# Ecodesign in Higher Education: Development of a Hands-on Toolkit to Support Integration of Ecodesign in Engineering Programmes

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#### Abstract

During the last decade, different initiatives have been taken in higher education to integrate sustainable development. This paper presents the results of a project on the integration of ecodesign in higher engineering education. Ecodesign is considered as a discipline that can strengthen the knowledge, skills and attitude of engineering students to deal with the growing complexity of sustainable development. Ecodesign is often integrated in design education. However, it also has a high relevance for engineering education, as people with different backgrounds work in the product development process spread over several departments within companies. The main goal of this project was to translate theoretical knowledge on the integration of ecodesign in higher education into a practical toolkit that can support, activate and inspire teaching staff in this integration process. The toolkit makes it possible to analyse the current state of ecodesign in the curriculum and to explore opportunities to integrate ecodesign aspects. It includes relevant subjects and teaching methods that support competences for sustainable development. The complete toolkit contains several parts: it includes a booklet with process guidelines and background information. Next to that, it entails a group of cards that offer information and inspiration on three subjects: ecodesign themes, teaching methods and examples from practice. The last elements of the toolkit are worksheets that can be used during active work sessions. Next to supporting, motivating and empowering teaching staff within engineering programmes to integrate ecodesign in their curriculum, the toolkit simultaneously increases their personal knowledge, skills and attitude towards ecodesign and their curriculum.

#### 1 Introduction

In recent years, the integration of sustainable development (SD) in higher education is receiving more attention. Different initiatives have been taken by higher education institutes (HEI) to integrate SD (Lozano, 2013). Some of those initiatives focus on the development of frameworks for integration (e.g. Lambrechts et al., 2009; Velazquez et al., 2006), whilst other researchers study success factors and barriers (e.g. Lozano et al., 2011; Wals, 2010). Several authors situate SD integration in higher education on different levels: education, research, outreach and operations (Lambrechts et al., 2009; Velazquez et al., 2006). A growing number of studies focus on the level of education, including curricula of educational programmes. Boks et al. (2006) for example describe the trajectory that has been followed to integrate SD in the curriculu of Industrial Design Engineering. Roorda (2010) studied the integration of SD in the curricula of several educational programmes of a HEI. Few studies focus on methods and tools to make SD integration in the curriculum more accessible and familiar for teaching staff (e.g. Ceulemans et al., 2010). The translation from available knowledge into a hands-on toolkit for teaching staff forms the challenge of the toolkit presented in this paper.

According to the definition of SD, it is the aim to 'meet the needs of the present without compromising

the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). Up to now, however, different authors state that there is still little agreement on what SD exactly means or how we can achieve it (Charter & Tischner, 2001; Dunphy et al., 2007). Sustainable design is a discipline that aims at supporting sustainable development by considering social, environmental and economic aspects during the design process of products and services. Whereas ecodesign can be described as a design activity that aims at minimising the ecological impacts of products and services by considering these impacts in decisions during the design process. It is considered as a discipline that can strengthen the knowledge, skills and attitude of students in higher education to deal with the growing complexity of product and service design for sustainable development. Figure 1 presents a framework as proposed by Charter and Tischner (2001) that shows the relationship between the different disciplines.



Figure 1 Relationship between ecodesign, sustainable design and SD, based on Charter and Tischner (2001)

Ecodesign is often integrated in design education. However, it also has a high relevance for engineering education. Boyle (2004) for example states that design and management of sustainable technology form important elements of the engineering context of sustainability, next to research into environmental and social impacts and management of resources from cradle to cradle. The interdisciplinary approach of a product development process also demands cooperation of several departments within companies: product development, marketing, production, purchasing, sales, research and management need to interact and cooperate in order to bring different knowledge domains together (Buijs & Valkenburg, 2005; Ulrich & Eppinger, 2008). When considering (environmental) sustainability issues, other departments also get involved, such as public relations, quality, health, safety & environment and social management (Maxwell & van der Vorst, 2003) or facility management, HR and legal services (Handfield et al., 2002). Knowledge on ecodesign is thus also relevant for higher educational programmes that deliver graduates to those departments involved in the product development process in companies. A limited qualitative study at the start of this project indicated two relevant groups of educational programmes: engineering programmes and applied economics and management related programmes. Based on the data, engineering programmes - and more specifically mechanical engineering education – came forward as the educational programme with the highest number of graduates getting involved in the product development process in business. Moreover, a low number of engineering programmes in Belgium did integrate ecodesign in their educational programme so far. With almost 8,000 students yearly, engineering education in Belgium forms the educational programme with high potential for ecodesign integration, which formed the focus of this project.

