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Reuse and remanufacturing, a practice based approach as base for integrated training for sustainable production

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Abstract

Reuse is a proven method for closing the loop of the material flow and it also reduces the energy consumption in the total lifecycle of a product. This renders reuse not only as a profitable but also a sustainable strategy including job creation regionally. It is a good mix of people, planet and value. Together with students an approach has been developed to help equipment manufacturers determine the options and profitability of reuse. The approach is called PROfitable Sustainable Production using Product Reuse and Remanufacturing (Prosperr approach).

The approach covers all technical and business issues that have to be addressed when running an enterprise: product design and redesign, assembling and disassembling, remanufacturing operations, marketing and selling or leasing, services and maintenance, logistics and reverse logistics. We therefore use this approach in Business Engineering education as basis to train students in these issues. Prosperr is the basis of a module in which students create their own business-model of reuse for a specific product. It proves to be a perfect way to bring all business engineering issues together as well as to show what sustainability means and how it could be profitable. Furthermore it offers students an excellent opportunity to practice it in an actual enterprise.

Keywords

Reuse of products, remanufacturing, business engineering education, sustainable business operation

Introduction

Present practice in the production, use and discarding of products is based on principles and methods which were founded, almost three centuries ago, at the start of the Industrial Revolution. At that time the impact on mankind on their surroundings and resources as a whole was still small. The attention of managers has therefore been focused on the profitability of a company by reducing costs and increasing sales. The continuity of companies has been taken care of by managing this in an effective and efficient way. This is still at the core of business operation today and present education programs for management and business engineering students reflect this.

The Industrial Revolution didn't take into consideration that there is a limitation in the Earth's natural resources such as rare metals and fossil fuels, which are used for the manufacture of goods. This way of producing and consuming worked for the number of people and the lifestyle at that period in time.

However the world has changed:

- the number of people has grown from one billion at the beginning of the Industrial Revolution to more than six and an half billion in 2010;
- the standard of living has improved which has caused an increased demand for products and therefore has increased the demand for all resources;
- impact on our living environment has grown to unsustainable levels, in particular because of excessive and inefficient use of resources .

For a long time already, these facts have been recognized and many very different actions and approaches have been promoted to counter impacts and depletion of resources and to guarantee a good standard of living for generations to come.

Whatever approach is proposed: a major issue is that there is an urgent need for a change in the way we design, produce, use and dispose products and recover the materials that are part of these products.

Many approaches have been developed and are increasingly practiced: recovery of materials through recycling, prolonged second use of products, bio-based products to reduce use of non-renewable resources etc. However, a classic one that is as yet not practiced to its full potential is reuse.

Production innovation using recovery of products and reuse of parts of it and transforming them to products with like-new conditions has already proven to lead to a profitable business and is common practice for some large companies. At the same time, as is becoming obvious in the last decade, it can contribute to sustainability of a business on major aspects. It reduces resource depletion, in particular of rare minerals in the case of electronics, it reduces energy use and CO₂ emissions over the total life cycle, it diverts material from landfill or incineration and it creates new opportunities for small businesses and creates jobs.

A lot of research has been done on reuse, remanufacturing and reverse logistics but its practical use has not yet spread, at least in the Netherlands [1, 2, 3]. The last decade interest has grown because reuse appears to offer opportunities to produce in a way that is both sustainable and profitable. It further rates higher than just recycling [4]. For most companies the likely options and business approach is not always clear. Therefore only a few companies applied the policy of reusing products and even then not to its full potential. Companies need assistance and effective, easy to use, models to determine and implement reuse as a 'regular' business model. To that aim we developed an approach, under the name Prosperr (PROfitable Sustainable Production using Product Reuse and Remanufacturing). It is used to assist companies in determining the actual feasibility for reuse, the best options and the major points for consideration.

Students Business Engineering should be trained in sustainable business management. So they should become familiar with reuse because it is a sustainable business approach, which integrates and covers all disciplines and subjects of their study. Management of reuse and remanufacturing offers a very straightforward and compelling case for 'sustainable business management'.

