A win-win-win approach

# TEACHING PSS IN BUSINESS PRACTICE

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**Abstract**

This paper presents the findings gained through the implementation of the renewed Product Service Systems (PSS) course within the Design for Sustainability curriculum in 2010. Based upon the outcomes of our recent PSS research projects in practice and evaluation of the earlier PSS courses a new setup was proposed. The main starting point for restructuring the course was the conclusion that co-operation and mutual understanding between "creative" designers and "commercial" entrepreneurs are important conditions for success of a new PSS. The course setup is based upon a structured step-by-step approach (www.d4s-sbs.org) in combination with an interactive character by which the students have frequent meetings with the company representatives who gave the assignments as well as with the involved PhD-candidates of the current research projects within the faculty. It was concluded that interaction of students with real life actors increases the feasibility of developed projects (benefit for the companies) and the engagement of students with a real life context (benefit for the students). In addition this new teaching approach delivered valuable research materials (benefit for the PhD-candidates).

**Keywords**
*Product Service Systems, course development, university-industry collaboration*

## 1. Background

This paper presents our findings gained through the implementation of our renewed Product Service Systems (PSS) course at the Faculty of Industrial Design Engineering (IDE) at the Delft University of Technology in 2010. The course is oriented at the development of new product-service systems (PSS), as a next strategy for dematerialization. Dematerialization of products by relatively increasing the service part of PSS is considered to be an important

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element of a sustainable economic development, after the Ecodesign of -physical- products. By taking the immaterial part of product-systems and the optimization of the use of existing physical infrastructures as point of departures, industrial design engineers can create new artifacts that are fostering the adoption of these new, dematerialized product-service systems (Mont 2002; Tukker and Tischner 2006).

The PSS course is being taught for over 10 years at the faculty of Industrial Design Engineering. Each year the course is evaluated and adjusted to the current state of the art knowledge on PSS. Based upon the outcomes of the recent PSS research projects in practice and evaluation of the earlier PSS courses a new setup was proposed for the academic year of 2009-2010. The main starting point for restructuring the course was the conclusion that co-operation and mutual understanding between creative designers and commercial entrepreneurs are important conditions for success for a new PSS (Keskin, Brezet et al. 2009). Therefore, the new PSS course is oriented on knowledge transfer in the field of entrepreneurship and business development in relation to PSS-innovation. In addition it was decided to focus on generating innovative 'new businesses' and 'new ventures' particularly within small and medium sized firms. Young and small firms are responsible for a substantial part of the economy in Europe and the USA as well as are characterized by a more open attitude for radical sustainable innovation.

Within the new program it was hypothesized that the interaction between students and PhD-researchers during the coursework could potentially create a win-win situation. PhD-researchers provide the students with more in-depth academic knowledge and research skills. In return the PhD candidates get worked out cases, which contribute to their thesis work. Working with 'real' entrepreneurs provides the students a good insight in the opportunities and barriers in practice as well as an understanding of the commercial considerations.

Based upon these inputs the setup and assignment were adjusted to bring the PSS one step further to developing it as a business reality. Not only developing new innovative and sustainable PSS concepts, but also to develop the PSS concepts to a level that they could be directly introduced commercially into the market.

Within the following paragraphs we will first introduce the outline of the new PSS course.

Next the result of the evaluation of the course by the students and the entrepreneurs will be discussed. We will finalize this paper with a conclusion and recommendations for further improvement of the course.

## 2. Course outline

### 2.1 Course objectives

The goal of the revised PSS course was to bring together different perspectives on PSS as well as to combine theory (literature) and practice (working with companies). Based upon these principles the four key course objectives were defined (Keskin and Brezet 2010). From a theoretical point of view the PSS course should provide students with basic essential knowledge on the theory, concepts, approaches, methods and tools for the development of PSS. Practice wise the PSS course should provide students with insight in and understanding of the conditions, drivers and obstacles for PSS implementation in practice. Next to this the learning path should offer students the knowledge related to the development and assessment of business plans that support the successful introduction of new PSS via existing businesses or new ventures. Last but not least the course should offer the student the opportunity to develop his or her skills in understanding of and co-operation with business venture oriented specialists.

### 2.2. Course setup

The course setup is based upon the structured step-by-step approach (www.d4s-sbs.org) in combination with an interactive character by which the students have frequent meetings with the company representatives as well as with the involved PhD-candidates of the ongoing research projects at the Design for Sustainability program.

In total 55 students from four different master programs of Delft University of Technology participated in the PSS course: MSc. Integrated Product Design, MSc. Strategic Product Design, MSc. Design for Interaction and MSc. Industrial Ecology. At the beginning of the course teams of five students are being formed with a mixture of students from the four master programs. This way multidisciplinary teams were created with skills in strategy and business, creativity and product development, and sustainability.