### 2 Development of a hands-on toolkit

The goal of this project was to develop a hands-on toolkit for engineering education that supports the integration of ecodesign in the educational programme. Theoretical knowledge on the integration of ecodesign in higher education is thereby translated into a practical toolkit that can support, motivate and inspire teaching staff in this integration process. A literature review provided a theoretical backbone on existing frameworks, methodologies, insights in competences for sustainable development, teaching methods, assessment methods, etc. Based on this theoretical background, an iterative process was followed to develop the hands-on toolkit. A transition was made from the theoretical knowledge into a first draft of the hands-on toolkit. In-depth interviews were taken from experts in sustainable development and ecodesign integration in education. Twelve experts cooperated from different Universities and University Colleges in Belgium and the Netherlands. The interviews were semi-structured and contained a) an introduction of the toolkit and its aims, b) an explanation of the concept of the toolkit, c) feedback on strengths and weaknesses of the toolkit, d) feedback on structure, content and terminology, and e) input concerning examples from practice. The insights and suggestions from the experts have been used as input for improvements of the second draft of the toolkit. In a next stage, the latest version of the toolkit has been verified in practice in a workshop. Participants were staff members from different engineering programmes in Flanders (Belgium). The results of the workshop have been incorporated and have led to the final version of the hands-on toolkit.

### 3 The 'Ecodesign in Higher Education'-toolkit

### 3.1 Materialisation of the EHE-kit

The Ecodesign in Higher Education (EHE)-toolkit forms the result of this project. The toolkit focuses on ecodesign in integration in the curriculum of engineering programmes in higher education and aims at making ecodesign integration more accessible and tangible for teaching staff. The complete toolkit contains several parts: it includes a guide with process guidelines and background information. Next to that, it entails a group of cards that offer information and inspiration on three subjects: ecodesign themes, teaching methods and examples from practice. The last elements of the toolkit are worksheets that can be used during active work sessions. A digital version of the toolkit (Dutch) is available online at <a href="http://www.ecodesignlink.be/nl/eho-kit">http://www.ecodesignlink.be/nl/eho-kit</a>. A printed version (Dutch) can be ordered for free.

#### Guide

The guide (Figures 2a and b) gives the users an introduction on the concept of the complete toolkit. In the first part, a general background is given on the relevance of ecodesign in higher education, as well as on the relations between ecodesign, sustainable design and sustainable development. The second part presents an integration model with different building blocks that all together can lead to the integration of ecodesign in higher education. These blocks are vision and mission of the educational programme, competences, curriculum, courses, learning content and teaching methods. Each of these building blocks are explained more in detail and linked with the integration of ecodesign in that building block. A third part '*At work'* proposes a workshop with a team of the teaching staff that focuses on a) an analysis of the presence of ecodesign themes in the current curriculum of the educational programme and b) opportunities for (further) integration of ecodesign in the curriculum.

The workshop forms an important part of the EHE-toolkit, as it makes the teaching staff reflect on their current curriculum and lets them think 'out of the box' about possible opportunities concerning ecodesign in their programme.



Figures 2a (left) and 2b (right) Guide with process guidelines and background information

# Cards

The cards contain specific and concise information on a workable format. There are three types of cards, each with a particular colour. This makes them easily recognisable and supports ease-of-use.

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Figure 3a (left). Example of an ecodesign theme - learning content card on 'system thinking' Figure 3b (right). Example of a teaching method card 'demonstration'

**Ecodesign themes** (Figure 3a): these cards describe several relevant themes related to ecodesign that can serve as learning content in the curriculum and its courses. Each card describes the theme, the most relevant references on the theme and the link to 'example from practice'-cards with that theme.

