4L	"…knowledge about application of fatigue analysis in engineering applications." (p.17) "…in a dialog on structural modifications in order to reduce the risk of fracture." (p. 18)	E.1. E.2.; also related with professional practice (C.)	Skills and competences
F. Economic	------	----------	--------	--------
G. Ethics and professional responsibility (**)	4.0P	"Have understanding of implications within the related research area including research ethics." (p.18)		Knowledge

(*)Indicators from the Global Report Initiative (GRI) - https://www.globalreporting.org/Pages/default.aspx. The GRI presents a set of indicators for the categories referred as example of good sustainable practice. The codes present in the last column is referred to a code given (see table 2.2.1, page x)

(**)Add to the indicators mentioned above

2.4. Remarks

Project modules imply cognitive operations as select, plan and assess.

3. Answering questions from data collection strategy

This section aims to point the PBL characteristics elements for ESD, followed by the some answer to the research questions formulated for curriculum analysis (Table 20).

Table 20 Different sub-questions addressed with results from the content analysis

Questions	Interpretation of curriculum
How, and why, is education for sustainability sustainable development integrated in the programme?	There is no explicit statement concerning sustainability, or sustainable development. However there are two courses that may be related. They are called, respectively, "*Risk and Reliability in Engineering*" (codded 2.3L) and "*Renewable Energy Structures: Wind Turbines and Wave energy Devices*" (codded 3.1L). Through individual written exam and individual oral exam (see, for example, page 7 of the written curriculum). When looking into specific courses, assessment might be oral or written examination, and the format is decided in the beginning of the semester. There are no learning objectives explicitly formulated in Structure and Civil Engineering master programme.
How is the curriculum organized around problems?	In every semester there is a project module of 15 ECTS, and students need to do 3 courses of 5 ECTS each. In the third and fourth semester there is the possible to choose different courses, make an extended master thesis, and study in another university and / or in collaboration with industry. In the first and second semester it seems to be related with the courses provided and the project module title. Students produced a written report which is object of assessment. Mainly cognitive and procedural. It has some learning outcomes formulated for metacognitive tasks. The course is focus mainly in civil engineering disciplines. Even if it appears to be some multidisciplinary approach, the interdisciplinary approach mentioned is not so quite evident in the written curriculum From the curriculum analysis it is very difficult to define and characterize the problems students work with, e.g. who formulate, how it is presented to students, who formulate, to what are related. However the learning outcomes stated problems appear associated, for example, to "*given structural problem*" (course codded as 1.1L), "*fluid dynamic problems*" (course codded 1.3L), or "*analyse soil-structure problems for various geotechnical structures*" (course codded as 3.3L), which means that there is a strong component of technical dimension in the problem, but thus not give the structuredness, openness and concreteness of the problems.

(*) focus on the catalogue of problems for the second semester of the programme. The problem catalogue is suggestions of problems presented to students by staff, where they need to choose. This process is also related with group formation. Also students have the possibility to present themselves themes where they want to work on. Notice that these situations, problems proposals, are is concrete and out of real contexts.

Interviews

1. Interviewees and summaries

In the following it will be present the interviewees and their interviews' summaries. To full fill the anonymity of the interviewees, their names are substitute by a code, the ID code, formulated by given the initials of the groups he, or she, belongs, and number, and the initials for programme. Example interviewee **SB1**$_{SCE}$ means: SB - member of study board; 1 - first being interviewed; SCE - Structural and Civil Engineering programme.

Following the interviewees and interviews characterization is given a brief summary of the interviews. The interview summaries are made by group (study board, lecturers, and facilitators). Each interview's summary is composed by following themes:

- Background
- Education for Sustainable Development (concerning the first cluster question from the empirical framework)
- Problem Based learning process and curriculum organization (concerning the second cluster question of the empirical framework)
- Process competencies (concerning the third cluster question of the empirical framework)
- Synergies between PBL and ESD (concerning the last cluster question of the empirical framework)
- Other experiences

In each clustering themes are putted most relevant quotes from interview analysis. Following the interview summaries are the checklists, and comments grid, fill by the interviewees during the interview session.

Start by characterizing the different target groups to be interview (Table 21).

Table 21 Interviews characterizations

Group	Master programme in UPM		
	ID code	**Interview's duration**	
Study Board	**SB1**$_{SCE}$	01h 02m 41s	
	SB2$_{SCE}$*	01h 10m 03s	
	SB3$_{SCE}$	01h 47m 33s	
	ID code	**Interview's duration**	**Course**
Lecturers	**L1**$_{SCE}$	44:53,7	Advanced Geotechnical Engineering
	L2$_{SCE}$	1:12:46,3	Fracture Mechanics and Fatigue
	L3$_{SCE}$**	1:10:05,6	Wind Loads on Structures
	Interviewee(s) name	**Interview's duration**	**Students**
Facilitators	**F1**$_{SCE}$	1:10:05,6	Not interviewed
	F2$_{SCE}$	1:07:50,9	Not interviewed

*At the moment **SB2**$_{SCE}$ is member of the Study Board of Architecture and Design, however he is much involved in the structure and civil engineering programme - such is explained in the interview. However his name still in the study board homepages as part of civil engineering.

** Join interview with facilitator **F1**$_{SCE}$, who also teach in this lecture in years before.

Study board

Interviewee $SB1_{SCE}$

Background

Holds a Bachelor, Master and PhD in Structure and Mechanical Engineering, with special focus on the field of field of Probabilistic Methods Applied for Engineering.

Has been part of study board for some years.

Education for sustainable Development (ESD)

Integration of sustainable development aspects depends on very much the subject and the content of the courses, projects. Along the bachelor and master education there are different opportunities to integrate and in different courses. One example is the bachelor's first semester project:

> "*And I also think it depends on the subject, how much you can but in, for example, this 1st semester where they make some analysis of some joint or something like this, and find the strength of it, maybe it would be more difficult to address these issues here. […] For example, on the second semester, they make the harbour because this harbour influences a lot of things, so maybe that's more naturally to have this*"

Integration of SD can be done through the projects but should not take much of the resources of which projects already given for engineering content learning.

Other programmes under school of civil engineering have a more visible integration of sustainable education, and also because it a central concept in their engineering field:

> "*That is an integrated part of curriculum. You can say water and environment, and indoor environmental engineering, you can say in a way they are lucky because it's already integrated and is a very important part... of course what water environment is about is preserving the environment, reducing pollution and so on. And indoor environmental engineering is something about, "ok, we should put more isolation in our houses in order to, also, save the environment". You could say that more in the structural part, for example, where I mostly into, not offshore but more about houses which are good, it is, you could say, more like design, you have to design this so that it can save the loads*."

Problem Based Learning (PBL) process and curriculum organization

The master curriculum is designed jointly by different expertise areas within civil engineering (which are reflected in the different courses):

> *"In the study board we have representatives from each of these fields: we have structural engineering, from where I am from, then we have indoor environmental engineering, we have traffic engineering, we have water and environment. And we have also building management, and we have, I think we have about 15 or 16 in total. It is not that we sit in the*

study board and do all the details but we sent it out to the experts [in the different field areas] *and them they come up with the curriculum and, you can say we approve it in the study board.*"

The first semester of the master study can be characterized as narrow in comparison in comparison with second, and following semesters. Students have less freedom to choose a problem, and the focus of project is more in technical and STEM content of the program. From the second semester, up to the end of the programme, problems tend to be more open and students more freedom to select what they want to do and how:

"[…] *is very strict what they have to do first semester in order to gain some basic knowledge on which they can build on the second semester. The second semester is freer there are three different topics in which they can work on, I think. There is kind of offshore structure, out in the ocean, and there is a harbour structure also on which they can work on, so there is more choices on the second. And this is typically here in this progression; they get more and more choices about the project*."