The teams of students were matched from the beginning of the course with a company of one of our ongoing research projects of the Design for Sustainability (DfS) research program. At first instance all academic staff of DfS were approached to come up with suitable company cases. In a next stage the proposed cases were evaluated on their suitability to

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function as challenging assignment within the PSS course (for example if the company was open for more radical sustainable innovation approaches). This resulted in the following selected three research projects and accompanying companies:

⇒ *Ecomind:* Energy Keeper, Qurrent, Sustainable Dance Club, Shifft, BioFutura
⇒ *LivinGreen:* De Witte Roos
⇒ *Cradle2Cradle Islands:* Vrachtfiets, Municipality of Texel

The main assignment for each team was to design a challenging, new and sustainable PSS, including a focus on needed radical novel products for these companies. To support the students in the PSS development process two methodologies were selected. The first one is the PSS module (Tischner, Ryan et al. 2009) of the UNEP Design for Sustainability Step-by-Step (D4S-SBS) manual (Crul, Diehl et al. 2009), which functioned as the core of the PSS development. The PSS module exists of three parts: 1) a theoretical introduction, 2) methods and tools, and 3) worksheets. The second methodology chosen was the Eco-costs / Value Ratio method (Vogtlander and Hendriks 2004), which was applied to evaluate and strengthen the business aspects of the cases. Both approaches are available on the Internet: www.d4s-sbs.org and www.ecocostsvalue.com.

During 8 weeks the students were provided with 2 lectures per week to introduce them the PSS approaches, tools and examples from practice. Moreover, related to each lecture additional reading materials (i.e. journal and conference papers) as well as slides of the presentation were made available at Blackboard, the e-learning environment in use at Delft University of Technology. For additional lectures on PSS was referred to the Lens Web-Site (www.lens.polimi.it).

In the second week each team could select one of the company cases and start working on the assignments. Consequently the student teams went through the steps of the PSS module of the D4S-SBS manual. During this process the PhD-researchers and teaching staff of the DfS research program supported the teams. The staff stimulated the teams to formulate innovative but feasible assignments.

Throughout the course the student teams did have at least three times a face-to-face interaction with the companies. In the beginning a visit to the company took place for the briefing of the assignment and learning more about the competencies of companies and

their vision on sustainability. Half way, the companies were involved in selecting the preferred PSS concept as well as to provide additional needed information. At the end the company representatives were involved in the evaluation of the outcomes. In between communications took place by e-mail or telephone. The student teams themselves were responsible for arranging the meetings and communications with the companies.

### 2.3. Assessment

At the end of the course the teams did have to present the developed PSS as well as the evaluation of it on the People, Planet, Profit and EVR criteria during a workshop with sustainability experts and representatives from the companies. During this workshop the companies provided direct feedback to the feasibility of the outcomes from business, technological and market perspectives.

In addition the course student teams presented their projects in the form of a "journal paper" consisting of an analysis of the assignment, company, the process of PSS development, and evaluation of the developed PSS as well as the course methods and tools. Furthermore, a detailed business plan was presented for each project.

### Evaluation by students

During the course the students often provided feedback to the course staff with regard to the setup of the course. In addition an online questionnaire was prepared for the evaluation of the course at the end of the period.

### Feedback by students

In general the students were very enthusiastic about the new course setup. Within a short period they were introduced to a new approach (theory) as well an opportunity to work with 'real' entrepreneurs (practice). With regards to these two components of the course they had the following opinions.

### Theory

In general the students were satisfied with the step-by-step approach of PSS module of the D4S-SBS manual. Within earlier courses they were used to develop products or product-systems. This was the first time that they were confronted with the development of a more complex product service system. The structured step-by-step approach of the D4S-SBS manual guided them throughout the whole design process as well as evaluating the concepts from a sustainability perspective.

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On the other hand, there were drawbacks of this structured approach.  One of the critics of the students on the PSS module of the D4S-SBS manual is that it was not intuitive and creative. Within the approach many checklists and guidelines are being used which does not stimulate 'out of the box' thinking and creativity. Especially in STEP 2: PSS Idea Generation, the students expressed a need for more freedom and flexibility as well as for brainstorming techniques within the framework of developing a PSS. Some stated that "it does not really stir creative brainstorming".

For students without an industrial design background (i.e. the industrial ecology students) the manual was difficult to understand. They would prefer to get additional training in product development and examples of end results in the beginning of the course or incorporated in the D4S-SBS manual. This would make it easier to understand especially for non-design students.