**Teaching methods** (Figure 3b): these cards describe activating teaching methods that can be used to integrate ecodesign in the educational programme. Each card describes the method, gives references to more detailed sources and a link to 'example from practice'-cards that use the teaching method.

**Examples from practice** (Figures 3c and d): these cards offer examples of ecodesign integration in engineering education. They can serve as inspiration for an educational programme. The examples are assembled from literature, based on experience of the team members and on input from experts. Each card describes the example, the ecodesign theme used, the applied teaching method, possible points of attention and a reference of the educational programme where the example has been applied.

Examples are available on all ecodesign themes included in the EHE-toolkit, combined with the different teaching methods.



Figures 3c (left) and 3d (right). Example of example card on 'product service system'

When using the cards, one can easily switch between different card types, e.g. from an example-card to a teaching-method card or ecodesign-theme card and vice versa. This makes it possible to use the toolkit starting from all perspectives.

### Worksheets

The work sheets are templates that can be used as a starting point in the workshop (see Guide). The toolkit provides a matrix template and an example card-template. The matrix template has predefined rows with the different ecodesign themes. During the workshop, the team can fill in the columns with the different courses from the curriculum in which ecodesign is or can be relevant. This matrix gets completed further throughout the workshop. Relevant ecodesign themes get indicated for each of the courses. Subsequently teaching methods are added. The three types of cards play a significant role to support and inspire the participants of the workshop. This way of working offers an overview of the current situation and of opportunities to (further) integrate ecodesign in the curriculum.

# 3.2 Concept of the EHE-kit

The concept of the EHE-toolkit is developed so that it informs, motivates and inspires teaching staff, whilst simultaneously raising awareness and connecting individuals. Moreover, it provides a bottomup approach, focuses on competence development and supports both horizontal and vertical integration of ecodesign in the curriculum. Each aspect is explained in more detail in the following paragraphs.

- **Inform**: many teachers are not familiar with the concept of ecodesign and in a broader sense with SD. This lack of knowledge is mentioned as an obstacle for integration of SD in the curriculum (Ceulemans et al., 2010). The toolkit offers information on the integration process, ecodesign themes that can serve as learning content and relevant teaching methods that introduce and support teachers in getting acquainted with ecodesign and its integration in education.
- Motivate: due to a number of obstacles, such as the multidisciplinary character of SD including ecodesign -, the misunderstanding of sustainability inclusion, the current workload of teachers and the fact that sustainability is not seen as a core issue (Lidgren, 2004), it is important to motivate teachers to integrate ecodesign in the curriculum. The toolkit starts from the current curriculum: the teachers scan the state-of-the art of ecodesign integration in the curriculum. This will give an

overview of what has already been done and offers space for improvements. It builds on the work previously done and the knowledge available, rather than starting from scratch. This will motivate the teachers and makes them aware of the concepts of ecodesign already linked to their curriculum. Moreover, this analysis makes it possible to improve ecodesign integration without raising the workload of the teachers, because it builds further on the existing curriculum.

