Teaching Strategic and Sustainable Design

Renee Wever [1,2], David Peck [1], Adam de Eyto [2]

[1] Design Engineering Department, Delft University of Technology, Delft, The Netherlands

[2] Department of Design and Manufacturing Technology, University of Limerick, Ireland

Abstract

Sustainable innovation comes in many forms and sizes. There are different philosophies about how to design, such as EcoDesign, bio-mimicry and Cradle-to-cradle. There are differences in organizational contexts, such as multinationals, small and medium sized enterprises, start-ups and design agencies. Furthermore, different product categories and/or industries are suited to different approaches. What leads to a successful and sustainable innovation in one particular context need not necessarily work in the next.

In order to make students fully aware of these strategic choices, a module was developed within the taught master's program of Integrated Product Design at Delft University of Technology, aiming at teaching students to perform a stakeholder analysis and a driver analysis for a given innovation project, in light of sustainability, and to empower students to discuss how sustainable innovation manifests itself differently in different organizational contexts, and to communicate about sustainable innovation using business language.

The course ran successfully with 120 students. Participants were required to submit weekly reflections on a diverse range of scientific and non-scientific materials. Assessment was based on a scientific case study written on a unique and self-chosen historical sustainable innovation, and a single blind peer-review executed on the work of fellow students.

This paper discusses the chosen set-up of the course, with the didactical substantiation. It also highlights pointers for other educators how want to apply similar teaching methods. The paper further discusses how this set-up allowed connecting ongoing research by senior researchers and PhD candidates to the taught master's program.

Keywords:
EcoDesign, Higher education, academic skills, strategic design

1 INTRODUCTION

Many undergraduate design students, when challenged to think about sustainability, come up with ideas along the lines of attaching PV cells to a product or setting up material recovery schemes. When looking at the tools in the literature, one sees these solutions are the obvious translations of more generic strategies such as 'low impact during the use phase' and 'optimizing the end-of-life phase'. Both strategies are usually part of the tools that have been developed so far for 'green ideation', such as the LiDS wheel [see *e.g.* 1-4]. Translating a possible strategy such as 'optimize the end-of-life phase' into the potential solution of 'setting up a material recovery scheme' isn't what is difficult for design students. Although it is sometimes a challenge to move beyond obvious options such as the ones described above [5].

What is more of a challenge for many design students, is how to align the many options they come up with, with other business drivers, and how to select those options that also make sense from an economic (be it short term or long term) and in some cases also from a social perspective. In manuals on EcoDesign the focus is strongly on the embodiment phase. The decision which product to develop is assumed to have been made already. In case attention is paid to the front end of innovation, it mainly addresses the selection of dedicated (pilot) projects [*e.g.* 2, pp. 32-38], instead of structural embedding sustainability in business processes.

Addressing the connection between strategic design and sustainability was thus assessed to be a developmental opportunity in the training of our industrial design engineers. As a result of this assessment, a course on strategic and sustainable design was developed and introduced into the taught master program 'Integrated Product Design'.

(For an overview of how sustainability has historically been integrated in the Delft curriculum see [6-8]. For a comparison of the Delft program with other Northern European programs in product design and other universities see [9,10].)

This paper discusses the chosen set-up of the Strategic and Sustainable Design (SSD) course, with a didactical

substantiation. The reason for doing this is to highlight lessons learnt for other educators who want to apply similar teaching methods. The paper further discusses how this set-up allowed connecting ongoing research by senior researchers and PhD candidates in relation to the taught master's program. It will first provide a brief overview of topics that are covered, followed by the learning objectives, the course set-up and the developed assignments. Finally the experiences of the first year of teaching and the identified improvements conclude the paper.

2 STRATEGIC AND SUSTAINABLE DESIGN

Structural integration of sustainability within the entire innovation process remains a challenge, in design practice, in the literature, as well as in design education. In generic product innovation literature, the front end-of innovation is argued to be the phase with the highest potential for change, which has therefore also been hypothesized for the sustainable front end of innovation [11,12]. Issues such as sustainable goal and target setting are beginning to be addressed in literature for different organizational contexts, such as multinational [12,13] and design agencies [14,15].