**Practice**

The students were excited to work with real companies on real problems. This approach made the course very much 'hands-on'. In their opinion working with entrepreneurs brought their PSS concept more close to reality. In addition, the collaboration gave them a glimpse of how start-ups operate (many IDE graduates do want to start up their own company). In general the communications and interactions with companies went very well and their briefings were clear. One of the advantages was that most of the participating companies were start-ups and as such existing a young and small staff. As a result they were easy to approach without many arrangements. The student stated that the entrepreneurs were open for discussion and open minded for more radical sustainability approaches. One of the disadvantages of working with start-ups was that some of the participating companies did not yet have a clear vision and as such it was difficult to decide on the proper direction for the PSS development. Furthermore, in one case confidentiality aspects were a barrier for getting more detailed information on the company and its specific know-how.

**Students questionnaire**

In addition to the feedback of the students during the course, an online questionnaire was prepared to get more detailed insight in the opinion of the student at the end of the course. In total 30 of the 55 students filled in the online questionnaire. The online questionnaire was created in 'Survey Monkey' and consisted of three sections: 1) setup of the course, 2) D4S-

SBS PSS approach, and 3) open questions about what students most liked and disliked about the course. For the setup of the course and D4S-SBS PSS approach students were asked to indicate on a list of statements if they strongly disagreed, disagreed, neither disagreed or agreed, agreed or strongly agreed. Based upon the input a value (average rating) was calculated in between 0 (strongly disagree) and 5 (strongly agree). In addition the students could enter their comments freely for each section of the survey. The last part of the survey consisted of open questions of what students liked and disliked about the course.

**Evaluation course setup and outcomes**

The students could provide their opinion on 11 aspects of the course setup. The most relevant and interesting ones are presented in table 1.

Table 1: Student evaluation of course setup and outcomes

| Statement | Strongly disagree | Dis-agree | Neither disagree or agree | Agree | Strongly agree | Rating average |
|---|---|---|---|---|---|---|
| The course was very inspiring and I would like to continue working in the field of sustainability. | 0% | 7% | 30% | **37%** | 26% | 3,81 |
| The course provided a new perspective on combining products and services for sustainability. | 0% | 0% | 15% | **59%** | 26% | 4.11 |
| Working with a company on a real assignment was very motivating. | 4% | 11% | 7% | **52%** | 26% | 3.85 |
| The company was very motivated to interact with us. | 15% | 11% | 15% | 26% | **34%** | 3.44 |
| The concept we developed was very useful for the company. | 4% | 15% | 26% | **29%** | 26% | 3.59 |
| The company is planning to implement (part of) the concept. | 4% | 4% | **37%** | 26% | 29% | 3.74 |
| The evaluation of our PSS proved to be very sustainable. | 0% | 19% | 26% | **48%** | 7% | 3.44 |

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The results show that in general the students were satisfied with the course setup, in particular working with a real company in a real life context. Although some students expressed a difficulty in organizing meetings with company representatives, they in general stated that the companies gave interesting and challenging assignments and were open for new sustainable solutions. One challenge express by the students was the difficulty in finding the balance between course objectives and company goals. The focus of the course is on sustainability and new combination of products and services with a lower environmental impact. This sometimes conflicted with company goals, which in some cases was more focused on developing products without a service component. This insight proved that for the next versions of the course, a briefing of the PSS concepts to the participating companies would be very useful in helping students creating the balance between course objectives and company goals.

**Evaluation D4S-SBS PSS approach**

Subsequently, the students were asked their opinion on the D4S-SBS approach. First they were confronted with two question related to the total approach and next about each step of the approach specifically (see table 2)

Table 2: Student evaluation of UNEP D4S-SBS PSS approach

| Statement | Strongly disagree | Dis-agree | Neither disagree or agree | Agree | Strongly agree | Rating average |
|---|---|---|---|---|---|---|
| The UNEP manual gives adequate information on Product-Service Systems? | 0% | 0% | **52%** | 37% | 11% | 3.59 |
| The tools proposed in UNEP manual are helpful in designing the PSS concept? | 0% | 15% | **52%** | 30% | 4% | 3.22 |
| STEP 1: Exploring opportunities was very useful in analyzing the existing reference system. | 0% | 0% | 15% | **74%** | 11% | 3.96 |
| STEP 2: PSS Idea Generation asked inspiring questions and helped us to think different aspects of sustainability. | 7% | 11% | **44%** | 30% | 7% | 3.22 |
| STEP 3: PSS Design helped us to prioritize certain aspects of sustainability that we | 7% | 11% | **44%** | 27% | 7% | 3.19 |

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| wanted to focus on for our PSS concept. | | | | | | |
| STEP 4: Evaluation of Detailed PSS was useful in evaluating our PSS concept. | 11% | 22% | **33%** | **33%** | 0% | 2.89 |
| STEP 5: Planning PSS implementation was very useful in evaluating the feasibility of our PSS concept. | 7% | 15% | 26% | **48%** | 4% | 3.00 |

The UNEP D4S-SBS manual was in general found to be clear and informative. Especially students find "STEP 1: Exploring opportunities" very useful in analyzing the existing references system, although in some assignments there was no existing reference system in which the students could search for opportunities. In such cases, they were advised to analyze the existing alternative systems, explore opportunities for improvement and learn lessons for the new PSS in development. For the steps related to design of the PSS, student stated that the amount of checklists decreased the time, freedom and creativity that could be devoted to idea generation and concept development. Some remarks were:

"The PSS methodology is too complex and strict with a lot of checklists. For example, STEP 2 is too rigid and not intuitive. Everything is fixed, no space for brainstorming."