Reason why is because it is needed to teach and learn the right and important tools (such as technical knowledge and methodologies to be a civil engineer. Nevertheless the problems are formulated from real situations instead of a "given book":

"[…] *so we don't take an entire structure but we take a small part of a structure, it could one be a joint in an offshore structure, or something like that. And them the students have to learn the tools, learn scientific methods to obtain results from different methods and compare them together so that they are able to analyse the structure in an independent way and not just look into a book and find the answer*."

Process competencies

The critical thinking and decision making in engineering practice, which not only is technical but also economic. Reflection in what you decided and why, what are the possible outcomes:

"[…] *you are aware of what you are doing and you make the right choices, for example, if you have to do a computation about something you don't just look up the first random formula, while the.. you can, you could find what you have to go into the formula but really think about if it is applicable here and what are, you could say, ... if you can say the uncertainties when use this method… Maybe not quantitatively but, at least, you have some idea of the impact of this. And also that you don't waste, for example, materials. You just use what should be use, and then you don't overdesign* […]"

However these references are linked regarding ethics and professional responsibility.

Project work is critical for students to assess and decide in different proper methods, solutions, etc., as well as provide a contextual learning since bachelor.

The new PBL model encloses some constraints for the curriculum design, where there is not space to add more content, and engineering knowledge should always come first:

> "*I think we have the problem that when, I don't know if you know but they change our curriculum, so this 15 ECTS project and then 5 + 5+ 5 courses, and, well I think that has been a little compressed everything since this new model. So we think it is very important that they learn the basic methods, in engineering. For example, they know how to design a structure on the soil and find the baring capacity, they can be sure that the structure can resist the waves, and so on. So I think is very interesting also to put in the others aspects but one should be in mind that at least, they should have the time to learn the basic engineering disciplines also.*"

In the bachelor, the first and second semester students have more open and unstructured projects, with more social aspects and impacts of engineering, however in the master level such dimension is not so visible:

> "*Yeah, but know we are talking about the master, but if I am allowed also to say something about the bachelor. We have on the first year of the bachelor we have this projects where you have, you can say, a technical aspect and then, you could say, how do you called in English, this contextual everything what is about the technical, for example the neighbours complaint if you built.*"
>
> "[…] *so they do a lot of that on the first study year and then it tends to... you could say, it gets more technical when you progress but something like this (STS) should be more include more than this now, than maybe it could be a good idea they make a technical project than at least they could make some reflections about how it will impact on other areas without making very detailed analysis but just be aware of that if you build a giant structure somewhere it could impact ion other things at society and so on*."

Master tends to be more specialized than the bachelor programme, which would me more easily to integrate sustainability in the bachelor level, at first semester project. In the fourth semester, in the bachelor, is a joint semester of structure, water engineering, indoor environment, and traffic, so students. In this way students have a taste of these fields.

Students expect a more detailed and specialized education in the master, being a challenge to cover several issues at same time.

There are some topics enclosed in the engineering practice that may be link to sustainable thinking: for example, not waste materials, deal with uncertainties and human life safety, etc.

Integration of sustainable development in the master level however can be done in the 3rd or 4th semester, with some constraints:

> "*But I would say that here in the 3rd and 4th semester that maybe also easy to look at this sustainability because the way the projects are formulated is not like on the 1st and 2nd semester, where just you have to learn an approach and we have to be sure that you understand the use of this methods and therefore you have to make a very strict formulated project. On 3rd and 4th semester is more like "ok now we have a real problem and you have to solve that", and maybe there are different possibilities for this solution and maybe it is very naturally that you have to compare this... solutions based on economics, statis-*

tics, whatever."

There is a recognition of the need to start to think about sustainability in engineering education:

"*But the problem is also that, I think, we have not been so much aware of this sustainability. It has just been somewhere where it is applicable.* […] *Suddenly you are requested to think about it...*"

Interviewee $SB2_{SCE}$

Background

$SB2_{SCE}$ was member of study board of civil engineering, and still participating in the meetings.

$SB2_{SCE}$ was educated in Aalborg University with environmental indoor and energy engineering, which are the programmes he is more involved in.

Education for sustainable Development (ESD)

Bachelor education it is not more open than master education, but in the master level it is more difficult to link the content of the programmes with sustainable development content. Also the students' attitude towards sustainability may be different in the bachelor and in the master:

"*Of course, you could say that it might be a bit more difficult on the master level to make the clear connections. On the other hand, my experience says that not all, or majority, but at least a large part of the students when they start at the university as engineers, they are more and less fed up with humanities and so on. They just want do calculations, which is... somewhat immature in a way, because this is not the way the world works, but this is their main interest and now they really on to focus on this. Sometimes is easier just to have them do a lot of maths and physics, and do a lot of calculations, and so on and so forth. And then later on when they found out… when they are approaching, you could say, the end of their educational career and focusing on "How can I get a job? What does the world outside, educational looks like?" And then sometimes they are more willing to learn something that is not about calculations only, and it also happens that some of them are a bit bored about doing all of these calculations; they want to do something else*."

It is bits tricky consider students a barrier to integrate sustainability in engineering education. In one hand students are being educated by people who may be shaped according to our expectations.

There are some sustainable development aspects in the curriculum however it is not make explicit as such to students, or even among academic staff. On the other hand other aspects, and tools, like LCA was present in the past but for some reason it become less and less visible, if not disappear.

Problem Based Learning (PBL) process and curriculum organization

Similarly with SCE master programme, the master programme in the curriculum follows the same struc-

ture: first semester is very close and structured while the rest tend to be more open. The master education, in comparison with bachelor, is theory oriented rather than practice oriented.

Problems are smaller and narrower aiming detailed analysis (e.g. measurements, numerical and analytical numerical work), with a lot of restrictions of what students can and cannot do, choose. When comparing, the content of both programmes regarding the semester mentioned is not so different.

