Chapter 10: Teaching

10.1 The teaching modules for Applied EcoDesign

From the very beginning teaching Applied EcoDesign has been high on my agenda. As a person who believes in 'action' and that 'practice will show the way', my courses and classes have been primarily based on practical experiences. From this perspective the science behind it has been built up.
The teaching materials that I have used developed as a function of time in a way similar to the development of Applied EcoDesign in general, see chapter 2.1.
It took many years of trial and before there was a comprehensive and consistent system in place. In the year 2000 I had a set of some 300 overhead sheets addressing EcoDesign, Environment and business, Benchmarking and Tools, Green Supply Chain Management, Recycling and Recycling Systems and General Items.
After the year 2000 the number of teaching modules and their extensions were expanded substantially. Particularly in the fields of Environment and Business and Recycling and Recycling Systems (chapters 7 and 8), a lot of material has been added.
In the year 2002 all materials were consolidated on one CD (which is still available on request from ranta@xs4all.nl). For this purpose it was necessary to put all presentations in an electronic version; until that moment overhead sheets were primarily used.
In 2006-2007 a completely new update of the teaching modules was developed. The most important additions include here: EcoDesign/Ecovalue (chapter 2), Organizing Take Back and Recycling (chapter 8), Legislation (chapter 9) and China (chapter 11).
Digitization of all the teaching material makes further extensions easier. More importantly it allows tailoring the teaching to specific needs. For preparing any training course, seminar or presentation today the procedure is as follows :
1. Presentation materials are continuously updated and extended according to latest research results and publications/presentations.
2. The organizer specifies subjects, time schedule of the training and learning goals.
3. Presentations are put together from the database including specific additions for the training.
4. Materials (presentations, reading material) are sent to the organizer.
5. The training/seminar is executed.

This approach has proven very satisfactory for preparing technically and business oriented training sessions. Completely new training modules had to be set up to include legal aspects. These include today:

- Recycling (the European and Chinese WEEE Directives):
  - The technical/scientific perspective
  - The system organization and compliance perspective
  - The rule interpretation/rule improvement perspective
- Potential toxic ('hazardous') substances (the European and Chinese RoHS Directives/laws):
  - The technical perspective
  - Lead free soldering
  - Chemical analysis
- EcoDesign in general (the European EuP Directive):
  - Positioning of EuP in design for functionality/EcoDesign
  - Making of environmental profiles and environmental validation
  - Interpretation of EuP
  - Best ways to implement EuP

Orientation of these seminars is to serve the intent of the Directives and Laws in the best possible (Eco-efficient) way. Focus is therefore on compliance in this case and not on pro-activeness. From a perspective of need this is understandable, from a perspective of moving forward environment really, it is far from the best. It is however the reality of life!

General teaching experiences involving EcoDesign, and in particular EcoDesign for competitive advantage, are described in the publication *"Teaching Modules On EcoDesign For Competitive Advantage"*. It was written in 2001, but most conclusions – both from the learning and the teaching perspective - are still very much relevant today. In the article it is demonstrated that with a practice oriented approach high 'take home value' for the participants can be produced.

Teaching Modules On EcoDesign For Competitive Advantage

Ab Stevels

Abstract

With Design for Environment having become a business issue affecting all parts of the value chain, the need for teaching and training of industrial as well as academic and other audiences is clear. At Philips Consumer Electronics and Delft University of Technology a comprehensive set of teaching modules has been developed addressing all relevant aspects of EcoDesign, including technicalities as well practicalities, ways to improve, experiences with implementation, how to deal with stakeholders, et cetera. The present paper gives a broad overview of available teaching material. Also, the importance of how to address the various audiences (designers, managers, students etc.) is stressed. Based on experiences with teaching applied EcoDesign, conditions for successful implementation of EcoDesign strategies are formulated.

Keywords: *Design for Environment, Design Education, Environmental Benchmarking, Take-back and recycling, Environmental validation*

1. Introduction

The concept of EcoDesign (or Design for Environment) has grown substantially in the last ten years. Once seen as a technical activity concerning materials, energy and end-of-life aspects it has moved now upstream (supplier relationships), downstream (green marketing and sales) to a strategic level (competitive advantage through 'green') and into the wider context of societal responsibility. EcoDesign has therefore become a business issue that affects all parts of the value chain. A successful EcoDesign program therefore requires therefore a cross functional approach. Being a business issue also mandates that the drivers for it need to be carefully examined. This means that apart from environment as such, customers' attitudes, legislation/regulation and cost, quality issues must also be addressed. Scoring well in 'green' is therefore not only scoring well in 'scientific green' but also in 'government