This paper will give a brief description of the approach and how it has been developed together with students and various companies, in particular small and medium-sized enterprises (SME's). It will furthermore focus on the implementation of this approach in the curriculum for Business Engineering at Avans University and presenting the findings from this course. Finally the future plans for the use of the Prosperr-approach in the education will be explained.

The development of the approach

In 2004 TNO (Netherlands Organization for Applied Scientific Research) and the Avans University of Applied Sciences joined forces in a small program aimed at SME's who produce equipment and/or take care of maintenance and refurbishment. These companies requested assistance to develop reuse options further. The program involved studies and workshops. Companies with a track record in reuse and remanufacturing (Xerox and Océ in the Netherlands) joined in. It showed that also for SME's reuse to some extent could in many cases be a sensible economic option. At the same time it showed that the instruments and practical expertise was not available to introduce such 'sustainable production through reuse' in SME's.

Therefore the Avans research group Sustainable Business Operation started a program in 2005 to develop this. A 'platform' was formed of equipment producers interested in or already practicing reuse and remanufacturing for their products, of maintenance and refurbishment companies, the University of Tilburg (research group 'reverse logistics') [5, 6] together with Avans. A crucial role was played by Xerox (now Flextronics) research [7] and Océ Technology Asset Recovery [5, 8], who offered their expertise on 'closing the product life cycle'¹. The research program aimed at the development of practical approaches and tools to determine feasibility, profitable options and the best business model to organize it.

¹ The Province Noord-Brabant supported the research with a grant within the framework of their program 'towards a sustainable Brabant'.

A practice based research method was used. In total circa 15 manufacturers, mostly SME's, were involved in pilot studies. About 25 who already practice remanufacturing were further interviewed as reference, or as 'critical' respondents in workshops. The firms mentioned included manufacturers of medical and healthcare equipment (Focal Instruments, Moving People), beverage dispensers (Coffee3) and office equipment (Flextronics and Océ). It led to an approach that can be used by equipment producers in a variety of branches. We promote it as 'Prosperr'² and its development is still continuing. Critical aspects are its effectiveness in selecting truly sustainable reuse innovations and in stimulating actual implementation.

The platform was transformed in a knowledge platform during the project to exchange information to companies and other research groups. Its website gives access to the models and manuals for the different steps in the approach. The project eventually resulted in a section within the industry sector organization for the equipment producing industry³. This section promotes and assists companies to develop reuse and remanufacturing. The cooperation of Avans, the Platform and the section still exists and forms a great stimulant to develop the models and approaches further.

Prosperr approach: a simple tool for decision making

The Prosperr approach aims to assess the profitable high-level recovery options that exist, as well as the possible constraints and efficient solutions to deal with those constraints. These solutions can be of a technical but also commercial or logistical nature. The objective is a method particularly suited to smaller equipment manufacturers, implying a simple and time-efficient approach.

The approach consists of three phases:

- a quick analysis with few but highly relevant questions: to show if it might be a likely opportunity at all;
- an in-depth analysis of parts available for reuse and the costs and profits involved, using a simple but effective structured model;
- a checklist of specific actions to be taken to implement reuse in a low-cost and efficient manner.

² Originally 'WARM' which in Dutch stands for 'profitable disposal and recovery management'

³ In Dutch 'Opnieuw Vereniging voor Hergebruik' affiliated to 'Koninklijke Metaalunie'