- **Inspire**: many teachers are unaware of the meaning of SD to specific disciplines and for the need of SD integration in higher education (Lidgren, 2004; Peet et al., 2004). Inspiration is important to raise the awareness of teachers on the need for ecodesign in the curriculum. Inspiration also motivates teachers to engage in new topics. The EHE-toolkit offers inspiration in different ways. Almost thirty cards with examples from practice are provided. The other types of cards have the function to inform and inspire, as well as to raise awareness on the different ecodesign themes that are relevant for engineering education, and on different activating teaching methods that support competences for SD.
- **Connect**: teachers that do have an interest in or are committed to ecodesign are often the ones that integrate it in their course. Although these efforts are very valuable, it often stays with isolated courses or even specific classes on a chosen ecodesign theme. In order to bring the integration of ecodesign to a broader level within the curriculum, it is important to bring together a larger group or even the complete teaching staff. The EHE-kit proposes a workshop for the teaching staff and/or the educational board, where all participants work together on the analysis of the existing curriculum and support each other in the search for opportunities for improvements. The workshop makes it possible for the teachers and their courses to connect with others courses and/or opportunities for ecodesign integration in the educational programme. The example cards support connection between different HEIs. Many of the examples are provided by teachers working at several HEIs in Belgium and the Netherlands and include contact information.
- **Bottom-up approach**: the EHE-kit provides the option to work bottom-up with a group of teachers as well as top-down with the educational board. Although this is left open to the users, the authors believe that the bottom-up approach will lead to a curriculum that is better supported by the complete teaching staff. This is also indicated by Peet et al. (2004), who indicate in their study that 'top-down attempts to influence the content of courses often triggered resistance among lecturers, as they feared the intermingling of laymen into their scientific/engineering discipline.' Moreover, the approach empowers the teachers by keeping them in charge of their own course whilst it acknowledges the specifics of each subject, aspects that were indicated as important by the same authors.
- **Competences for SD**: a comparative study of Lambrechts et al. (2012) indicates six recurring competences for SD: responsibility, emotional intelligence, system thinking, future thinking, personal involvement and action-oriented skills. Teaching methods are needed that actively involve students with attaining these competences. These teaching methods should be interactive, participative, action-oriented and research-oriented (Lambrechts et al, 2009). A selection of such teaching methods is included in the EHE-kit.
- Horizontal versus vertical integration: SD and in this case ecodesign can be integrated in the curriculum in different manners. With a vertical integration, ecodesign gets integrated in the curriculum in one or more separate courses. When a horizontal integration approach is taken, one aims at interweaving ecodesign in different courses throughout the curriculum. Both integration approaches can be combined. Many authors are in favour of the horizontal or the combined approach, because it focuses on the interdisciplinarity and necessity of a systemic and holistic approach (Ceulemans et al., 2010, 2011; Peet et al., 2004). The EHE-kit introduces the different

integration methods and the workshop leaves the choice to the users. However, the authors are positive that the toolkit will support a horizontal or combined approach rather than a vertical one.

### 3.3 Verification in practice: workshop with teaching staff

A verification workshop with members of the teaching staff from several HEIs in Belgian was held to test a late draft version of the EHE-kit. An introduction on the toolkit was given to the group consisting of teachers, educational programme coordinators and SD coordinators from higher engineering education, followed by work sessions. In these sessions, two groups worked on the curriculum of one of the participants. This made it possible to verify the toolkit in practice, to get insights on how the users received the toolkit and if they understood the concept of the EHE-kit. The results of the workshop were very positive. There was a large enthusiasm of the participants, whereby many questions about the current curriculum led to a nice overview of the state-of-the-art of the two curricula used in the work sessions. The next step – brainstorming about improvements – was kept limited due to a lack of time in the workshop. A good time management thus forms a point of attention for future workshops. After the workshop, a feedback session provided us with the insights that a) the participants liked the way of working together in a team, whereby they participated all together in the process – even when it was not about their own curriculum – and b) connected to each other as well as to ecodesign and the curricula used. Based on the work sessions, a more detailed plan for the workshop was added in the Guide, with information on the composition of the team, the different steps of the workshop, and on how and when to use the different cards and worksheets. Feedback was also given on the accessibility of the toolkit, which led to the decision to provide both a printed version simultaneously accessible to more teachers - and a digital version of the tool - tangible toolkits improves ease-of-use and motivates users.

# 4 Conclusion

This paper presents the Ecodesign in Higher Education-toolkit. The complete toolkit aims at supporting, activating and empowering teaching staff within engineering programmes to integrate ecodesign in their curriculum. The toolkit offers an accessible way to actively think and discuss about the integration of ecodesign in the curriculum of the educational programme. The toolkit makes it possible to analyse the current state of ecodesign in the curriculum and to explore opportunities to integrate ecodesign aspects. It includes relevant subjects and teaching methods that support competences for sustainable development. Moreover, using the toolkit can increase awareness of and connectedness between the teaching staff, as well as it can extend the personal knowledge, skills and attitude of teachers towards ecodesign and their educational programme.

In order to further improve the toolkit, more testing needs to be done in several HEIs. Other future developments of the toolkit could explore different subjects within SD - such as social corporate responsibility -, or other educational programmes – e.g. applied economics and management programmes. In both cases, new themes need to be added and examples from practice need to get assembled. A translation to English would make the tool accessible on an international level. An important development that should not be neglected is to provide support on the application and implementation of the EHE-kit in higher education.

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