green', 'customer green' (perceptions) and Eco-efficiency. The multitude of activities that nowadays are included in EcoDesign need to be supported by all kinds of tools. They are now available in abundance and careful selection seems more urgent than increasing their numbers further.
The underlying idea of EcoDesign is a paradigm shift: think in terms of functionality rather than in embodiments. Present technological developments (digitalisation, miniaturisation, more powerful ICs) enhance this functionality thinking further. The natural result of this is that creativity in EcoDesign is gaining more importance. This also holds for moving into higher levels of EcoDesign. Practical efforts should take place mainly at an improvement level. The best is to start on the basis of proven technology but to exploit it more successfully than it was before. In a later stage - by considering latest technological developments in more depth - radical redesigns and product alternatives (both exploiting other physical principles and by replacing products by services) can be much better addressed.
The developments in the field of EcoDesign as described above have far reaching consequences for teaching and training, both in terms of content and in terms of audiences.

2. Development of the teaching modules

As soon as EcoDesign activities were initiated at Philips Consumer Electronics the need to include training and teaching in the program was felt. In the very beginning it was decided that these activities should be focussed on implementation in an industrial organisation in the electronics business. As starting points the mandatory design rules and the Environmental Design Manual already in place were taken. To this the more conceptual approach of the Design for Environment Class 211 at Delft University of Technology and the PROMISE (a promising approach to sustainable production and consumption) EcoDesign handbook [1] were added. The teaching material has been organised in modules, which take 50-80 minutes to present. To each module (see §3) extension modules were added which elaborate on items in the module. Apart from the modular structure a principle was established that each year the modules should be updated and revised. Content wise the teaching modules embody four chief elements:
1. Teaching material should be primarily derived from experiences in the company itself (in this case Philips Consumer Electronics). Teaching material that originates from work in academic institutes is only incorporated when it has been tested with respect to robustness and practicality.
2. Wording and language used should be the one of the user. Therefore, teaching material should be primarily concentrated at the five environmental focal areas which constitute easily understandable items: energy, material application, packaging and transport, substances and end-of-life/recyclability. The life cycle principle should be introduced later, rather as a check for overall performance than as a starting point. This approach also includes a primary focus on internal environmental effects, that is on items which can be influenced by the company. Subsequently, it should include the external effects, addressing items which contribute to the overall environmental effect over a product life cycle but that cannot be directly influenced by the company. For instance electronics companies can influence the electricity consumption of their products through design, however not influence the environmental load of generating electricity.
3. Chief targets of the training are to assist participants in:

- Becoming better than the competition in their environmental performance
- Combining environmental improvement and cost reduction and/or quality increase
- Achieving proactivity in compliance with regulation/legislation

4. The training should also contribute to the strategic and commercial dimensions of 'green':

- Assist in making appropriate strategies and roadmaps
- Foster creativity and test 'green' options so that they can be incorporated into product concepts and product specifications
- Prepare for green marketing and sales campaigns

The basis of all this should be self empowerment; employees should become self propelled on environmental issues without the need to be continuously supported by environmental specialists from inside or outside the company.

3. Survey of teaching modules

Below an overview of the main and extended teaching modules is given, followed by a short description of the content of each of the main modules. For each item, the year in which the module was first developed and used is given. This clearly illustrates the developments in EcoDesign that took place in the past decennium:

- From 'technical' to 'business'
- From 'defensive' to 'proactive'
- From 'standalone' to 'integrated'
- From 'absolute scores' to 'being better than the competition'.

The present list of teaching modules is given in Table 1.

Table 1: Overview of teaching modules for EcoDesign.

Teaching Modules	**First year of use**	**Module extensions**	**First year of use**
1. Introduction to EcoDesign	1995	- Levels in EcoDesign	1997
2. Environment and Business			
2.1 Vision, Strategy, Roadmap	1998	- How to make money with 'green'	1999
		- Roadmap details	2000
		- Stakeholder issues	1999
		- Environmental Performance Indicators	2001
		- Environmental Value	2001
2.2 Environmental Programs	1998	- Green Flagships	1999
		- Environmental Value Chains	1999
		- Score Cards	2000
		- Product Environmental Care	2001
		- Five ways to make money with green	2000
2.3 Experiences in Environment and Business	2000	- Green at department level	1997
		- How to operate design manuals	1996
		- Green projects	1996
		- Moving towards Sustainability	1998
		- Modern EcoDesign	2000
3. Benchmarking, validation and creativity			
3.1 Environmental Benchmarking	1998	- Benchmark Audio Systems	1998
		- Benchmark Monitors	1997
		- Benchmarking Communication Equipment	1999
		- Benchmark TV sets	2000
		- LCD vs. CRT monitors	2000
		- Benchmark DVDs	2001
3.2 Environmental Validation	1997	- Environmental Weight	1996
		- LCA Applications	1998
		- Life Cycle Cost	1997
		- Industrial Applications of the EcoIndicator	1999
3.3 STRETCH	1997	- Durability	1997
		- Replacement behaviour	1998
		- Human power applications	1999
		- How to prepare for green 2010	2000
		- TV refurbishment	2001

