

## **Sustainable design of products and services course: designing through materials' sustainability lenses**

**J Segalas**

Director

Research Institute for Sustainability Science and Technology , Universitat Politècnica de Catalunya – Barcelona Tech  
Barcelona, Spain

E-mail: [Jordi.segalas@upc.edu](mailto:Jordi.segalas@upc.edu)

### **ABSTRACT**

“Sustainability” in design is not a simple constrain that can be quantified and optimized in an engineering design. Issues of sustainability are inherently complex and wicked; their assessment requires acceptance of this complexity and working with it. Each aspect (e.g. environment, society, regulations, design, materials...) can be explored in a systematic way but the integration of the aspects to give a final assessment needs judgment and reflection, as there is no one single sustainable solution to a problem. Integrating the different articulations of Sustainable Development needs a holistic approach and stakeholder participation. How can we teach this to engineering design students in an efficient and effective way?

This paper presents the scheme of the Sustainable design of products and services master course and the ideas behind new teaching resources for Sustainable Development, designed for engineering design and materials science courses. These resources identify the complexity and transdisciplinary issues of sustainability and new methodologies and tools to help student understand and analyse them. This paper describes the course and the reasoning behind the resources, which include a method and a database of background information. The outcome is, inevitably, subjective, influenced by social, cultural and political background and therefore one requiring debate, but the method creates a common background of accepted facts on which an informed debate can be based. Since 2013, the course has been run at the Master in Sustainability Science and Technology at the Universitat Politècnica de Catalunya, providing experiences in a real educational setting. This paper summarises some of their outcomes in terms of learning, course design and participatory approaches in education.

Conference Key Areas: Sustainability and Engineering Education, Engineering Skills

Keywords: Engineering Design, Sustainable Design Education, Design Education

### **INTRODUCTION**

Since 1991, the Universitat Politècnica de Catalunya (UPC) has focused on introducing Sustainability education in all its engineering and architectural programs through two environmental plans and currently through the UPC Sustainable 2015 [1] plan.

Since 2013 the course Sustainable design of products and services has been run in the Master in Sustainability Science and Technology at the Universitat Politècnica de

Catalunya. Next sections will present the experience which may help when introducing new teaching for Sustainable Development, designed for engineering design and materials science courses.

## 1 SUSTAINABLE DESIGN OF PRODUCTS AND SERVICES COURSE

The Sustainable Design of Products and services (SDPS) is a 5 ECTS course offered at the third semester (out of four) of the master degree in Sustainability Science and Technology at UPC.

## 2 COURSE STRUCTURE

The course uses constructive and community oriented learning for sustainable design. It is organized around three axes (Figure 1): Strategies, Tools and Projects. First, students are introduced to sustainable design strategies principles (Eco-design, Cradle 2 Cradle, Biomimicry, Product Service Systems, Design for Sustainable Behavior, Human Centered Design, Social design, etc.). Second, students use CES-Edupack software using the Advanced SUSTAINABILITY database tool and finally, students apply the tool to a contextualized project taking into consideration the sustainable strategies available. Students spent approx. 50-60% of the course time on the group project. They presented the progress after each project phase. Next paragraph focus in this methodological approach.