There is a need to control and orient to students for what they have to do, there is not much of freedom to choose in different methods, measurements, etc. because of limitations of resources such as laboratory use and equipment. Instrumentation and measurement work is very type consuming, and normally students (all groups) join the laboratory part (from planning to execute, even share results, proceeding to analytical and numerical work in their own groups):

> "*I think for structure engineering is quite similar to how we do it, indoor environment engineering, for the 7th semester* [means 1st semester of master programme] *is actually fixed what they have to do, because it is very.... is the first semester of the master so we go from being practice oriented to be theoretical oriented so... so it tends to be focused in a very small problem... for instance in structural engineering it can be a plate with a hole, and then analyse in detail. For us, it can be a wall analyses in detail heat transfer through the wall at the services, and so on, or... then expanding, perhaps, to a room. So it a very small and we... it is normally on this 7th semester that you do some in detail, you do measurements in detail, you do some analytical work and you do some numerical work. And them combine them and compare them, and so on. I think the content is more or less the same, of course applied to different subjects but this gives quite a lot restriction on what students can actually chose in this semester because it needs to be something that we can instrument in order to measure, and it´s also limited to how many different set ups we can actually have. So if two students want to look at this, and three students want to look at that and four want to look at that, than we have limitations on laboratories, and equipment, and so on. So in principle they could actually choose whatever but in practice we come with one, or two, suggestions on what they can do, and that is what they normally follow. Normally the instrumentation is, or the experimental work, is very time consuming, so normally all the groups actually joining the experimental part, planning it together and dividing the work, and sharing the measurements results. And then they do the analytical and numerical part in their groups."*

The crowded curriculum and "adding a lit bit more of something" approach can be a problem in the actual engineering curricula, where courses have more content and less time allocated to projects. Such can brings some barriers, including the nature of students learning process, when comparing the initial and previous PBL model:

> "*With the new curriculum, we have added so much so they don't really have much time to study and just wonder about something and then investigate, we really... I think... When you have a new curriculum that we did a few years ago, one way of getting everybody satisfied is adding a lot more so that everybody gets a little bit more than what they have before. And I fear that has happened a little bit, we have put in more course, we have shorten the projects, we have added a lot of things perhaps. I don't think we added more to the projects but we have shortened them which are more and less the same so there are less time. We have change the first study year also. The first years of the university when I started all the different engineering specialties were grouped together so we could choose among everything. I thought I was going to study acoustics and electronics and I came into groups with students who wanted to become civil engineers and so on. Now, I mean... It is almost that we have*

made every moment of the studying live filled by something, this task and this task and this task."

"*I think what will happen first is that the students on paper have been working with a lot of topics but they really do not understand them fully. So I think, in the beginning and I think, we can do that it for several years, we can add more and what will just happen is that understanding of… will become less… Maybe that is not a big problem because, I mean, for engineering, of course, you have some basic sciences that you have to know but you also need to be aware of a lot of things, to be introduce to a lot of things, and so on. So you have to have knowledge in different levels so it becomes a problems when... when we lose their critical sense, when the students lose their ability to be critical, challenged different methodologies, understanding a complex area, been unable to themselves... familiarize themselves with a new topic. So actually if... I think the biggest danger, perhaps, is if we put so much in the curriculum that they don't have time to learn to study because they need to produce small reports for courses, big reports for projects, and working*"

The problems are close and structure, tend to be more open and unstructured for last semesters of the programme, with exception of the bachelor first semester. The problems and cases are chosen by the academic staff.

There is a need for cross disciplinary work in engineering programmes, as it is verified in other departments, or even institutions in Denmark.

Process competencies

One of the main challenges of educating through PBL is to accept that not always what students perceive as relevant and important is the same perceived by academic staff. However it gives some degree of freedom for students to explore, create and be self-directed learners:

"I think probably the main challenge is to accept that are things that I find important that students do not want, because it is impose by the problem. On the other hand it might be healthy because, all studies show that people don't use very much of their... you could say, specific knowledge that they obtain in their education. And if I look back to my education, 12, 13 years ago, what I learn about low energy buildings is completely obsolete, what structural engineers learn 10 years, 15 years ago is in some way obsolete due to advance calculation methods and so on."

Project based learning lead to students develop critical thinking. Projects are design as close as possible to reality, but not too much or otherwise students will not be able to finish them due to time constraints. In most of the projects students focus on calculations to a specific object, the real context is not completely remove from the project otherwise students would lose their motivation:

"*To run a project. I think it's actually a challenge that... that we make the projects as close as possible to reality but in a way so the students are able to complete them. I mean, we have discussion with external lecturers that say "Why do they have to do this, project like work?", because they do not do a full project. In reality they just do calculation in a beam, in a column, in a wall. And we say, yes we agree but... there are still... I mean if we reduce*

the project into an assignment, or exercises, then we lose motivation of the students, and we also lose, I think, some of the complexity because even though its... in... essentially they are just doing simple calculations but they learn something by having to take a complex building and then simplifying it down to something that they can actually fit with the method they have learn in calculation. And I think it is important that... I think doing a project motivates them so we should... it is important but also the complexity. I mean a big part of being engineer, I think, is to take a complex problem and then simplifying it down to something you can actually calculate. And understand, break down in pieces, not so that... it always has to be done in pieces, you can make complex structures and whatever. But you need to be able to understand it and also you need to be able to develop, you could say, the ability to have an overview of the complex project and understand it."

There is also a need to work more in contextual learning, make engineering students "*look out to the rest of the world*".

Synergies between PBL & ESD

There are not fix answers in where to integrate sustainability in the curriculum, it depends of curriculum, programme. Even the courses are fix, who teach within the course can change year from year, even when the content is more and less the same.

ESD can be integrated in the project work but also in some courses and modules (because courses and modules are not seen as lectures but also small projects).

Other experiences

Two example of "failure" projects aims because the human factor, or how householders were making use of the house, was not take into consideration in the project.

Interviewee $SB3_{SCE}$

Background

In 1975 **$SB3_{SCE}$** graduated from DTU and did the PhD in the same institutions within construction, technology and road constructions.

He also worked for Danish Road Directory and municipalities dealing with traffic, roads but also with sewer and water systems. He returns to University as teacher around five years ago, where is responsible for master programme in traffic and some other courses taught in bachelor level.

Education for sustainable Development (ESD)

Some aspects of sustainable development are already considered to be integrated in one 1st semester course, of the master programme, the consequences of traffic on society (e.g. noise, accidents, effective barriers, conflicts with water supply, agriculture). Also some these issues are addressed in the projects as

part of the regulations and policies requirements that guide students in the road planning process. Frequently, students have to make an evaluation on the ethics, on environment:

> "*Well what we integrate is on the master level, is consequences of traffic on society… noise and traffic accidents and... What we call effective barriers* […] *If you have a town and if you have a major road passing through with a lot of traffic, people living here may find difficult to get to the other side and that can influence in the possibility in making friends for students... Of course, it should reflect also on the planning of the town. So if you make this way, and you have all this then you should not place your school here, but anyway you will see it regularly,* […] *rearranging the school systems, where a lot of smaller schools in the country side were just laid down and the children should... transport themselves but nobody seems to think about that and when we laid this town maybe we should built a bicycle lane or several bicycle tracks for them. But that kind of consequences we are working actually in the 7th semester, or first semester of* kandidat*. We do not look into those parts very much in the third semester, where we have the infrastructure because that is mainly a problem of learning them the core content and, and we look at it a little bit on it when.. in. when we do highway, which is usually building a highway around the town, something like 10, 20 km long... because that you would have to look into consequences on the small... you could get into conflict with areas for nature preservation, or conflict with water supply fields, or you can get into conflict with agriculture.. You always get into conflict with that but anyway you can do it more or less smart.*"

Problem Based Learning (PBL) process and curriculum organization

The bachelor programme comprises four specializations within civil engineering field, being one of them in traffic and road infrastructures. The programme curriculum is quite rigid structure, especially regarding the first semester of the bachelor, where no courses concerning the subfield of traffic are taught.

The traffic related courses (comprising content regarding sewer systems and traffic) are present in second year of bachelor education (third and in the fourth semester), under the infrastructures component.

Regarding the road infrastructures the curriculum is very technical, even been the planning part remove from the course.