4. Disassembly Session	1996	- Disassembly times	2000
5. How to Improve			
5.1 Energy Consumption	1995		
5.2 Material Application	1996	- Material Science and EcoDesign	1998
5.3 Packaging and Transport	1994		
5.4 Chemical Content	1994	- Potential Toxicity	2001
6. Suppliers			
6.1 Supplier Requirements	1996	- EcoQuest	1998
6.2 Supply cost and green	1999	- Supplier benchmarking	2001
6.3 Suppliers and EcoDesign	1998	- Reverse supply chains	1999
7. Green Marketing and Sales	1997	- Eco labels - Green marketing II	1996 2001
8. Take-back and recycling			
8.1 Generalities of Take-back	1998	- Eco-efficiency of take-back - Producer responsibility - Roadmap for take-back - Recyclability definitions - Experiences with take-back in NL	1998 1996 1997 2000 2001
8.2 Technicalities of End-of-life	1997	- Design for non-disassembly - Plastics recycling - Glass recycling - Design for End-of-life - Lessons learned from 10 years of take-back and recycling	1998 1996 1996 2000 2000
8.3 How to make product-specific EOL strategies	1997	- Take-back and product characteristics - Business case recycling - Env. uncertainty in EOL scenarios - Weighted Recyclability Quotes - ELDA - ELSEIM	1996 1998 2001 1998 2000 2001
8.4 End-of-life design rules	1996	- Design evaluation based on end-of-life cost	1996
9. What is happening in the world			
9.1 Europe	1998	- Learning from EOL discussions in Europe - WEEE - EEE and IPP - Effectiveness of Regulation	1999 2000 2001 2001
9.2 Japan	1999	- Lead-free soldering	2000
9.3 USA	1999	- USA 2000	2000

- Module 1, **Introduction to EcoDesign** explains first of all the differences between environmental care for products and environmental care for processes. Furthermore the interrelationships of EcoDesign with other stakeholders (customers, society) are shown with help from the 'green circle'. The drivers to EcoDesign and the various type of 'green' (scientific, governmental, perceptions) are examined. Also the different levels of EcoDesign (improvement, radical redesign, product alternatives and sustainable systems) are explained.

- Module 2, **Environment and Business** considers the managerial aspects of making money while being 'green'. This includes both the avenues of vision, policy, strategy and roadmaps (module 2.1) as well as organising the processes of idea generation, product creation and validation and green marketing and sales.
- Module 2.2, **Environmental Programs** describes how to move from defensive to proactive actions, while developing parallel programs to reduce costs.
- Module 2.3, **Experiences in Environment and Business** analyses the conditions under which environmental programs will be successful or will fail. Internal factors, business conditions, external pressure, room to manoeuvre have turned out to be the chief determinants.
- Module 3.1, **Environmental Benchmarking** teaches the approach to be taken in this field. Five focal areas: Energy, Material application, Packaging and Transport, Chemical Content and recyclability need to be addressed as well as the Life Cycle perspective.
- Module 3.2, **Environmental Validation** explains how validation methods work from a business perspective. Methods include common sense, factor methods, Life Cycle Analysis, Life Cycle Cost and various methods tailored to specific areas. The applicability of the methods is reviewed from a practical perspective as well as from the different 'green' perspectives (scientific, governmental and perception).
- Module 3.3, **STRETCH** (selection of strategic environmental challenges), is a brainstorming technique to systematically generate ideas for radical environmental improvement. It is shown how this technique works and how ideas generated in this way can fit be aligned with business objectives.
- Module 4 consists of a **disassembly session** which is a way to organise do-it-yourself disassembly by participant groups. In three hours time a quick environmental analysis is done for the chosen products and the first set improvement options are generated.
- Module 5.1, **How to improve Energy Consumption** teaches from a practical perspective how to make this work. Chief approaches are roadmaps with suppliers, internal energy analysis, intelligent catalogue work, and specifically addressing battery issues.
- Module 5.2 shows that for improving **Material Application** similar paths can be followed. Main elements here include: design review, specification tightening, materials substitution and detailed examination of surface treatments.
- Module 5.3, **How to improve Packaging and Transport** looks primarily at the different functions of packaging and transport; through parallel environmental and economical analysis priorities are set. These are subsequently related to eight main strategies for improvement.
- Module 5.4, **How to improve chemical content**, digs deep into the different definitions of hazardousness and environmental relevance. In relation to this a two–tier approach is presented for chemical content improvement. The first part deals with how to eliminate of "banned" substances. The second part is about reducing environmentally relevant substances.
- Module 6 is about improving the environment through **Supplier** Relationships. For the different types of suppliers, effective approaches are presented ranging from checklists for jobbers, best practice process management for component suppliers to joint roadmaps and EcoDesign for key suppliers.
- Module 7 addresses **Green Marketing and Sales**. On the basis of seven archetypes of consumer orientation it is shown that 'green' as such does not sell. However by linking to other benefits (material, immaterial and emotional) 'green' can become a strong business asset. 'Green' communication strategies are taught to be strongly dependent on the type of audience. Generally speaking image items are more important than technical achievements.
- Module 8.1 describes the **generalities of take back** and recycling systems. Subsequently political, industrial, financial and environmental perspectives are discussed. On the basis of the stakeholder communalities an item agenda is developed. Ways and means to bridge the gaps between the various stakeholders are demonstrated.
- Module 8.2 reviews **the technicalities of end of life**. After presenting the various treatments possibilities, these are discussed in more detail, particularly disassembly and mechanical treatments. An overview of material compatibilities in recycling forms the basis for the cost and yield tables presented.