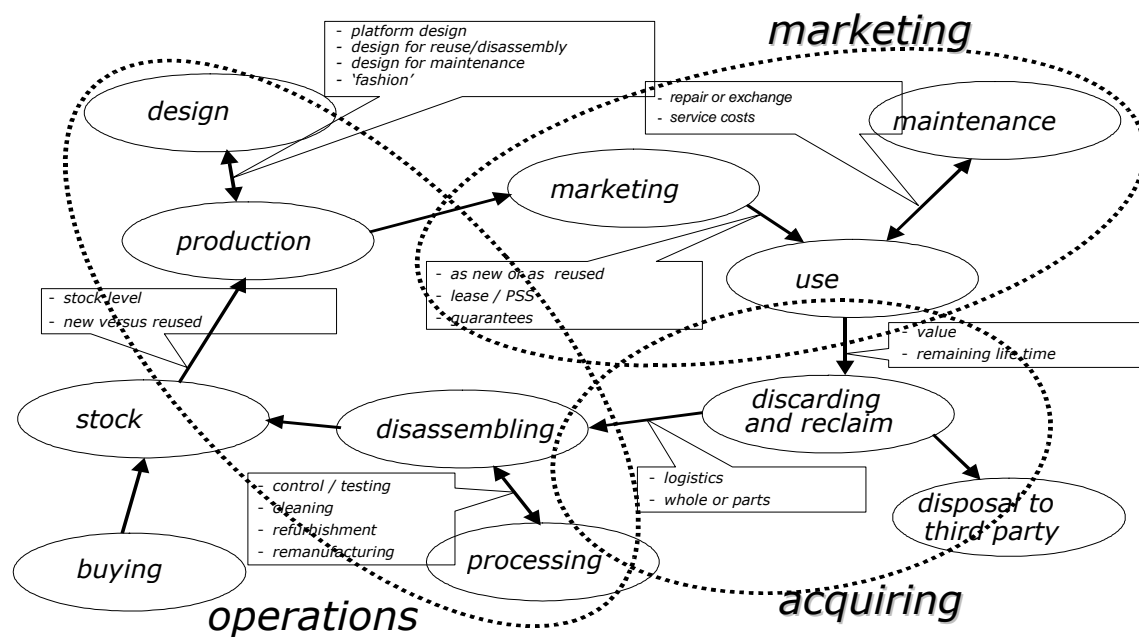


Figure 1. Repeat business scheme

Figure 1 shows the scheme as presented to the manufacturer. The first phase of the approach is quick assessment of opportunities and this assessment is fairly qualitative. It is based on the 'subjectively perceived extent' of options and problems in the three main areas. This is done through interviews within a space of a few hours. However these opinions are critically reviewed by the consultant.

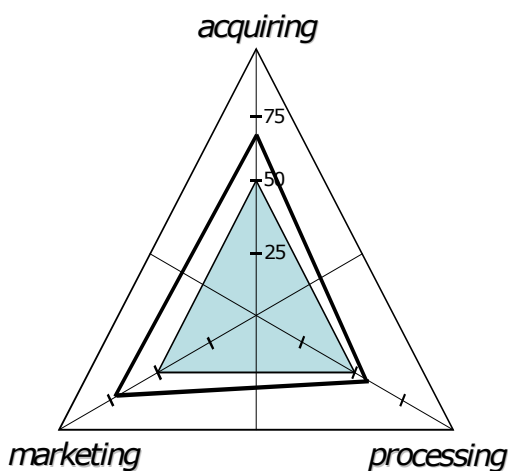


Figure 2. constraints or opportunities

The result of the first phase is a sample diagram as shown in figure on the left. A score of over 50 indicates a positive view of the possibilities, below 50 indicates a less attractive situation. This step also makes the company aware of the actual possibilities that reuse offers in their case. Since it takes so little time, the threshold to 'discuss it just once' is low. Even if the score is below 50, some companies continue to consider the options and will come back to it later. Problems posed here were often easy to solve by just simply introducing an innovative procedure or minor adaptation to the design.

In the second phase, the critical factors determining the feasibility of reuse are identified for all parts and modules. This concerns:

- technical aspects, expected wear and remaining lifetime
- testing method and guarantees that have to be given
- costs for refurbishment and remanufacturing against remaining value, using 'activity based costing'
- market options
- specific company priorities and ambitions.

Name course:	Acquiring	Marketing	Operations	Financial aspects	Organizational aspects
Financing				X	
Production techniques (intro)			X		
Mechanical testing (lab.)			X		
Quality management			X		
Market analysis		X			
Technological management			X		
Competitors analysis		X			

Based on these results, the parts and modules which can be reused in a profitable manner are selected. In some of the cases within the research program it was observed that up to 90% of parts could be reused. Nevertheless, for practical reasons companies were advised to start with a limited number of high-value parts such as electrical motors, the main frames of the equipment and so on. Refurbishment for these parts is not very complicated and redesign is mostly not directly required, implying that a producer can start reusing the parts in their present form.