In the last year of bachelor education, students have to write their thesis. Here students have freedom to choose whatever they want within the highway traffic theme:

> "*You have the curriculum for the three years, where the first is the basic course and we cannot do anything about it. This is more and less the first two semesters. Than we have the discussion of what to do next, and we divided in a way that you have: the infrastructure and building, for the third and fourth semester. That is building construction and clime inside de houses. Here you have the sewer systems and the road traffic systems; this is more and less what we did before but there was some changes. One of them was that nobody else wants to use time in planning, so it was taking out*. […] *we have only one course here, and we will not use half of the course to give the students' knowledge about planning systems when nobody else wanted to support that. We would rather have something else and into engineering fields. Also one of the reasons is that those people that are coming in here* [referring to students] *probably are very oriented towards mathematics and not into discussion and so on...*"

> "*and what we did on next part was that we decided to put in the highway construction* [3rd year - 5th and 6th semester] *upon on the road construction on the remaining part of*

the bachelor meaning that they have the road geometry and the they have some geotectonic ... which we do not lecture"

Educating through PBL encloses some challenges. The challenges depend on the semester, year or programme (bachelor or master). For example, at master level, students come that come in have different backgrounds (different learning programmes, institutions, and/ or environments). One of the challenges for beginners is the adaptation to learning environment: group work and problem oriented, project based.

Process competencies

In the **SB3**$_{SCE}$ it is important for engineers to learn how to communicate with public. In real life context engineers have to present their projects in municipalities for public participation, and need to be aware of the background of target group (not engineering expertise) and understand the type of questions raised by public and the implications of those questions.

Synergies between PBL & ESD

In the specific programme in traffic, the integration of ESD would make more sense in the project due to the programme structure: specialization of a bigger programme, and reduce number of courses. It also can be embedded in some courses, however the course are already "full". There are some courses where lecturers look into aspects such ethics in environment in open areas:

"*I think, for our case, it would be in the project. Hum... because we haven't got that number of courses that we would like to have. And really we have, you can say this course in road administration and road management, or what would you called it, we can take it in various parts but my feeling we should not put more.. Taking in the administration of law of roads is enough for the students for that course. And I know that our colleagues have another course where they look on this ethics on environment in open areas: They do that at the water supply ... and it would be relevant for us to actually have the same course but then we will have to replace by something else and... We will have to look to what. Same as this and what to throughout instead.*"

There are other possibilities when come to the last semesters of the master programmes, for example, where students are able to make their own study plan, including type of problem, project and courses to attend. However such comprises problems of assessment procedures, for example. The study board could also create elective courses but the planning the semester comprises time allocation problems, like for example given time for students to go for those elective and relevant courses.

Lecturers

Interviewee L1$_{SCE}$

Background

L1$_{SCE}$ teach the course in both bachelor and master programmes, and for about 15 years. **L1**$_{SCE}$ worked

with industry for 20 years, construct buildings in all Denmark and world. For 15 was an external lecturer for AAU, and has been a full time lecturer for three years.

He was educated in Aalborg University.

Education for sustainable Development (ESD)

It is recognize that SCE has a need for more ESD in their education, but at the moment is not a priority. According to **L1**$_{SCE}$, it will come to the time that the links with sustainability have to be made, but at the moment is not a priority in their education programmes.

There is a limited time for educate engineers; there is a lot of barriers in this context, and as consequence students have to learn by themselves, after when they finish their education. In this sense, university education is a very controlled and clean environment when comparing what is demanded of students when go out to the real world.

> "*When it comes to industry, they* [ref. students] *have to all these things. A process starting up again to learn these things because they come from university. They only have the theoretical knowledge for all formulas. And they all have to learn these things.*" […]
>
> "*We can teach the basics to some level and they have to learn by themselves. That's why say they have to learn how to learn.*"

There is a need for courses on sustainable development.

The SD aspects that emerge from the curriculum content analysis show that there are themes in it that can used as a link with ESD:

> "*Yes, we can make the links with university.* […] *Out in practice, where the way to earn money is to make these kind of links, it is not calculating because everyone can calculate. There are a lot of pressures, a lot of programmes, and whatever, so it is where the money is, to connect the technical, the environmental and economic aspects. Everyone can calculate but not everyone can make this connections. For now at University we are not very good are doing these connections.*"

Integration of ESD should be done both on bachelor and master level.

Problem Based Learning (PBL) process and curriculum organization

The course has total of 5 ECTS and is taught in the third semester of the master programme of SCE. The course have a direct relation, and use for type problems solved by students in the mentioned semester. However many other courses taught by **L1**$_{SCE}$ face a time gap between when the they are delivered, and when its knowledge is mobilized to solve problems in project work:

> "*This is a very direct course because this is precisely what they are going to work in their projects. But we have a great problem because many of my courses, they are 1, or 2, semesters before they are going to use it. The students can't see what are they going to use it for, and the motivation is falling quite significantly.*"
>
> "*Three years ago when I started here, we were making a revision of the study regulation*

[meaning written curriculum], *before that it was like 'you are going to use this in your project so we are going to teach you this.' But now, is more 'you have this in your project but we are going to teach you something else, and maybe you use this in another semester'. It is not always the other way around. We made this time gap, and it is a great problem because if you want to do this PBL model you need to have some knowledge and use it in a concrete level, to support your project.*"

Regarding the assessment of project, there are learning outcomes formulated for project assessment and final examination of course.

In the bachelor education the curriculum is broader in the beginning and gets structured and narrower until the end of the bachelor. It is more focus on calculations. In the second year of the master programme the curriculum becomes broader. In the master education students have to get out of the box. Some students can, for example, make a jump from solving a narrower problem to a more open problem but not all:

"*In bachelor is more we giving, do this and this! And then we come now* [at master level] *and say - you'll have to tell us what to do and what you need'. And it is a quite another form.*"

"*This is the main different between an engineer from a bachelor and from the master. As a master you have to think by yourself. In the bachelor they are good making calculations and whatever you may give, but have a lower grade of thinking, studying. But now at the master they have to do this, and they do struggle with it.*"

It is also observed that the solving process also becomes mechanical when student reach the end of bachelor, become "experts" how to solve process rather than critical reflect on it. In the master, and through changing the strategy by asking students to be more autonomous, to get out of their comfort zone, is also something they do struggle:

"*But they don't want to and it is a shock and we would like to give them the shock before they get out of this university, because when to come to industry they will face the shock*."

The problems presented to students are not structured, unlike in other semesters and the solving process is unknown to students:

"*This time they don't know; don't have the way to solve. They have to come to me and say 'is this the way?' In all other semesters we say more "this is the way to solve", now we are saying "no, we are not giving it, the way to solve, you have to think yourself.*"

Process competencies

The time gap between the course content delivered need for problem solving and project work constitutes a problem for students but is also a learning process. When working in real live context, as engineers, students don not have "courses" giving the resources, and knowledge, to solve the problem they have to find it for themselves. This is a principle underlying the self-direct learning (learn how to learn). This is one of aspects students struggle in the PBL approach, even when they come to the end of their education (specially learn how to learn).

"*They are in the master now and you think if you are an engineer out in the real world you*

have to sit down, and you have to find out what is the problem. And when you know what the problem is, what can solve this problem. So we are telling the students 'you have to recognize the problems and came to us, and say what you need' and then we teach because it is like the real world now. And the students say 'oh no! You have to teach us all that you know because we cannot find out what we need.' They are quite afraid of this approach to teaching."