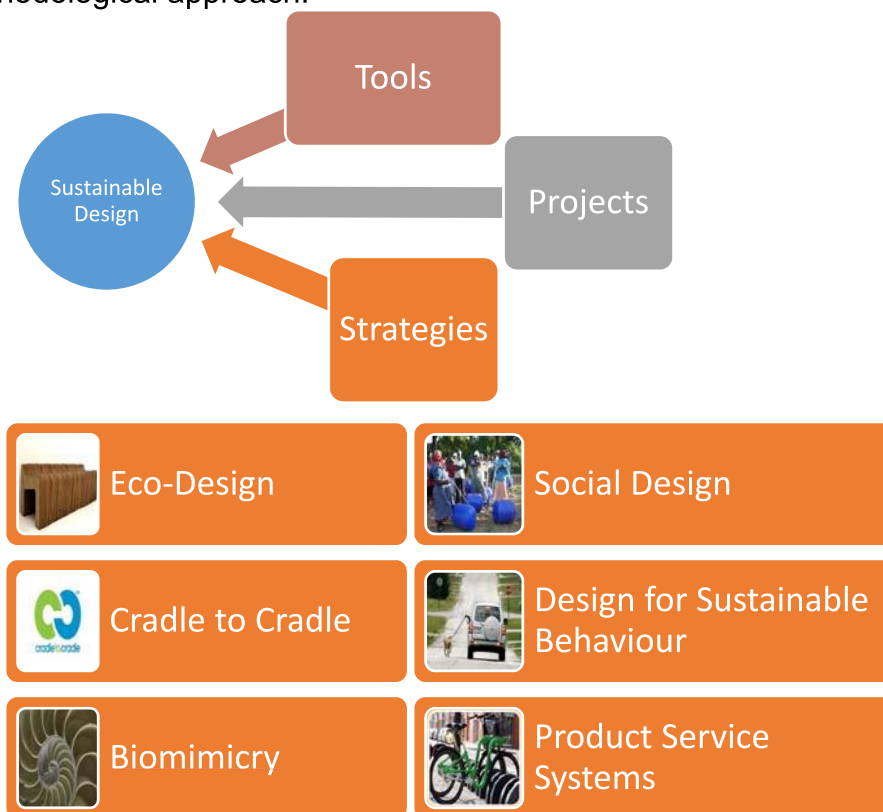


Figure 1. Main features of the course with sustainability design strategies.

## 3 METHODOLOGY

A “Sustainable Development” is one that contributes in an equitable way to human welfare and does so in a way that minimizes the drain on natural resources. Many academic, civil, commercial and legislative projects claim to do this – promoting biopolymers, carbon taxes, design for recycling are examples. Following Mulder et al.

[2] we shall refer to them as “articulations” of sustainable development. But how are they to be assessed? There is no simple, “right” answer to questions of sustainable development – instead, there is a thoughtful, well-researched response that recognizes the concerns of stakeholders, the conflicting priorities and the economic, legal and social constraints of a design as well as its environmental legacy. How can students be introduced to this complexity and equipped to assess the viability of designs that claim to be sustainable? The aim of the method described here is not to define a single metric of index of sustainability; rather it is to improve the quality of discussion by providing a reasoning-path and guided access to relevant data [3].

“Wealth” is a generic term for all that we value. Global or national “wealth” can be seen as the sum of three components: the net manufactured capital, the net human capital and the net natural capital [4]. Sustainable development is as a development that takes in account the evolution of the three capitals, and aims at the increase of all of them. Examination of many articulations of sustainable development suggests the following picture. Each articulation has a motivating target that we will refer to as its “Prime Objective”. Each involves a set of Stakeholders. In assessing the sustainability of project the first step is to identify these: if the Prime Objective is not achievable or major Stakeholders are left dissatisfied, the project is unlikely to be sustainable. Further examination suggests that the central issues might be grouped under the six broad headings:

- Materials and Manufacture: supply-chain risk, life-cycle demands and recycle potential.
- Design: product function, performance and safety.
- Environment: energy efficiency, resource conservation, preserving clean air, water and land.
- Regulation: awareness of, and compliance with, National and International Agreements, Legislation, Directives, Restrictions and Agreements.
- Society: individual health, education, shelter, employment, equity and happiness.
- Economics: the cost of the project, and the benefits that it might provide.

This suggests the following way of analysing articulations of sustainable development. It has 5 steps (Figure 2). The first is a statement of Prime Objective, its scale and time envisage to achieve it (Step 1). Stakeholders are identified and their concerns listed (Step 2). These concerns are mapped onto a Fact-Finding search (Step 3) assembling data relevant to each of the headings listed above. This provides the background for a debate or discussion of the impact of these facts on Human, Natural and Manufactured capital (Step 4). The analysis ends with reflection on possible priority changes (Step 5). The first three steps are objective and deterministic; the last two are subjective, and therefore open to debate and creative thinking.

The methodology is applied during the course and it is articulated in order to facilitate discussion and debate about the interim and final results at class with stakeholders, faculty and other students. See figure 3 and table 1.

Table 1 shows the distribution of the five step methodology during the 12 weeks of the course. The table schedules the introduction of sustainable design strategies, the work related to the project that is realized in the classroom, the task to fulfil each week and finally the outcomes expected after the task are performed.