Another strategic choice for industry is which philosophical approach to design and sustainability is most suitable to the business, *e.g.* Cradle-to-cradle (C2C), biomimicry, circular design or EcoDesign? Or for instance a combination of strengths of C2C and life cycle assessment [*e.g.*16]. The outcomes of different approaches are indeed found to be distinctively different [17,18]. And a choice for one, such as C2C, may have strategic consequences as well, as in the example where a company of a sudden finds itself involved in the field of material development as a consequence of a choice for C2C [19].

In addition to training students to deal with the role of sustainability in the embodiment phase, where issues such as material selection [20] may arise, questions such as the implications of strategic corporate level decisions being connected to design, are deemed by the faculty to be essential to their training as modern day design professionals.

3 LEARNING OBJECTIVES

As advised in the didactical literature, the learning objectives for the SSD course were formulated in an active form, describing what the student should be able to do after completion of the course. In line with the observations raised in the introduction on the Industrial Design Engineering curriculum as a whole, the objectives were formulated as follows.

"*After completion of the course the student is able:*

1. *to perform a stakeholder analysis and a driver analysis for a given innovation project, in light of sustainability, and to translate the gained insights into a prioritized action plan,*
2. *to discuss how sustainable innovation manifests itself differently in different organizational contexts,*
3. *to communicate about sustainable innovation using business language.*"

Note that this does not require the students to execute a design project. This was a deliberate choice, as a large portion of the curriculum is already developed around project-based learning. An observation with regard to the skills and competences of the design graduates is that their academic writing skills are observed to be deficient. (ranging from language and style issues to argumentation and epistemology). Hence, a set-up was chosen where students had to execute and write a scientific case study.

4 COURSE SET-UP

The course is a 3 EC point course, which roughly corresponds to a study load of 80 hours per student. It runs for 10 weeks, and has weekly taught sessions. It is structured around discussion (both during the contact hours and on the blackboard discussion forum – Blackboard is the on-line virtual learning environment used). Students are challenged to find, assess and compare information regarding sustainable innovation in practice.

The weekly sessions, roughly three hours each, consisted of multiple short presentations, often by multiple speakers per session. Many of the presentations were 1-on-1 repetitions of recent conference contributions (for instance the presentations connected to [13,14,18]). This was a deliberate choice, to invite fellow researchers to present an actual conference presentation. Not because they do not have the time or willingness to transfer their material into a lecture style, but to actually enable students to experience academic reality, and get a feel for how research is presented at a conference.

The topics of the weekly sessions were:

1. the KICK-OFF. the WHY, WHAT, WHO, HOW, LAW and COMMUNICATION of Strategic & Sustainable Design
2. the WHY. drivers for sustainable innovation
3. the WHAT. goal finding and goal setting
4. the WHO (EXTERNAL). stakeholder analysis
5. the HOW? methodologies and philosophies
6. the WHO (INTERNAL). employees, departments and champions
7. the LAW. legislation & standards
8. the COMMUNICATION. green marketing, sales, CSR

This course addressed the business case for sustainable innovation. It challenged students to consider sustainable strategies and innovations that help businesses in creating long-term competitive advantage.

The course addressed the drafting of a corporate sustainability strategy, translation of that strategy into a product (portfolio) strategy, sustainability target setting, management of Eco-design, and green marketing & communication.

Each week students prepared for the session by studying some source (*e.g.* a scientific article, a wider media publication or a documentary).

Students wrote a well-researched case study on a real sustainable innovation project in either a multinational, a Small or Medium-sized Enterprise (SME), a design agency or an entrepreneurial start-up. These cases were then subjected to a peer-review.