- Module 8.3 shows **how to make optimal end of life strategies** for individual products. This can be done by taking into account product characteristics, form of ownership, reasons for discarding, supplier relations, age of products coming back and the legislation and regulation currently in place.
- Module 8.4 gives an overview of **end-of-life design rules** and their applicability.
- In module 9, actual developments in "greening" of the electronics industry in Europe (module 9.1), Japan (module 9.2) and the USA (module 9.3) are reviewed.

The audiences for which the teaching modules are intended are summarised in Table 2.

Table 2: Relevance of teaching modules for various audiences.

Audiences	**Teaching module number**								
Academia	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
- Design	√	√	√	√	√	√		√	
- Engineering	√	√	√	√	√			√	
- Business	√	√				√	√	√	√
Industry									
- Strategic management	√	√				√	√	√	√
- Product management	√	√	√	√		√	√	√	√
- Purchasing	√	√			√	√			
- Development	√	√	√	√	√	√		√	
- Production	√	√		√		√			
- Sales	√	√	√				√	√	√
- Quality	√	√	√			√		√	√
- Environment	√	√	√	√	√	√	√	√	√

This table shows that the teaching modules aim at a very wide audience, both in academia and industry and to a wide variety of professional backgrounds. Module 1 and 2 form the common platform for all participants. All other modules have been set up in such a way that they are of interest to at least half of the group they were intended for.

4. Experiences from teaching EcoDesign for Competitive Advantage

The modules and their extensions as described in sections 3 and 4 have been used to do a variety of training, seminars and brainstorms inside Philips Consumer Electronics: programs lasted from 1 hour up to 3 days depending on demand and on opportunity. The material has also been used for similar activities at the corporate level of Royal Philips Electronics.

An important part of its application has also been in academia. Classes and courses have been held at Delft University of Technology in the Netherlands (where the author has the part-time chair of Applied EcoDesign), Stanford University, USA (where the author has been a visiting professor in 1999), TU Berlin (Germany), TU Vienna (Austria), Georgia Tech (Atlanta, Georgia, USA), Hong Kong Polytechnic and National University of Mexico.

Part of the material has also been presented at international conferences like ISEE (USA), CIRP Life Cycle Engineering conferences (international), CARE conferences (Europe) and EcoDesign conferences of various backgrounds. Sizes of groups addressed varied between 5 and 200 persons. When evaluating feedback, the practical approach is highly rated; particularly the learning-by-doing-it-yourself method of the disassembly session (module 4), which consistently gets very high marks.

4.1 Experiences from the course participants' perspective

Based on the feedback received from the various participants that have attended the courses outlined above, it has become clear that learning experiences consist of two specific types, namely the practical and conceptual learning. For the various modules they are as explained in Table 3.

Table 3: Chief learning's from the teaching modules.