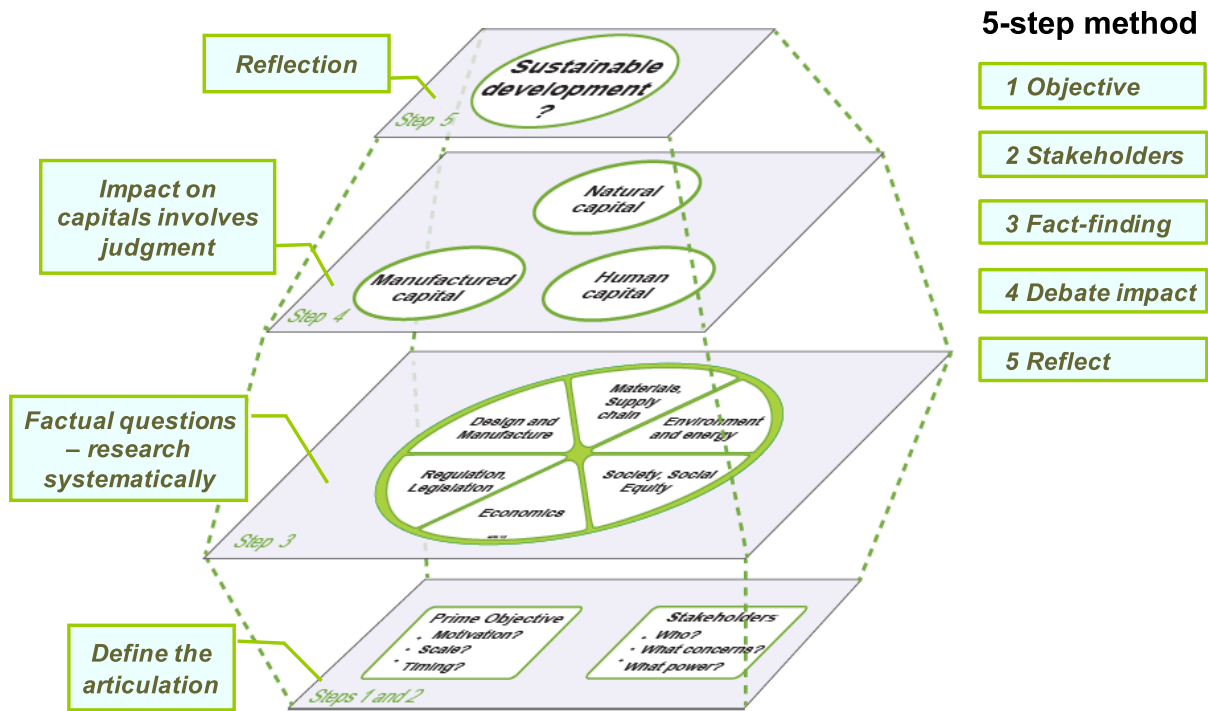


Figure 2. Methodology applied at Sustainable Design of Products and services course [3].

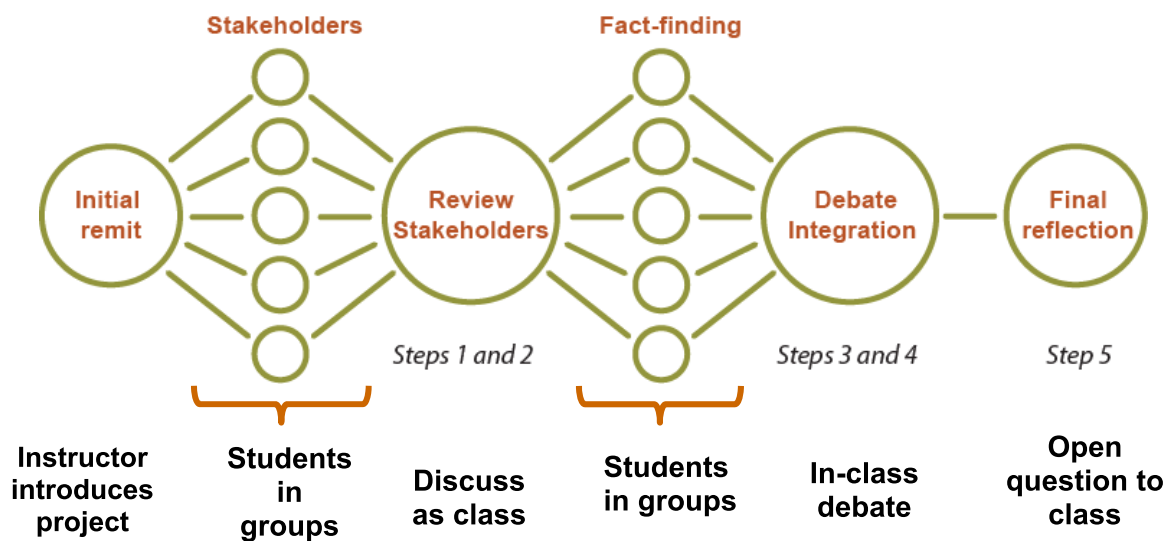


Figure 3. Articulation of the methodology facilitating discussion and debate [3].