5   ASSIGNMENTS

First students were invited to choose the organizational context they would prefer for their case. They were challenged to for instance consider in which organizational context they would prefer to work in after graduation (multinational, SME, design agency, new venture). Subsequently, students formed groups of three, with fellow students with a preference for the same organizational context. In these groups, they wrote a case study on a sustainable innovation. This was either about a single innovation or a specific innovation process within a company. This case study needed to be supported by at least two distinct sources of information. These could for instance be:

- A student report (e.g. graduation project).
- An interview with director in the company
- An interview with a designer in the company
- interviews with retailers
- interviews with consumers
- a CSR report by the company

Students had to acquire their own case as a group. As a guide they were encouraged to consider:

- a follow-up of a graduation project that is 2-5 years old.
- a case of a company where they did a previous assignment.
- a company from their network (e.g. former employer, internship, family)

Their selected case needed to be approved by staff, and was judged both on appropriateness, on the proposed two case-specific sources and whether it was too similar to previously approved cases by other students. The case study was the basis of 70% of their final grade.

In week 7 students submitted their case for the first time, after which it was peer reviewed (see below). One week later they received the feedback from their peers, and in week 10 they submitted the final version accompanied with a separate 'letter to the editor' explaining what they did with the reviewer comments (*i.e.* adopted, or a rebuttal).

5.1   Peer review

Each team submitted their case study for peer review in week 7. At that time, the manuscripts had to be complete, and meticulously presented, so a rough draft was not accepted. That same day, the cases were redistributed to their fellow students for peer review. Those students had one week to perform the peer review, which they could base on a standard list of review questions. These questions were already available at the start of the course, so they could help in writing the case as well.

The standard list of review questions was an elaborate version of the questions that journals ask their reviewers, and included questions such as:

"1a. Are the description of the studied company and specific innovation project/process clear?

1b. How good is the fit between the chosen case and the objectives of the S&SD course?

1c. Are the reasons for selecting this case clearly described?

1d. Is the title of the case study appropriate?

...

6a. Is the literature clearly connected to the case (or the other way around), and reflected upon? (e.g. are identified hurdles / success factors the same?)

6b. Is the literature used correctly (is the interpretation correct? it the academic value of the reference judged correctly, or is too much weight given to the reference?)"

(The full list of case review questions is available upon request with the first author, for educators who would like to reproduce this educational set-up.)

Each student did one peer review. Each group member reviewed a different case study. The aim was that a student would review a case study from a different context (multinational, SME, design agency, or new venture) than the context of his or her own case study. Hence, the members of a group that studied a design agency for their own case, would each review a different case focused on either a multinational, an SME or a start-up.

The peer review was single-blind. Hence, the authors of the case did not know who wrote the reviews of their case. Double blind peer review would be far more complicated to organize. Furthermore, it would be overly ambitious, as students often know the topics of other groups, which would therefore not be blind anyway. Moreover, single blind peer review is the most common form of review in engineering and sustainability journals.

The peer review that students wrote was graded, and accounted for 20% of their grade. This may seem cumbersome for the tutor, but is kept manageable by only using a few possible grades (roughly equivalent to A, B, C, and F).

5.2 Weekly reflections

From week 2 to week 8 students had to study reading material before class ([12,16,21] are examples of such papers). For each session this material was available on blackboard (directly of via a link). Each time, multiple pieces of literature were available. The material provided was a mix of scientific publications (both journal, book chapters and conference papers), wider media articles (*e.g.* magazines) and documentaries. Hence, students could select the material most appropriate to their particular case study. Thereby, the reading load for the weekly sessions, and for their case study's literature review was to a greater degree combined.

The weekly reflections were an individual assignment. Each student read one of the papers. Based on this they have two tasks:

Task 1. They assessed the material on its usefulness as a source/reference (not necessarily only for their current case, but more in general, for instance for their graduation thesis as well). They judged the quality of the work, by looking especially at the underlying research, but also whether it was based on literature, whether it was cited often, the authority of the author, the place it was published etc. Based on these points students indicated the usefulness as a reference in 3 to 4 sentences.

This part of the assignment aims to improve academic writing skills in students.

Task 2. Based on the content of the material the student also posed a question or reflection as input for the weekly session. This could be:

- addressing something that is simply unclear to them after reading,

- something that they disagree with, or that they feel conflicts with other literature they are aware of (*e.g.* *"How does this or that argumentation/conclusion of the author relate to what we read last week in the paper on…"*)

- something regarding consequences (*e.g.* *"following the line of argument of the authors, does this mean that in this or that particular case…"*)

Questions were forwarded to speakers, in order to help them prepare for the session, and were also actively referred to during class. The proper submission of the weekly submission accounted for 10% of their final grade.