"These tools were too generic to relate to the details of a specific concept. Also, the questions used to evaluate concepts were extremely redundant and often confusing."

The steps related to the evaluation and implementation of PSS were found to be average. One challenge stated was related to the parameters, which are found to be too general. One student stated:

"For the radar, we understood that it is important to consider 3Ps all together and I think it is pretty challenging and require a very broad view. Having all of requirements and checklists did not help us to find a truthful answer. There were too many questions that almost impossible to answer."

*Like and dislike*

The students were satisfied with the *course topic*: designing a system of product and services with a lower environmental impact. They stated that this new look on designing products in combination of services is very inspiring and give some new insights on new system development and links with sustainability. Then, students were in general very satisfied with *working with a real company*. Some stated that this setup created a strong link between sustainability and feasibility of the concepts, which asks for translating of visions and ideals into more marketing/ economic oriented language. Another aspect students find inspiring was the *lectures*. In addition to the lectures related to theory, the course involved many guest lecturers with different backgrounds from academia and industry. Especially some lectures given by the entrepreneurs themselves was found to be very inspiring case studies for especially those students who aims at developing their own companies.

The students expressed their dislikes mainly related to the worksheets, weekly assignments, and the balance between course objectives and company goals. According to the students the worksheets were not always clear, time consuming and sometimes repetitive. The students were requested to finish every week one step of the approach and to communicate it with their supervisors. This way the time pressure was high and to less flexibility was offered for the students to manage the process. Besides the positive aspects of working with real companies, also small problems were mentioned. One of the students mentioned: "Managing the expectations of both our client (practice) and our coach (academic) was sometimes difficult and frustrating".

**Benefits for the companies**
All participating companies were invited to join a workshop at the end of the course. The first goal of this workshop was to present the students' work (PSS concept and the accompanying business plan and evaluation) to the participating companies. Company representatives provided direct feedback to the students. The second goal was to reflect and discuss with the entrepreneurs their experience an opinion with participating within the PSS course, the process, outcomes and potential follow-up.

Figure 1: Presentation by student teams for companies and sustainability experts.

The main reactions of the companies are stated below. At the time of their reflection the companies had attended the five minutes presentations of each group. The final paper and business plan was still to be delivered afterwards.

The majority of companies found it very interesting to give assignments to young creative design students, which enabled them to get insights into new product-service ideas as well as new approaches like PSS. Companies also stated that coming together with other companies in a workshop enabled them to *learn from each other* and how others deal with complex issues like sustainability. Most of the new PSS ideas were useful for the participating companies or at least provoked thinking about new business opportunities.

*Products in combination with services* were a very useful idea for some companies, and not for others due to the differences in business focus. In addition, it was concluded that a PSS approach might not be the most suitable approach for small entrepreneurial companies since it requires the involvement of various stakeholders, which requires considerable amount of time and effort. The size and low power of these companies in the value chain might hinder this process.

Since one of the requirements of PSS is the involvement of a broad range of stakeholders, and this requirement was present in many of the student projects, some companies questioned the *interest of other actors*, which were proposed by students to be involved in the PSS concepts.

For the companies the outcomes related to the target market, potential benefits and the business plan were the most important. They were asking the student teams additional information on willingness of potential customers to use the proposed PSS concepts, initial investments, specific characteristics of the customers, activities of competitors etc. They

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were less interested in translating the PSS scenarios into visuals. One company for example suggested that the students could focus more on detailed results than on fancy movies and nice looking storyboards.

**Conclusions**

The new setup of the PSS course proved to be a win-win-win situation for all involved stakeholders. It was concluded that interaction of students with real life actors increases the feasibility of developed projects (benefit for the companies) and the engagement of students with the real life context (benefit for the students). In addition this new teaching approach delivered valuable research materials (benefit for the PhD-candidates) and the entrepreneurs were provided new PSS concept ideas and accompanying business plans as well as a for the new insight in and understanding of the PSS concept (benefit for the companies).

The course also led to a range of learning experiences for the teaching staff and recommendations for improvement. With regard to the applied D4S-SBS PSS approach, it came to the front that according to the students that the current approach is to rigid and in some cases redundant. Another challenge will be to find a good balance between the expectations of the entrepreneurs (detailed business related aspects) and the ones of the academic supervisors (structured approach, evaluation on sustainability aspects and visualisation and communication of results). These and other recommendations will be incorporated into the next PSS course in 2011.

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