"*They have to know who shall to contact to solve this problem, and that's the way we want to teach them. We say 'Ok, you are in the master you have to see what do you have to know, what do you need to solve them, and tell your boss in your company - I need to talk to somebody who knows about this, and this, because I don't have the knowledge. You have to educate all this people together and make them see that this is the way to solve problems*"

"*We always say - why you are here? You are here to learn how to learn*"

Synergies between PBL & ESD

Integration of ESD can be done through project work because project is a suitable way to learn it, and can also be a mean for motivation:

"*You have the perspective when using real problems, in this PBL learning, where they can go out and see 'yes, we have problems with climate change. Yes, we have an interaction with economics. Yes, people are starving because for this and this'. This could be a way we can make it interesting. Having it in projects* [and make it also technical], *because they can relate with their life, out and with what they see daily in television*".

Other experiences

Even being one of the references in the qualification framework of the programmes, ethics and professional responsibility is not defined or taught to students.

Students profile is related with the "*all they want is to do calculation*".

Interviewee $L2_{SCE}$

Background

Educated in mechanical engineering in Aalborg University.

Education for sustainable Development (ESD)

There is no sustainability in the course, not because **$L2_{SCE}$** is against but because it does not fit with course content:

"*My part of the course is kind of be able to do this kind of analysis, so where is applied is up to students. Some are in the project but not necessarily all. You don't put sustainability in your course it is not because you are against it as framework; it is just because it doesn't*

fit."

Add on is not a suitable strategy for ESD because with an add-on strategy there is not interference with other (courses, content, etc.):

> "*If it is just an add-on it is not useful, it should interfere* [ref. with technical knowledge as aspects of the field]. *You choose something, or something else, with that argumentation alone. This is sustainable, this is not. Because if it is an add-on they* [ref. students] *will never have interest in it, any consequences, so why bother*."

It may be very difficult to get students engage in an elective or free study activity, in ESD because their main focus is on their technical education:

> "*They* [ref students] *are so busy in learning the technical discipline of their trade so if they have time to spend they will try to keep supervising on that. They are hard to take these things around them, a trade that could be useful. There's a quite a lot, economics is very useful - how a company runs? How to obtain finance? How to take it out in society? - but they do not take such courses*"

Problem Based Learning (PBL) process and curriculum organization

Course encloses some small projects and it is assess through oral examination. It is not through the project. SCE students don't contact very often the course lecturer. The course is focus on doing technical and mathematics analysis.

The course is held under the department of mechanical engineering and also in some of this department's programmes it is verified a time gap between courses content delivered and its use in project work solving problems:

> "*You have to fit in a certain no. of courses that could be useful later, or now. But you have to choose 5ECTS, which is big chunk, and that cannot be done on what you need right now because there's more part of it.* […]
>
> *On the 3rd semester that kind of goes away, your courses are different from projects. And it would be the same in many curricula, in civil and in mechanical. You take courses that are not link to the rest of the studies. There's something you like to know but you don't know what it is for. They* [ref. students] *make the link if they want to, it's their choice. It may be something not useful for project but is something they find useful in general.*"

Projects' assessment is focus mainly on the technical aspects of solving the problem rather than what is the impact of their outcomes in society, for example, as it also should be. Even some students may take this into considerations, it is not a common practice, and it is not required and assessed.

Process competencies

The time gaps, according to **L2**$_{SCE}$, turn students more critical in application of knowledge, deep learners:

> "*The time gap makes students more critical. It's hard to explain in English but… The way*

you learn something in a course is screeching the surface, and in the project you are going to apply it and see the difficulties and weaknesses of theory when you apply something real.

That makes much more in depth learning if what you are doing. So the coupling is important. If you only learn through courses, you think you have a lot of knowledge but not applicable. When you use it, the knowledge you gain is processed; beyond useful you also develop a critical way of looking at the new knowledge you are getting. And then you learn at text book level, before is useful I have to take it to a new level, that I have to do it on my own and go back to find new text book knowledge. It fits very well in my opinion."

Synergies between PBL & ESD

The type gap strategy may help to integrate sustainability in engineering because the project content is, to same extent, decided by the students. Sustainability can be integrated through the projects. For example, it could come in background of project, while in the conclusions the focus is on technical. Also it is relevant to aligned what is relevant to be assessed and make it explicit for students and staff:

"*Yeah, it has to be… It's difficult again because we are very fix on the technical aspects of being an engineer. Realistically, your grade will not depend on how much you take this. That will be in the technical stuff; calculations are correct, drawings correct and so on. So that will be very much in the background in the first five pages.*" […]

"*Also maybe in the conclusions required that is something about that in but how much work goes into that is hard to say. And it is now, not much goes into that.*"

Also the integration of ESD in project will be able to students to assess the impact of their decisions, and project outcome:

"*When solving a problem, or whatever they do, they have to assess the impact of what they are doing, the social, economic, sustainable, whatever, and decide if they still want to participate in that. Ah! All go back to engineers and physics that make the atomic bomb almost by accident and then have a bad conscious about that. In that category it has to be part of every project. But students don't think like that these days. I had some students doing something to a sniper gun, and I ask them 'How is your conscious about this? Do you have any? No… it's just taking a problem'.*"

Other experiences

Definition of ethics is not given, and not worked with. However there are some examples that require some discussion, mainly examples brought from students (e.g. constructions of a riffle).

Ethical code and professional responsibility can be, to some extent, part of regulations and standards students have to work with.

Interviewee $L3_{SCE}$ & $F1_{SCE}$

Background

$L3_{SCE}$ started in 1975 as AAU student. Got is bachelor, master and PhD degree from this institution in field of structure and construction. It is member of two committees – Joint Committee on Structural Risk Assessment (see http://www.jcss.byg.dtu.dk/), and a Danish committee of standards for design of buildings. On both, sustainability is an aspect that is being introduced as part of guidelines and standards making risk analysis of structures and design buildings.

$F1_{SCE}$ has a bachelor, master and PhD degree from Aalborg University.

Education for sustainable Development (ESD)

It is very hard to integrate sustainability in engineering education, partly because we deal a lot with calculation and you cannot put it in an equation. If so, than most of problem would be solved (**$F1_{SCE}$**):

> "*What you do is easier things like calculate the energy consumption in a building to be within a certain level. But know you move on to the next thing and become a little… The sustainability word is very hard, to put in to equation, that's actually should be a goal. If you cannot do that, if it doesn't enter in the equation somewhere then you actually have a hard time to quantify.*" (**$F1_{SCE}$**)

Integration of sustainability would be more successful in SCE if has professional relevance and use, to be defined in concrete level, and not fluffy or ambiguous.

Problem Based Learning (PBL) process and curriculum organization

Educating engineers through PBL encloses several challenges, one is for example the expectation of lecturers regarding the knowledge students should know, and actually know.