6 EXPERIENCES AND FEEDBACK

Based on the quality of the handed-in assignments, the staff feels the learning objectives have been met. Many groups produced decent to good case studies, and the quality of the peer reviews was excellent.

The challenge to groups to find their own case study turned out to be quite manageable for students. It was motivating both for students and staff. Also, it meant that cases were included that the staff and their immediate colleagues were not aware of. Hence, providing new insights to the research group on potentially relevant examples for research and teaching.

The choice of asking guest speakers (mainly colleagues from the school) to present recent conference presentations worked well. It meant that they needed only limited time to prepare. Furthermore they could connect with students that were particularly interested in their research.

The course was evaluated in two distinct ways. A student response group was interviewed with regards to their experiences with the entire semester, which contained two other compulsory courses. Furthermore a quantitative questionnaire was disseminated.

The qualitative semester evaluation that was executed by the school, yielded the following feedback:

- The students perceived the documentaries that were provided as interesting. They would have preferred to see more of these during the course.

- Students think the guest lectures were interesting, but not all of the regular lectures were perceived as relevant. Not all discussion on the papers that they had to read was interesting. Some took too long, according to the students.

- It was unclear to students how to write the weekly reflections. They were not sure what was expected from them for these reflections. However they think it is a good way to stimulate careful reading of the papers.

- Students appreciate that the SSD course pays attention to writing scientifically; they think this course could be offered earlier in the program to benefit from it in other courses.

There also was a quantitative questionnaire, which was filled out by 34 of the 120 participating students. Students were moderately positive (scoring around 6 to 7 on a ten point scale). Scores will have partly been influenced by issues which had to do with the course running for the first time, as logistically, not everything ran smoothly yet.

7 OPTIMIZATION PLANS

Given that this year was the first running of the course Strategic and Sustainable Design, the staff was pleased with the results of the evaluation, as these showed that students value the course.

There are, however, aspects about the course that can be improved according to both the students and teachers involved. The most salient of these are related to the feedback that was given to the students regarding their work. To improve this for next year's running of the course, the staff will take a number of actions. For the weekly reflections on the literature, students will receive a clear template that they can use to write their reflections. If the reflections are written according to a fixed format, it

will take less time for the staff to provide individual feedback on these reflections and to put students on the right track during the first weeks of the course.

In addition, the staff will communicate more clearly to the students how the peer reviews that they write for papers of fellow students will be reviewed and assessed.

For next year's running of the course the staff aims to improve the contribution of the lectures to the content of the course in a number of ways. First of all, guest speakers will be invited to every session. Secondly, the staff will strive for a better balance between providing feedback on student work during the lectures and discussing topics concerning the content of the course. With regard to these topics, the staff will prevent any overlap between the research that is discussed in one of the papers that students should prepare before the lecture, and the research that is discussed in the lecture itself. Finally, the total number of sessions will be reduced, which is done partly to reduce the workload in the course as well.

Finally, the staff will reformulate some of the learning objectives of the course to better manage the students' expectations, especially with regard to the way in which the topics of sustainable innovation are taught during the course: in the approach of the course Strategic Design, students determine success factors for sustainable innovation by reflecting on real world examples rather than applying sustainable innovation in a design project.

REFERENCES

[1] Brezet, H., Van Hemel, C., (1997). *Ecodesign: a promising approach to sustainable production and consumption*. H. Böttcher, & R. Clarke (Eds.). Paris, UNEP.

[2] Lewis, H., Gertsakis, J., Grant, T., Morelli, N., & Sweatman, A. (2001). *Design + environment: a global guide to designing greener goods*. Sheffield: Greenleaf.

[3] White, P., Pierre, L. S., & Belletire, S. (2007). *Okala: Learning ecological design*. IDSA.

[4] Crul, M., Diehl, J. C., & Ryan, C. (2009). *Design for sustainability-A step-by-step approach*. Paris, UNEP.