The last phase of the approach is the implementation, for which much knowledge is already available, such as for reverse logistics and testing methodology. In the Netherlands, a platform has been set up to make such knowledge easily available to companies, considering introducing closed-loop reuse.

The fit between the reuse-approach and the curriculum for Business Engineering

There are a large number of similarities between the Prosperr framework for reuse and the courses in the curriculum for Business Engineering. The Prosperr framework is divided into three topics, i.e. acquiring, marketing and operations. Table 1 and 2 on the next page show where the courses from the curriculum for Business Engineering at Avans University in 's-Hertogenbosch are related to the Prosperr framework. In addition to the afore-mentioned topics, the financial and organizational aspects play a major role in the Prosperr framework and have also been added.

Only the courses for the first and second year have been added to the table, because in the first two years the students gain a certain level of knowledge about sustainability in general and reuse specifically. From year three and on each student follows an individual specialism traject so a general comparison is not possible. Nevertheless students still learn about different areas of sustainability. So the following semesters have been omitted from the table, the 5th semester is an internship, the 6th and 7th semester are not obligatory minors⁴ and the 8th minor is a graduation project.

⁴ The faculty of Engineering and Informatics at Avans in 's-Hertogenbosch offers three minors. Students need to do two minors. They have to choose at least one of these three 'internal' minors but may also choose to participate in one 'external' minor.

Primary business processes		X
Business Process Management		X
Logistics	X	
Business economics 1		X
Production systems 1	X	
Production techniques 1	X	
Technical measurement	X	
Cost price accounting		X

Table 1. Fit between the courses in year 1 and the Prosperr approach

Name course:	Acquiring	Marketing	Operations	Financial aspects	Organizational aspects
Organizational management					X
Change management					X
Project management					X
Queuing theory	X		X		
System theory	X		X		
Logistics 1	X				
Managing production	X		X		
Marketing		X			
Marketing research		X			
Innovation		X	X		
Automation and information					X
Enterprise Resource Planning			X		
Management Control				X	

Table 2. Fit between the courses in year 2 and the Prosperr approach

The tables show that each of the five aspects of the Prosperr approach, i.e. acquiring, marketing, operations, finance and organization, is supported by on average five different courses. An exception is the aspect ‘operations’ which is supported by twelve courses. This can be explained because operations is the main issue of the curriculum.

Business Engineering students can earn a total of 120 ECTS⁵ in the first two years. From this 120, 16 are earned with the personal competencies⁶ and therefore have no direct relation with the reuse subject. Of the remaining 104 ECTS, 43 are earned with teamwork projects. Because the courses are designed to support projects, there is a clear relation between the courses, the projects and the framework.

The other 61 are earned with courses related to the functional competencies⁷ and 50 (> 80%) of them are related to the Prosperr framework for reuse. In conclusion circa 77,5% of the curriculum is related to the subject of reuse.

Functional competencies

⁵ European Credit Transfer System (ECTS), part of the Bologna Declaration - 19th of June 1999.

⁶ Personal competencies: Relates to the attitudes and behaviours of individuals preparing to enter a career or profession. Developing these personal competencies enhances the way relationships are handled in a student's career, and facilitates individual learning and personal improvement in making life choices and in solving problems [9].

⁷ Functional competencies: Relates to the technical competencies, which are most closely aligned with the value contributed by a student's career or profession. These functional competencies align with the traditional course objectives for each course [9].

Because of the tight relation between the courses and the approach for reuse, it is expected that there is also a strong relation between the different functional competencies for a Business Engineer student and the Prosperr framework.

Prosperr framework	Competencies of a student Business Engineering			
	Gaining insight	Design	Planning	Implementation
Fase 1: Quick analysis	X			Optional*
Fase 2: In-depth analysis	X	X		Optional*
Fase 3: Business model		X	X	Optional*

Table3. Fit between the Prosperr approach and the Business Engineering competencies

Three out of the four competencies which are designed for a Business Engineer student can directly be related to the different steps in the Prosperr framework. Only the implementation competence is not part of the framework due to it being optional*.