The SCE curriculum can be considered an overcrowded which may compromised the "quantity" and "quality" of technical knowledge students learn:

> "*Can be difficult to really go to the basic of the problem, so you don't have enough time to learn all the basic things. So maybe more in the surface. If you could maybe have more courses going directly to subjects that you could go deeper that what is possible in some areas and that is maybe missing in some areas. There is a tendency to cut away those theoretical very difficult things, and then just give an introduction. Sometimes that is not always sufficient when you have to design very complicated buildings or wind turbines, or other things. You need to know the details also*." (**$L3_{SCE}$**)

On the hand PBL also has positive elements, such as work with allowing students to work with real wold problems:

> "*The real good thing about PBL is that you can bring real life problems and they* [ref. students] *can solve larger problems that could not be if you don't have PBL. Than you would give small exercises like calculate beam or something like that. When you have PBL you*

can put the context together. I think a main good thing but the problem is to define this semester problem. You actually target all the things you should do in the education. And all the problems we would like for them to go through actually be involved in this projects." (**F1**$_{SCE}$)

Even working through projects seems to give some room for students to deepen their technical knowledge, there is also some constraints:

"*Sometimes too much time is going to define the broad things* [e.g. time allocated to define the problem], *which is also important. But there is not much time to learn all the theoretical, difficult things. There has to be a balance*." (**L3**$_{SCE}$)

Both **L3**$_{SCE}$ and **F1**$_{SCE}$ lecture in the course "*Wind loads on structures*". The course does not have a direct relation with the project themes for the 3rd semester of the master SCE education:

"*There is no direct relation; some are very relevant for the projects they are doing. They are evaluated separately and they could do something completely different in their project. They do not necessarily use the content (models, equations. etc.) directly in the project, but that is how the whole curriculum is made. So the courses are in fact self-contained in a way, of course they can be used in different projects, but is not that so that there is a direct link*." (**L3**$_{SCE}$)

The course is organized in lectures, assignment and two mini projects.

"*Courses are basically lectures with assignments for each lecture, and two mini projects, which constitute the base for the evaluation. And examination is based on the mini projects, why they* [ref. to students] *do that? Etc. We could also choose a written examination.*

Almost everything is given in the mini projects, is very structured and defined, where students need to apply what they have learned in the course. Like for example, calculate a wind load in a building. I choose the building" (**L3**$_{SCE}$)

In the projects, the assessment is mainly focus on technical aspects, of solving a problem.

"*To some extent, we have defined maybe the overall goals for the project (and into connection with industry), of course there is some basic problem to be solved and they can develop those further things*, *and look into other things. Of course it has to be very well formulated: what is the problem, what do them* [ref. students] *consider, what they not consider. So it is clear what is the goal for this project, what they conclude from their findings but it is not sol that they develop in a new direction or anything, I would say it is rather fix*" (**L3**$_{SCE}$)

One of the major challenges **F1**$_{SCE}$ face as a facilitator, and while educating through PBL, is in understanding the new PBL model and system, in comparison with the previous model in which he was educated as civil engineer.

Also he sees his role of facilitator as someone that should guide and redirect students along a problem solving process. Problems are abstract enough in order even facilitators not always know the right way to

solve the problem, the approach to take and to where will lead:

> "*To some extent we control the direction but are also that students by themselves find out what is the next step. You should not give them all the answers on the way but, of course, we, perhaps, when we define the project have an idea of which direction it should go. We don't tell them the direction but we try to push them into that direction. If they ask for methods, I try to pull them form that direction. But if along the way they find in the project this very detailed and it is very interesting for them, then they should also be free to move into that direction, even when it is not expected when we formulate the project. So they can move relatively freely.*" (**F1**$_{SCE}$)

Process competencies

Students through their education develop a more critical and broader view towards the field. However there are limitation in their "learn to learn":

> "*They can identify what they need but not always have the ability to learn or to understand and that can be a problem*" (**L3$_{SCE}$**)

Synergies between PBL & ESD

Probably integrate SD in an already existent course and which may be more content related such as risk and reliability, and, to go into more detailed, maybe integrate in the master level (**F1**$_{SCE}$).

Other experiences

Definition of ethics and professional responsibility also related how you should behave and work in a group. But it does not move further than that.

There are a diversity of students, of their aims, expectations and abilities (**F1**$_{SCE}$).

Facilitators

Interviewee F1$_{SCE}$

NOTE: **F1**$_{SCE}$ was interviewed jointly with **L3**$_{SCE}$ therefore his interview summary is with **L3**$_{SCE}$ interview summary.

Interviewee F2$_{SCE}$

Background

He is a PhD student, working with coastal protection waves, and got his bachelor and master education in structured engineering in AAU.

Education for sustainable Development (ESD)

Only pointed through filling Checklist A and B.

Problem Based Learning (PBL) process and curriculum organization

F2$_{SCE}$ doesn't find many challenges in education civil engineers through problem based, project organized. Actually in another way finds in PBL systems several advantages. However one problem that emerges in the master education is students from different educational systems than Aalborg university, which may encloses some problems regarding students' performance and managing PBL work:

> *"I don't really see big challenges in these systems (ref. to PBL systems]. I think I see mostly good things about them, and get good feedback. This is was also my thinking during my education. It is very nice to have courses, which build up your theory, and then you can use your theory and knowledge from the courses to actually to apply to something more practical. You learn how to use all your tools from the courses yourself. This is really strength in to do it in this way. When I am supervising groups, I think the biggest challenge is when you have people from different systems which come to Aalborg for the master and the to teach them, to fastly introduce them to the system that can be difficult because they are not used to work in this way. They work more freely and that can have a lot of pros and cons."*

> "*In the 1st and 2nd semester of the master, I would say they* [ref. to students] *are using it directly. There is no really time gap because they are having some courses in building a harbour, for example, and they actually designing a harbour in the project in the 2nd semester. Or in the 1st semester they are having courses in advanced computer models, and they will be doing a computer model. But for the 9th and 10th* [ref. to 3rd and 4th semesters of master programme] *semester it will be some time gaps, because students can choose vary different projects and it is very difficult to provide exact courses they need for their projects.*"

> "*They are using the knowledge from the previous courses as basic knowledge, but then they gain extra knowledge that they need for specific project. In the 9th semester, they, by themselves, are reading related articles of research on the subject. They use as general knowledge the one from previous courses, which they need to understand the new – they build on that.*"

In the 9th semester academic staff compiled a set of project proposals for students have an idea of what themes and cases they can work in their projects, and within they have to formulate their problems. Such catalogue is considered by **F2**$_{SCE}$ examples, and students have freedom to change and pursue problems within the area they find more interesting:

> "*In the 9th semester we write some examples of projects that they could work, and a paper for each project. If one is interested that come and ask about this project, and mostly they are not doing this exact project, we provide. But we do something they find more interesting, we can change around the subject*. […] *It is just an example for let them know what is possible.* […]
>
> *When we get to talk about the example, they sometimes realize that there are other things*

that they find more interesting. Than we can easily change."

Such leaves room for students to be more engage and ownership over the projects, which reflects on their motivation.

"*And that's why we are not telling 'If you choose this subject you should work with this because they may not be motivated as if they have the possibility to design the project, or the problem, themselves*."

Process competencies

F2$_{SCE}$ think civil engineering students may be quite innovative and creative regarding within their own field but they would have difficult to be adaptable and flexible to creative by combine and cross fields:

"*I think there is a different way of thinking about this "think out of the box", because when I see it this is being able to find new ways of doing thing and that can be within your own field or it can be combined with others. When I thick it off* [ref. to checklist A] *I think are they not very good to combine with other fields but they are able to do it within their own field of engineering. And I don't know whether they would adapt to combine with social sciences.*"

Synergies between PBL & ESD

Where to integrate ESD in the programme/ in the PBL process:

"*That's a good question… I really don't have a good answer for that. I think it should be mostly efficient in the project, and not with in a course but that's just my opinion. Because than can relate with a specific topic that they can generalize, instead of having a general knowledge on the topic.*

I think it should be in the master definitely, because in our education you learn all the basic tools in the bachelor and then you build upon these tools on your master. You move in to more specific things but also much more advanced things.