Teaching Module	Chief practical learning	Chief conceptual learning
1. Introduction to EcoDesign	EcoDesign can bring money, synergetic effects are abundant. It is also cross-functional, it relates to various disciplines other than design or engineering, including for example finance, marketing, social sciences	The ability to analyse drivers for EcoDesign, and to understand and analyse different types of 'green' (industrial, scientific, political)
2.1 Vision, Strategy, Roadmap	Processes to operate and implement EcoDesign in industry	The need for vision and strategy, and for cross-functionality
2.2 Environmental Programs	Learning to think and act, changing from a defensive attitude to a proactive one	Separate idea generation and validation to enhance creativity
2.3 Experiences in Environment and Business	Addressing the internal value chain within companies is imperative to getting things accomplished	The understanding that generic processes apply, but that tailor-made solutions are strongly preferred
3.1 Environmental Benchmarking	Evidence proves that big design differences exist for the same functionality. No product ever scores best on all criteria.	Fact-finding and metrics for fact interpretation are the basis of many EcoDesign activities
3.2 Environmental Validation	The importance of separating internal and external effects, the importance of properly addressing various audiences using appropriate languages	There are much more tools than LCA. LCA is to be used for scientific validation rather that creating environmental improvement options
3.3 STRETCH	Thinking out of the box	Functionality should be the driver for design instead of embodiment
4. Disassembly Session	Reveals low hanging fruit, enables the instant generation of ideas for environmental performance improvement, creates commitment with participants	Practice shows the way, knowing about your products enables you to substantiate your own claims and respond to hostile claims
5.1 Energy Consumption	The need for roadmaps becomes apparent	The importance of energy analysis as this is often a main contributor to environmental impacts
5.2 Material Application	Like with the disassembly session it becomes evident that potential for improvement is large	The revealing of opportunities for alternative solutions, the elimination of narrow-minded design histories within companies
5.3 Packaging and Transport	This creates almost always a win-win situation for environment and general business activities	Straightforward approaches exists to accomplish these improvements
5.4 Chemical Content	How to make and implement substance lists	The issue is very complex, affects many stakeholders, but needs to be dealt with

6. Suppliers	How to cooperate creatively, how to vertically integrate in the supply chain, how to know better about your products	The importance of implementing environmental care systems that stretch beyond the OEM
7. Green Marketing and Sales	How to link 'green' and other benefits for communication with customers	'Green' as such does not automatically sell
8.1 Generalities of Take-back	The importance of negotiation agendas	The understanding that this is mainly a political issue, but that it is affected by a considerable amount of emotion
8.2 Technicalities of End-of-life	To be able to assess yields and costs of products in the end-of-life stage	Different value chains, the interests of OEMs, recyclers and legislations are often different
8.3 How to make product-specific EOL strategies	The importance of linking end-of-life issues with product characteristics	Only tailor-made solutions will survive in the end

4.2 Experiences from the teaching perspective

From the teaching perspective the most important lesson I learned was to keep it as simple as possible. Environmental items, irrespective of their nature, are easily taken on board by a variety of audiences when presented in an honest and straightforward manner with an emphasis on "what to do when back home". It is of particular importance to show practical examples from 'real life' in which it is shown that people with whom the audience can identify itself have done a great job.

Since most of the participants of the training course are not environmental specialists and never will be, it is also important to avoid esoteric environmental language. For the teacher it is important to put him or herself 'in the shoes' of the recipient of the messages including mindset, cultural background and profession. This experience allows for the conclusion that the content of teaching EcoDesign for Competitive Advantage is of a generic nature, but that the way this content is taught should be very specific ('tailor-made').

A further observation is that although audiences on the courses are generally highly motivated and eager to learn and get results, there are also a lot of preset ideas when entering the course. These include:

- "Environment is something technical"
- "Environment will always cost money in the end"
- "Environment should be a kind of corporate activity, not for us here"
- "Environment is nice but does not rank high on the business agenda etc"

It is therefore crucial to address such issues at the very beginning of the classes and to ensure that the participants are convinced that the reservations they (or their classmates) might have are dealt with either earlier of later in the training course.

What turned out to be very important were "the learning by doing" or "self-discovery" experiences. Disassembly sessions on products developed, manufactured and sold by the organisation hosting the course were highly instrumental towards achieving this effect. Also having participants fill out forms and do some simple calculations themselves turned out to be very beneficial for meeting the learning targets. By doing so the overall picture emerges before them and for drawing conclusions they can easily refer to details, which have been jotted down earlier. Such processes turn out to yield far more creativity than feeding data into software programmes – this will produce fast and accurate results but creates less insight.

A further teaching experience is drawn from the issue "what to do back home, how to set priorities in the environmental field". Most of the time participants leave the training courses with a wealth of ideas and insights – when they are back at their jobs the usual day to day worries take over and little time is left to address the lessons learned. It is of crucial importance to help in prioritising the actions to be taken – in this way the scarce time available is used efficiently. When this produces results, the effect will be that of a multiplier: more time will arise

or be made available and the standing of environmental issues in the department where the course participant is working will increase.

5. Achieving the desired learning; the future of EcoDesign teaching

The modular set-up of the training curriculum, its regular updates, and the addition of new modules has ensured that in ten years the dynamic development of EcoDesign [2] has been able to achieve the desired learning goals in each of the stages (see §3). Although the basic structure of the course has not changed substantially as a function of time, the centre of gravity of EcoDesign teaching has gradually moved.