In addition to the fact that the framework fits in very closely with the curriculum for Business Engineering it also provides an excellent opportunity for students to combine the knowledge that they gain in all the Business Engineering courses.

In other words not learning completely new things but doing the same things in a different manner and looking at it from a different, sustainable, perspective without losing sight of the financial profits.

Integration of the Prosperr approach/reuse/sustainability in the curriculum

The course Sustainable Business started in the academic year 2007 – 2008 as a single course in the second part of the fourth semester in the curriculum of Business Engineering. Originally the lectures were organized according to the different chapters from the book ‘Elementary book for sustainable development’ [10]. Students worked together in groups of four and had to build a website which contained the workouts of the assignments. Every week the lecturer discussed these workouts with the students.

Starting from the academic year 2008 – 2009 this course has been given in its current form. The course consists of seven work lectures from two hours and each lecture is divided into two parts. The first part of each lesson is dedicated to sustainable development in general and each lecture a different topic from the book ‘Working on sustainable development’ [11] is covered. The topics are briefly introduced and the students are expected to gather most of the information from the book by self-study. The set-up of the book supports this type of education. In the next/following lesson/class the workouts of the assignments are being discussed in detail.

The second part of each lecturer covers the subject of reuse and will now be explained week by week.

Week 1

In the first week the main principles of reuse are introduced to the students. The subject of Cradle-to-Cradle [12, 13] and its relation to reuse is also discussed after watching the movie 'Waste equals food (VPRO)⁸. Finally, the details of the mini-project of reuse are explained. The main aim of the mini-project is to develop a practical application for the reuse of a product and the Prosperr-framework is a tool to achieve this goal. Every week each project team works out the application of a specific subject of the framework on their specific product. At the end of the course all the gathered information is combined into a new business model.

Moreover project teams are formed and it is their first assignment to think of and describe three different product/company combinations with a possible commercial application of reuse. For each combination the project team has to give a brief description of the company, the product and the primary process. The team also has to explain their considerations for each combination and why they think reuse could be a profitable solution.

From week two and further on each project team has an individual discussion about their progress with the lecturer. The assignment of the mini-project from the previous week and the possible pitfalls of the current assignment are discussed during that meeting.

Week 2:

This week the three different product/company combinations and the considerations of each project team are discussed with the lecturer. At the end of the meeting a choice for the most promising combination is made and this one is worked out in the next five weeks. In this week the first step of the Prosperr framework, the quick scan, is also explained to the students and the subjects marketing, acquiring and operations are introduced. The assignment of this week is to conduct a quick scan (phase 1), if possible, of the company. Questions about the three subjects from the framework have to be answered. If a question can't be answered immediately then at least a realistic guess should be made.

Week 3:

From now on a different subject from the Prosperr approach is in the spotlight each week.

Week 3 focuses on the subject of 'Acquiring'. A new 'reversed logistic' process has to be designed. According to Kopicki et al. [14] there are opportunities but also challenges in collecting used products and transporting them to the remanufacturer. It is a challenge to fine-tune the number of used products coming in at the remanufacturer, with the number of good-as-new products that are produced in a specific period of time. After all you don't want stock to grow above an uneconomically acceptable level and at the same time you have to avoid shortcomings of used-products in the production process.

Week 4:

The focus of this week is on the subject of 'Marketing'. An important question for the students is how to sell a function instead of a product to a customer? In this construction the manufacturer will always be the owner of the product and customers only have to pay for the use instead of the ownership of a product, e.g. paying for copies instead of buying a copier.

Week 5:

This week's lesson focuses on 'Operations'. A remanufacturing process has to be designed or has to be outsourced to a specialized company. According to Sundin et. al. [15] the most common activities in a remanufacturing process are: visual inspection, investigation (failures), cleaning, disassembly, storage, repair, reassembly and testing. Another issue is that machines in the production process sometimes have to be changed/adapted to make them more flexible. These machines should have the ability to alternate between the use of new and used parts with hardly any or no adjustments.