I think it would very healthy if they could learn how to generalize but I think I have the problem myself. I also like to focus in very single and in specific"

See their projects' solutions in the bigger picture, as a way to integrate a their piece in a bigger puzzle

"*I think it should be at end of project, where they* [ref. to students] *have all conclusions from their findings. I think the conclusions is what they should generalize and have more sustainable relation and also with other topics. Actually some projects, people are also trying to do this but it still very narrow. It is a question of how broad they should go. Perhaps also a bit in the beginning where you define the problem, to see what they could… 'When we do research within this field, what does actually make the difference?' And at the end relate it with some of their findings*."

According to **F2**$_{SCE}$ students considered, and reflect upon the limitations of the models and approaches

used for solving a problem, and specifically some are related with external factors such as human factor and its affects the solutions proposed.

> "*They are considering all the effects they have not account for definitely in* [ref. to, e.g. external factors like for example human factor, climate, biodiversity, others]. *This is one of the most important things when I say about they should know what is being assume within the models that they used. They use a computer model, or something for designing a brick wall, and then they should know what this model not accounts for, and what would the problem be*."

This gives some room for a bigger picture, systems and holistic systems thinking in the project room and also in the programme, and can be formalized and link with ESD principles.

Other experiences

Definition of ethics and professional responsibility is something difficult to say. However the in civil engineering, the work done by a civil engineer is always checked by a third part while as a researcher it is more at an individual level:

> *"Well... It is difficult to say because within the field of civil engineering the work that you do is checked by others, by third parts because some of the things can involve a lot of lives if they fail. But within the research filed I would say the ethics it not to plagiarize other works"*

2. Checklist & comments

Checklist A: Education for Sustainable Principles

	Programme	*Structure & Civil Engineering*						
	ID code	**SB1**	**SB2**	**L1**	**L2**	**L3**	**F1**	**F2**
	Group	*Study Board*			*Lecturers*		*Supervisors*	
A.1.Systemic & holistic	A.1.1. Capable of placing engineering field in perspective with others areas of knowledge	X						
	A.1.2. Develop knowledge beyond core STEM disciplines like sociology, ethics, business, etc.							
	A.1.3. Aware that engineering practice influences, and is influenced by, other professional practices	**X**		**X**	**X**			**X**
A.2.Flexibility and adaptability	A.2.1. Handle uncertainty by keeping open as many future options possible		X			X		
	A.2.2. Reflect on how alternative solutions that fit with the sustainable development approach can be identified				X			
	A.2.3. Accept that there are no guarantees that our solutions will be truly sustainable – we therefore must do our best with the skills, knowledge and resources we have at our disposal				X			
A.3.Contextual	A.3.1. Develop alternative solutions that are locally relevant	X			X			X
	A.3.2. Develop alternative solutions that are culturally appropriate							
	A.3.3. Seek to minimize the negative, and maximizing the positive, impacts of engineering practices both locally and globally				X			
A.4.Problem Solvers	A.4.1. Use technical engineering knowledge to solve real problems	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	A.4.2. Involve others' perspectives and knowledge (e.g. local representatives, politicians, stakeholders, etc.) in defining and solving complex problems							
	A.4.3. Retain the sustainability focus on the intended outcome right through the assessment and/ or implementation of the solution				X			
A.5.Participatory & decision maker	A.5.1. Bring social, economic and environmental experts and implications to seek a balanced decision							
	A.5.2. Professional engineers participate in the decision making as well as in their professional roles	X		X	X			
	A.5.3. Participate actively in the discussion and definition of social and economic policies to redirect society to a more sustainable development.							
A.6.Creativity and innovation	A.6.1. Divergent thinking among peers		X					
	A.6.2. Thinking "out-of-the box"			X			X	X
	A.6.3. Combining old ideas with new ideas		**X**	**X**	**X**	**X**		**X**
	A.6.4. Create new ideas with others		X					

Checklist B: Sustainable Development aspects

		Programme	Structure & Civil Engineering						
		ID code	SB1	SB2	L1	L2	L3	F1	F2
		Group	Study Board			Lecturers			Supervisors
B.1.Environmental	B.1.1.Materials (e.g. conservation of the global resource base and efforts to reduce the material intensity and increase the efficiency of the economy; ability to use recycled input materials; conservation of the global resource base; recycled materials and the overall costs of operations.)		**X**	**X**		**X**	**X**	**X**	**X**
	B.1.2.Energy (renewable, efficiency, consumption, etc.)			**X**			**X**	**X**	**X**
	B.1.3.Water (e.g. consumption, efficiency, etc.)								
	B.1.4.Biodiversity (e.g. impacts on, recovering, etc.)				X				
	B.1.5.Emissions, effluents and waste (e.g. reduction, management)			X					
	B.1.6.Products and services (e.g. life cycle assessment, impact of, initiatives for mitigation, transportation etc.)		**X**	**X**	**X**	**X**			
B.2.Social	B.2.1.Human rights (e.g. child labor, forced and compulsory labor, discriminatory								
	B.2.2.Labor practices and decent work (employment, labor/ management relations, training and education, diversity & equal opportunity, etc.)								
	B.2.3.Local government								
	B.2.4.Public policy and legislation				X	X			
	B.2.5.Local community engagement, impacts assessment and development programs								
	B.2.6.Product responsibility (e.g. public safety and health, marketing discourse, labeling and customer privacy)		X			X			X
B.3.Economic	B.3.1.Economic performance (e.g. direct economic impacts of the organization's activities and the economic value added by these activities on local communities)		X		X	X			
	B.3.2.Market presence and interactions in specific markets (e.g. policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation)								
	B.3.3.Indirect economic impacts (e.g. economic impacts created as a result of the organization's economic activities and transactions)								X
	B.3.4.Risk analysis (e.g. financial implications and other risks and opportunities for the organization's activities due to climate change)		**X**	**X**	**X**	**X**	**X**	**X**	**X**
	B.3.5.Emerging economies in low-carbon economy and growth in developing country investment								

Checklist C: Type of Knowledge

		Programme	Structure & Civil Engineering						
		ID code	SB1	SB2	L1	L2	L3	F1	F2
		Group	Study Board			Lecturers			Supervisors
C.1.Factual & conceptual (know-what)	C.1.1. Knowledge about facts, elements and/ or terminology			**X**	**X**	**X**	**X**	**X**	**X**
	C.1.2. Knowledge of principles and generalizations					X	X		
	C.1.3. Knowledge of theories, models and structures		**X**	**X**	**X**	**X**	**X**	**X**	**X**
C.2.Procedural (know-how)	C.2.1. Knowledge of subject-specific skills and algorithms				X	X		X	X
	C.2.2. Knowledge of subject-specific techniques and methods		**X**	**X**	**X**	**X**	**X**	**X**	**X**
	C.2.3. Knowledge of criteria for determining when to use appropriate procedures (e.g. systematic assessment and readjustment of the solving methodology - methods, approaches to questions formulated, etc.)		**X**	**X**		**X**	**X**		
C.3.Metacognitive	C.3.1. Strategic knowledge (combination of know what, know when and know how) (e.g. transfer and apply knowledge according to the situation - which methods, how to use, when to use, why it is use and related with the overall problem)			X	X	X			
	C.3.2. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (combination of know-what, know-when, know-how) (e.g. go back and look if the solving process is aligned with the problem formulated)		X			X			
	C.3.3. Awareness of the limits of one's knowledge (self-knowledge)		**X**		**X (?)**	**X**	**X**		**X**
C.4.Evolutionary, or world	C.4.1. Knowledge regarding the reasons behind the know-what, know-when, know-how and know-who					X			
	C.4.2. Knowledge shared and cultured (relate with knowledge production)					X			
	C.4.3. Knowledge about others (actors, disciplines, communities, systems) values and attitudes (importance and challenges of others moral perspectives on issues) (e.g. other discipline members beliefs of what is right and wrong, values and behavior, etc.)					X			