[5] Wever, R. & Boks, C. (2007) Design for Sustainability in the Fuzzy Front End. *Sustainable Innovation 07 Conference*, Farnham, UK, October 29-30.

[6] Boks, C., & Diehl, J.C. (2006). Integration of sustainability in regular courses: experiences in industrial design engineering. *Journal of Cleaner Production*, **14**(9), pp. 932-939.

[7] Boks, C.B., Diehl, J.C., & Wever, R. (2006) Sustainable product design, engineering and management education for industrial design engineering. *Proceedings of the 13th CIRP International Conference on Life Cycle Engineering*, Leuven, pp. 161-166).

[8] Diehl, J.C., Boks, C., & Silvester, S. (2005). The Evolution of Design for Sustainability Courses. *In Environmentally Conscious Design and Inverse Manufacturing, 2005. Eco Design 2005*. pp. 78-85. IEEE.

[9] Dewulf, K., Wever, R., Boks, C., Bakker, C., D'hulster, F. (2009) Sustainability in Design Engineering Education; Experiences in Northern Europe. *Proceedings of EcoDesign 2009*, December 7-9, Sapporo, Japan.

[10] De Eyto, A., McMahon, M., Mulder, K., Wever, R., De Werk, G.J., Overschie, M. (2013) Does the boat float? - The impact of teaching sustainable development in design and engineering. *Proceedings of Engineering Education for Sustainable Development*, September 22-25 2013, Cambridge, UK.

[11] Hassi, L., Peck, D., Dewulf, K., Wever, R. (2009) Sustainable Innovation - Organisation And Goal Finding. *Proceedings of Joint Action on Climate Change*, Aalborg, Denmark, June 8-10.

[12] Petala, E., Wever, R., Dutilh, C., Brezet, H. (2010) The role of new product development briefs in implementing sustainability; a case study. *Journal of Engineering and Technology Management*, **27**(3/4) pp. 172-182.

[13] Hassi, L., Wever, R. (2010) Practices of a "Green" Front End of Innovation; a Gateway to Environmental Innovation. *Proceedings of ERSCP-EMSU 2010*, October 25-29, Delft, the Netherlands.

[14] Dewulf, K., Wever, R., Brezet, H. (2011) Greening the Design Brief. *Proceedings of EcoDesign2011, 7th International Symposium on Environmentally Conscious Design and Inverse Manufacturing; Design for innovative value towards sustainable society*, Kyoto, Japan, November 30 - December 2, 2011

[15] Storaker, A. Wever, R., Dewulf, K., Blankenburg, D (2013) Sustainability in the front-end of innovation at design agencies. *EcoDesign 2013*, December 4-6, Jeju, South Korea.

[16] Bakker, C. A., Wever, R., Teoh, C., & De Clercq, S. (2010). Designing cradle-to-cradle products: a reality check. *International Journal of Sustainable Engineering*, **3**(1), pp. 2-8.

[17] De Pauw, I., Kandachar, P., Karana, E., Peck, D., & Wever, R. (2010). Nature inspired design: Strategies towards sustainability. *Proceedings of ERSCP-EMSU 2010*, October 25-29, Delft, the Netherlands.

[18] De Pauw, I. C., Karana, E., & Kandachar, P. V. (2012). Nature-Inspired Design Strategies In Sustainable Product Development: A Case-Study Of Student Projects. *In Proceedings of the 12th International Design Conference DESIGN 2012* (pp. 787-796).

[19] De Pauw, I., Karana, E., & Kandachar, P. (2013). Cradle to Cradle in Product Development: A Case

Study of Closed-Loop Design. *In Re-engineering Manufacturing for Sustainability* (pp. 47-52). Springer Singapore.

[20] Ashby, M. F. (2012). *Materials and the environment: eco-informed material choice*. Elsevier online.

[21] Köhler, A. R., Bakker, C., & Peck, D. (2013). Critical materials: A reason for sustainable education of industrial designers and engineers. *European Journal of Engineering Education*, **38**(4), pp. 441-451