In the start up period, in the early nineties, modules 1 (what is EcoDesign) and 5 (how to do it) were the most important. When more structured approaches were introduced in the mid nineties modules 3 (benchmark, brainstorm, validation) and 4 (exercises) gained in importance. Business integration of EcoDesign, starting in 1997 – 1998 meant that module 2 (environmental business) and 7 (green marketing and sales) became very relevant for the internal value chain, whereas 6 (suppliers) and 8 (take back and recycling) did so for the external value chain. Currently, EcoDesign is seen more and more in a wider societal context. This means that module 9 (what is happening in the regions of the world) has gained substantial priority.

A further evolution will be that the EcoDesign will go beyond the limits of individual companies. Product design will be a part of system design as a whole. This will require more intensive interplay of companies (business coalition building) and stakeholders in general. The first experiences in "system design" are now trickling in and this will add new chapters to the teaching module kit, for instance on:

- EcoDesign coalition building.
- Infrastructure and EcoDesign.
- Cultural impacts of EcoDesign systems.
- Corporate governance (triple bottom line) and EcoDesign.

6. Conditions for success for EcoDesign teaching

The conditions for successful teaching of EcoDesign depend not only on the content (see §3) and the way it is taught (see §4) but also of a number of internal and external circumstances related to the company. These include:

- Internal company culture. This is chiefly the way environment is perceived by the various participants in the internal value chain (management, development, production, marketing and sales, purchasing, logistics). Generally speaking people have a positive perception towards environmental topics but business perception varies widely; from threat to opportunity; from a cost factor to a potential source of profit; from a business enhancement to a complication etc. Attitudes can be improved by bottom-up processes, for instance by environmental management, but in the end top-down action is needed as well, particularly when different corporate (sub)cultures exist.
- Business conditions. Depending on whether business is profitable (or loss making), is expanding (or restructuring) has ethical drivers (or not), interest in EcoDesign and EcoDesign teaching will be greater of smaller. In the last ten years it has been observed to fluctuate widely both as a function of time but also per decision or with each business unit within one company.
- Presence of outside pressures for instance from customers, governments of NGOs.
- Competitors. In the electronic industry EcoDesign performance of competitors has been a strong driver in the last decade.

7. Conclusions

On the basis of practical experiences is Philips Consumer Electronics and conceptual inputs from the Design for Sustainability Group of the Faculty of Industrial Design Engineering at Delft University of Technology a comprehensive set of EcoDesign teaching modules has been developed. These teaching modules have been used for teaching a variety of audiences in industry, academia and at international conferences.

The evaluation of the learning results, throughout training, shows substantial self-empowerment of participants,

both in terms of practicalities and conceptual items. Important learning experiences have also been obtained from the teaching perspective. Simplicity, tailoring to participants values and learning by doing are key ideas here. The modular set up of the EcoDesign training courses has ensured that its flexibile content and emphasis could be easily adapted to changing circumstances. Conditions for the success of EcoDesign training include corporate culture, business conditions, external pressures, competition behaviour and perceived benefits of the participant.

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Cities, 14

Trondheim, the inspiration of nature

Trondheim is 600 km north of Oslo at 62° latitude. It is the centre of research in Norway and the town is full of scholars and students. Although it has approximately 150,000 inhabitants it is quiet; the population is spread over a large area. This means that nature is close by wherever you live in town. The workday starts early (08:00) and ends early (16:00, in summer 15:00). This means that you have plenty of opportunity to do outdoor activities. In spite of its latitude, the weather in Trondheim is mild with relatively little rain.

When we were living in Trondheim (Aug-Nov 2003), such opportunities were taken advantage of as much as possible, such as walking every day and being out on weekend trips to the countryside.

The atmosphere at the Institute of Industrial Ecology (Indecol) was inspiring, a lot of new ideas were generated through all kinds of in-depth discussions. This institute is doing excellent work, which deserves to be known better in the world. It is a great environment to rethink Ecodesign and other environmental activities.

Nature contributes too, through long walks to little villages tucked away in marshy woodlands, hills, mountains but most of all the fjells. You can roam for hours, and be impressed by the variety of colors in green, grey and black. You can struggle with the wind and rain, and see new horizons.

An exceptional highlight was a 2-hour spell of Northern Lights over Trondheim in November, 2003. I described it as follows in the Indecol newsletter: standing, and after some time sitting, in the early snow on the lawn in front of the university building (which is on a hill above town), looking to the skies over town where this wild 'game of green' was on display for almost two hours. People next to us told me, ''the best in twenty years.'' That was really what it was in a broader sense for us too!

Trondheim, jeg vil komme tilbake!