Checklist D: Disciplinarity

	Programme	*Structure & Civil Engineering*						
	ID code	**SB1**	**SB2**	**L1**	**L2**	**L3**	**F1**	**F2**
	Group	*Study Board*			*Lecturers*		*Supervisors*	
D.1.Disciplinary	D.1.1. Knowledge within your engineering subfield	**X**	**X**		**X**	**X**	**X**	**X**
	D.1.2. Study of courses related with engineering (e.g. mathematics, physics, etc.)	**X**	**X**	**X**	**X**	**X**	**X**	**X**
D.2.Multidisciplinary	D.2.1. Have knowledge from different disciplines (e.g. history)			X				
	D.2.2. Aware of others disciplines works		**X**		**X**	**X**	**X**	**X**
	D.2.3. Study of others subjects like finance, humanities, etc.							
D.3.Cross-Disciplinary	D.3.1. Topic of investigation is from other area of study							
	D.3.2. Use of techniques and tools that is commonly used by experts of other disciplines (e.g. using interview as method in civil engineering project)		X		X	X		
D.4.Interdisciplinary	D.4.1. Combines methods and approaches from different disciplines	**X**		**X**			**X**	**X**
	D.4.2. Two or more disciplines which interact and combine their expertise to jointly address an area of common concern.					X (?)		
D.5.Transdisciplinary	D.5.1. Formulate new theories and methodologies from different disciplines	X		X (?)		X (?)		X
	D.5.2. Two disciplines merge to create a new one (e.g. nanotechnology, product design and technology…)		X					

Checklist E: Criticality

	Programme	*Structure & Civil Engineering*	
	ID code	**F1**	**F2**
	Group	*Supervisors*	
E.1.Epistemological	E.1.1. Identify factual and normative aspects of the problem	X	
	E.1.2. Explain and understand and questioning the factual and normative aspects of the problem	X	X
	E.1.3. Analyzing and assessing the factual and normative aspects of the problem in order to outline strategies	X	
	E.1.4. Individual questioning and examining of the settings around problem		
E.2.Transformative	E.2.1. Transformation of values and beliefs		
	E.2.2. Change own points of view of existing economic, political, scientific and environmental structures and mechanisms		
	E.2.3. Community (group) analysis as well as assess alternative possibilities and strategies	X	
E.3.Dialectical	E.3.1. Different points of views on each case	X	X
	E.3.2. Recognition that knowledge is dependent on latent interests and values		X
	E.3.3. Recognition that progress and development take place by challenging, querying, criticizing and breaking down parts of existing parts to reconstruct a new and alternative one.		
	E.3.4. Re-built new practices without the deficiencies and errors of previous one.		
	E.3.5. Consistent criteria of assessment to oneself and others (e.g. group is acknowledgeable of each member potentialities, skills, knowledge and opinions)		
E.4.Holistic	E.4.1. Thinking involves emotions, feelings, intuition, and reason		
	E.4.2. Urge to transform an intention to act in a real action to promote change		

3. Answering the questions from strategy for data collection

The following table addresses questions, and goals, formulated in the empirical framework to be pursuit using interviews as methods.

Table 22 Synthesis

Questions	Analytical framework sub questions' answers
How, and why, is education for sustainable development integrated in the programme?	There is no strategy to integrate education for sustainable development into the structural and civil engineering programme. The main challenges to integrate ESD it would be: the crowded curriculum and students' strong profile/ identity towards technical education. The integration of ESD in civil engineering could be through: 1 the bachelor's first year course named PV course 2 the project 3 provide also some theories and tools through course There is certain recognition of sustainable development importance, and point some themes that can be used as "integrators".
How is the curriculum organized around problems?	The curriculum is defined as structured and narrow due to the concerns to educate students to be competent civil engineers. The PBL model presents challenges in educating civil engineers like: 1. Adaptation of new students to the PBL learning mode; 2. Risk of students' solving process become mechanical (not much room for reflection); 3. Time gap between courses and project work (partly due to the new PBL model); 4. Academic staff expectations towards students' knowledge; 5. Academic staff familiarization with new PBL model. The challenges depend on the specific programme, year and semester. The PBL model presents possibilities such: 1. Apply theories in a real problem 2. Develop ability to learn how to learn 3. Deepen knowledge learn through a course 4. Close relation with "real life engineering" 5. Motivation to learn In assessment is done through oral examination when it comes to projects' modules, and written examination when it comes to lecturers. However the course "*Winds Loads on Structures*" has its point of departure of assessment in mini projects students do as part of the course. The main object of assessment in the projects is mainly technical knowledge, and the reasons behind the methodological choices and results. The problems are presented to students through a catalogue. A catalogue is a compilation of projects' proposals. Each proposal consists in one page description with: i) title; ii) purpose; iii) background (in some); iv) main activities; v) contact person(s); and vi) relative amount of theory, experimental work and computer modeling should the project enclose.

Questions	Analytical framework sub questions' answers
	The catalogue is putted together in the beginning of the semester and with contributions of academic staff of the programme. The problems are formulated by the students, what they want to investigate. However the degree of freedom changes along the different semesters of the programme. In the first two semester of the programme the problems are quite structured and fix by academic staff. In the third and fourth semesters students have more freedom to decide what they want to investigate and decide which methods. According with the checklists C (type of knowledge) and D (type of disciplinarity) filled by the interviewees it is pointed: 1. Mainly factual and procedural knowledge, with some references to metacognitive knowledge; 2. Mainly disciplinary and multidisciplinary learning environment, with some references to interdisciplinary knowledge
What are the process competencies developed by students?	From the interviewee discourses the main process competence pointed is the critical thinking, and ability to learn how to learn (self-directed learning). However such is targeting, or towards the technical knowledge and professional as engineer.
How do students use SD in the PBL process? How can SD be integrated in a PBL environment?	The interview encloses two checklists where principles of ESD are stated (checklist A) and possible aspects that may work as SD themes (checklist B). It is asked to interviewees to fill them based on what behaviours and activities students for checklist A and what key words are related with concepts present in the programme and courses for checklist B. The interviewees considered creativity and innovation as something students develop, and see them as problem solvers. There are also references to systemic and holistic aspects. Regarding the SD aspects/ themes it is pointed: environmental (materials, energy and product services) and economic (such as risk analysis).
Ethics and professional responsibility	There is no clear standards and frame in which ways ethics and professional responsibility is defined. Some may lay on professional standards and safety guidelines from engineering associations, other are more naïve like no plagiarism and how to work in group.