To help with the fact finding step the sustainability database have been jointly designed with Granta Design [6]. The CES EduPack Sustainability Database is designed to support the teaching of sustainability at all levels of study. The database consists of seven interlinked data-tables. They provide the data needed for engineering design and for the eco-audit of products. The Sustainability Database allows materials to be traced back to their countries of origin and enables exploration of possible supply constraints. The data includes relevant legislation and regulations that bear on the use and disposal of materials. The information on price allows cost comparison of alternative design choices. Finally, the database allows the investigation of the economic, environmental and social profiles of the countries from which materials are

sourced or in which manufacturing takes place. (Figure 4).

Table 1. Distribution in time of the methodology

WEEK	Strategies	Project	Tasks	Outcome
W1		Sustainable Design Project Methodology	Grouping + Project selection	
W2	Eco-design	Presentation of Campus Lab CE projects		Project Selection
W3		Grand objective	Discuss the grand Objective	Definition of the Grand Objective
W4	Cradle to cradle + Biomimicry	Stakeholders	Stakeholders Definition and strategy for their assessment	Definition stakeholders and stakeholders analysis strategy
W5		CES SUST. DB	Discuss Stakeholders	Stakeholder analysis
W6	Product-Service systems		Fact finding with CES-SUST DB or other sources	
W7	Social design		Fact finding with CES-SUST DB or other sources	
W8		Fact finding	Discuss fact finding	Fact Finding analysis
W9	Design for sustainable behaviour		Integration: Grand Objective + Stakeholders analysis + Fact finding	
W10		Integration > Sustainability analysis	Discuss integration	Integration > Sustainability analysis
W11		Alternatives and Redesign proposals	Discuss alternatives / Prepare defence of the project	Sustainable analysis and alternatives.
W12		Project Presentations	Project defence	Sustainable design report and presentation.

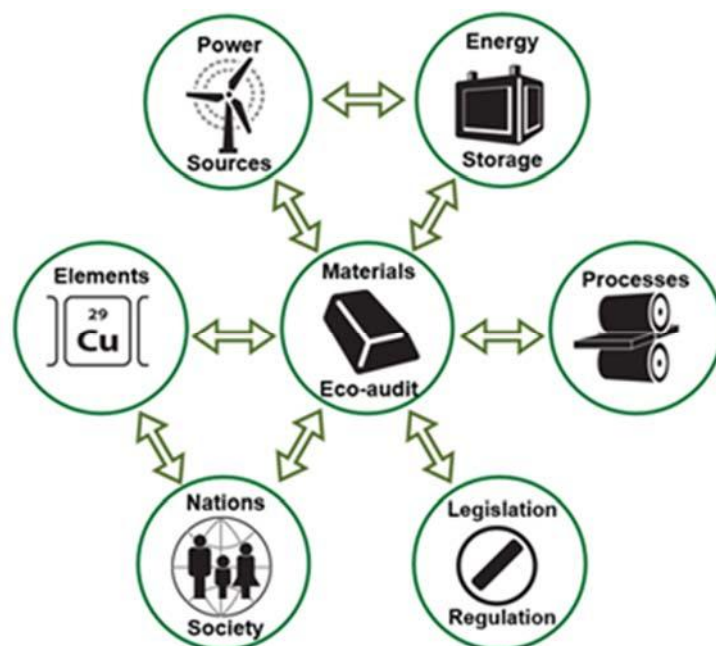


Figure 4. Interlinked data-tables of CES EduPack Sustainability Database tool [3].

The 5-step method and the SUSTAINABILITY database described here are contributions towards the difficult task of introducing students to the multi-dimensional aspects of Sustainable Development. It can be used for individual or for group projects. As a group activity, the role of a stakeholder and the responsibility for one fact-finding task can be assigned to each member of the group, the individuals research their assignment and report back to the group as a whole. This is then followed by a group “debate” seeking consensus on the impact of each of the fact-finding searches on the three capitals. The analysis as whole has a purpose and conclusions: while the underlying problem may be complex, it is important to report the result in a simple manner, making them accessible to non-experts.

At the end of the course, students were asked to give their opinion about the teaching method, the tools and their learning progress. The students appreciated the methodology as a holistic and practical approach to exploring sustainability. They commented that it gives guidance and focus while tackling the complexity of the task. They greatly appreciated the continuous feed-back from the teachers after each phase.

#### **4 CONCLUSIONS**

This paper has introduced a specific course in Sustainable Design of Products and Services (5 ECTS) at Master level at UPC Barcelona Tech. The author highlights that using community oriented and constructive learning approaches [3], where students work most of the time in real projects proposed by companies is crucial for sustainability education in general and specially in Sustainable Design education. Moreover, the five steps methodology here introduced, facilitates the sustainable holistic and systematic analysis of engineering projects where materials are relevant.

#### **5 ACKNOWLEDGMENTS**

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