City walk: Start at Trondheim Central Station; cross the Jernbanebrua and go right to Fjordgata to Ravinkloa. Proceed through Munkegata all the way to the Nidarosdom. Go through the Erkebispegarden and cross the Nidelva river through Elgeseter bridge. Go left to Klostergata and climb up to the building of the NTN University. Go the same way back, but now walk through Vollabakken and Øvre Bakkelandet. Cross the Nidelva through the Bybrua and go right on Køpmannsgata,go L to Dronningsgata and go R through Søndre Gata and back to the Station.

Favorite Restaurant: Bakkelands Skyddshuset, Øvre Bakkelandet.

Favorite Pub: Den Gode Nabo, near Bakkebru.

Country walk: Take the tramway from the city centre to Lian. Walk from there to Grønlia and Elgesethytta. Go back from there to Skistua, follow the paved road from there and go R at the second parking, back to Lian again.

10.2 Teaching Applied EcoDesign in Academia

10.2.1 Organizational and financial issues

It has been a hard fight to get Applied EcoDesign appropriately positioned in the teaching curriculum and in the research programs. This is because it is CROSSFUNCTIONAL and therefore it is at odds with the traditional university structure.

At TUDelft, Faculties (this is the continental European name for 'Schools') are not only organizationally separate, but also mentally separate. Faculty members usually consider themselves to be (vastly) different from the other faculties. Faculties are split into departments, departments have sections and finally sections have individual chairs. The idea that each chair should represent a 'discipline' is widespread and working together with other 'disciplines' is an issue. At Industrial Design Engineering in Delft (IDE) it is a big issue, although it is imperative today it should be natural that such territorial instincts are over. Simultaneously it is to be realized that the universities of today the time for brilliant individuals is over: it is all group work and groups need a certain minimum size to ensure continuity and to have a chance to become world class. Fragmentation is the best guarantee of mediocrity.

At TUDelft time for individuals is also over in a different way; the 'collegial ' principle among professors has been abolished by law. Collegiality meant that each of the chairs were responsible for all of its affairs. The great thing about this is that each professor can manage their activities very efficiently. However, if this is not done in a proper way, there were few possibilities for correction.

Instead of enhancing mechanisms for such corrections a completely new hierarchical system has been introduced. Currently a professor in Delft has to deal with a section leader, a department head and a Dean which are supposed to be his bosses. Management teams assist these persons to deal with the numerous plans that must be submitted, procedures followed and approvals to be obtained. Instead of a lean and mean system in which the performance of professors can be checked with regards to output and finances a huge bureaucracy has been developed. Professors at universities are no saints, but this institutionalized distrust worries me as a Dutch taxpayer. This applies not only for Delft, at other Dutch universities the same problem exist.

The situation is aggravated by the financial system which is in place in the Netherlands. Universities still get money from the State (at TUDelft some 80% of the University's budget; at IDE more than 90% is coming from this money stream). It is distributed over the Faculties according to a certain formula (which is regularly 'updated', in my opinion to consolidate status quo rather than to reward success). Faculties distribute money to the departments in a similar way. Both inside a Faculty and a department a policy to invest more in successful activities and to reduce budgets for other ones does not exist. In practice the opposite happens, the surpluses generated by successes are used to cover deficits elsewhere.

The Design for Sustainability Group (DfS) has existed now in its present form for eight years in a Faculty (a School) which has been in place for some forty years. The tradition of the University as a whole goes back some hundred and sixty years. In practice this simply means that the IDE Faculty, including DfS, is simply on the wrong side of the equation. The only chance for financial survival is therefore to go for money provided by third parties; in this respect DfS has been pretty successful. In practice this circumstance is very stimulating. However it means that the more fundamental research questions cannot be addressed.

A part-time chair representing cross functional engineering activities, has to fight even harder. It would be most obvious to integrate applied EcoDesign into the existing programs and courses inside and outside the Faculty like Design Engineering, Mechanical & Electrical Engineering, Materials Science, Economics, Social Sciences, etc. This did not happen, the mental and administrative barriers simply prevent this.

It was even difficult to get a place in the mandatory sophomore class on Design for Sustainability. It took an assistant professor with very specific 'Ecobelief' to retire to get Applied EcoDesign appropriately on board.

Altogether the conclusion is that the most satisfactory way to operate is to run separate research programs and to give specific elective courses. As a part-time professor this is not preferred, but in practice it is the best means of survival; run your own show without being bothered by all kinds of 'blood group thinking' and endless fights about money.

Pictures, 14

Nisse, Zeeland, NL, the tower of the Dutch Reformed Church.
"They will rest from their labor, their deeds will follow them" (Relevations 14:13)

10.2.2 The Applied EcoDesign Classes

For IDE, two courses have been developed, each with seven sessions:

Applied EcoDesign (AE)	Environment and business (EB)
Introduction to Applied EcoDesign	Introduction into Environment & Business
Basics of AE and how it can be organized	Strategy, roadmap, and measurement of performance
AE and energy reduction	Integration of green into Product Creation Processes
AE and Material application	Green supply chain management
AE and Packaging/Transport	Green marketing and communication
AE and Take-back/Recycling	How to organize for legal compliance

Both classes are internet based which makes it more flexible for the participants and allows interaction between the participants themselves and the lecturers.
Apart from participation in the sessions, students should also take an active part in the proceedings.
For Applied EcoDesign this is a disassembly session. Groups of students (3-4) should take apart an electronic product and do a functionality/user friendliness analysis and measure basic technical and 'green' parameters (benchmark, see chapter 6.3). On top of the group report, each individual should come up with a report with suggestions for improvement including a prioritization according to the EcoDesign matrix. Apart from this the final exam includes an essay about a subject chosen by themselves (but related to the course material), and five questions.
For Environment and Business the approach is different. Here the Sustainability Report of four electronic companies is the material to be studied. Before each session students review reports for discussion, for instance what is mentioned (or not mentioned) about it, how companies are doing in respect to each other etc. At least one proposition has to be formulated and put on the electronic blackboard. From these, two opposing propositions are selected and the submitters have to defend them in class. After 20 minutes discussions are stopped (which is often difficult to do because it is great, so you let it go) and I try to put the

discussion into the broader perspective of the subject with the help of the class material. The exam consists of three items. The questions to be answered, the essay and a report on how one of the companies can improve their sustainability report.
How does this work out in practice? First of all, students love these subjects. The maximum number allowed for on elective is 25 (more is difficult to handle) and mostly it is fully booked. Only few 'vote with their feet', that is do not turn up anymore in later sessions because of lack of interest.
It is fun, particularly the disassembly sessions and the group discussions about the propositions are the best. It is interactive, with improvisation and strong arguments. It is great to do, every year, again and again.
On top of the two classes a third one called 'Recycling and Recycling Systems' has been developed. It has the following subjects:

- Material recycling
- Legislation on recycling, particularly the European WEEE Directive
- Making End-of-Life Strategies
- Experiences in the Netherlands and the EU with take-back and recycling
- Design and end-of-life
- Materials and chemical content issues in products to be recycled
- Eco-efficiency of recycling
- Implementation issues of the WEEE Directive
- How can we do better than the current WEEE Directive.

Coupled with this course is a disassembly session with particular emphasis on recycling issues. This course, or part of it, received great attention at the Universities where I was a visiting professor, in particular at Tsinghua University in Beijing.
Both students and I will remember it all of our life (see Tidbits, 15).
Recycling and recycling systems have been taught at IDE. This is understandable because the main focus is design. My hope to have an outreach version of this class elsewhere at TUDelft did not materialize. At Earth Sciences for instance recycling and recycling technology is an important subject. The approach involves a different technology -metallurgy – but design is supposed to adapt to that. Why not incorporate design in a more balanced way? Real science has little to do with superiority feelings.
(Applied) EcoDesign can also be considered to be part of an Industrial Ecology curriculum. My visiting professorship at NTNU in Trondheim (see Cities, 14) shows that this could be a good match; there can be a lot of synergy. Together with Delft, Leiden University and Erasmus University Rotterdam an Industrial Ecology program has been set up. Several Delft Faculties were involved, but not the Faculty IDE. I became aware of this through Philips! I contacted them to offer my support and help and they said, "We will call you". I am still waiting.
What happens in Delft is not unique. Almost all universities struggle with how to integrate EcoDesign, environment and products.
Many institutions have only one chair for it. This forces specialization and does not permit cross-functionality, there is just not enough body.
In Delft Design for Sustainability is located in one Faculty only – may be it is too 'heavy' for that one Faculty, but the very limited outreach beyond that makes this the only way to survive. If all experience and know-how in environmental design, technology and management available in Delft could be brought together, it would be a powerhouse on a world-level.
At NTNU in Trondheim there is a joint Master Course in Industrial Ecology. Different Faculties work together here – with success. A big problem however is the big spread in influx of bachelors. It ranges from sociologists to engineers and from knowledge of the mathematics to economists.
The University of Brandenburg on the contrary has a problem with its outflow. There is an integrated Faculty solely devoted to 'green', which is great. The stumbling block is outside: the status of the graduates in the labor market is weak. Prospective employees have little idea how to value the diploma.
Wanting to teach Applied EcoDesign makes you collide with traditional university organizational structures. This is here to stay. The only way forward is to keep on going for it and try to integrate it!