⁸ <http://tegenlicht.vpro.nl/afleveringen/2006-2007/afval-is-voedsel-deel-1.html>. An inspiring documentary on the Cradle to Cradle design concept of M. Braungart and W. McDonough. Winner of the Silver Dragon at the Beijing International Science Film Festival 2006

Week 6:

In this week's lesson the theory of the 'Business Model Canvas' [16] is explained.

The building blocks of this model help students to reconsider all aspects which are involved in the application of reuse. It describes the motivations and options of how a company could create, deliver and capture value with the application of reuse. Although this model is designed to develop business models in general it is surprising how the building blocks of this model can be used together with the issues of the Prosperr approach. Furthermore the Business Model Canvas is a visual and a very practical tool which makes it easily accessible and easy to use for students.

Week 7:

In week seven each project team has to present its final report to the other project teams and the lecturer. And the results of the project work are discussed.

Conclusions of the course sustainable business

Evaluation of the course sustainable business management

The course was followed by 48 students in 2009 and by 68 students in 2010. They were asked to make comments and fill in an extensive form to evaluate its impact. The results of both evaluations are similar.

Positive findings:

- Sustainability is considered to be a very important and interesting subject;
- The subject of reuse fits very well in the curriculum for Business Engineering because of the relations with all the other courses;
- It was highly rewarding to have the possibility to choose their own product/company combination instead of working on a compulsory case;
- The diversity of subjects in each lecture, switching between sustainability in general, the Prosperr work for reuse and discussing the mini-project, renders it dynamic and attractive;
- The different subjects from the Prosperr framework and the building blocks of the Business Model Canvas were easy to use and conveniently arranged;
- A great deal of creativity and imagination was necessary to come up with solutions for reuse.

Negative findings:

- The mini-project was very time consuming (also for the lecturer);
- It was not always possible to get all the information from the companies, needed for the mini-project, in time;
- It is hard to predict how the mini-project develops. In the end students sometimes have to conclude that their findings are not feasible. But this may also be a very valuable study-experience (personal note from the lecturer).

Curriculum for business engineering

In 2007 it was decided that the Business Engineering study at Avans University in 's-Hertogenbosch should implement sustainability in its curriculum. And, against the ideas of Sterling [17], sustainable business was introduced as just another issue added to an already (over)crowded curriculum.

Although this wasn't the ideal situation it may be seen as a first step in the right direction. Last year we took another step by adapting a subject, in our case reuse, with multiple relations in the current curriculum. This has proved to be an excellent approach to make students enthusiastic for the subject of sustainability. And it also encourages other lecturers to cross the threshold and to get involved in the subject of sustainability from their own professional perspective.

Future plans

Curriculum for Business Engineering

It is our intention to show other lecturers how to use (with small changes) the specific subject of reuse in their current courses. Once they realize how small a step this is it will stimulate them to show a greater interest in sustainability and integrate more of these issues in their lectures.

Finally, when most current courses have taken up one or more sustainability topics, the time will be right for the necessary transformation of the whole curriculum towards a more integrated and systematic view of sustainability in the curriculum, which is the preferred situation according to Sterling [14].

That principle, integrating sustainability throughout the whole curriculum has been advocated and tested before at Avans University. This was not implemented easily, at that time, but seems now much more feasible.[18, 19]

European Project Semester (EPS)

The engineering department of Avans University, together with ten other European universities, provides an English spoken semester, called EPS. In this semester 25 international engineering students can participate. EPS is an alternative for an internship and consists of 25% short intensive courses and workshops and the remaining 75% of the time the students work in project teams at companies.

Avans has provided this program since 2002 and until now the focus of the EPS-program has been on marketing. In the next two years we are planning to transform the focus of the program to sustainable innovation. The program of the course sustainable business together with the mini-project of reuse seems to fit perfectly into such a program. This is because all students have a different engineering and cultural background and the subject of sustainability should preferably be discussed in such an interdisciplinary environment.

ICT-facilities

At Avans we already make use of state of the art ICT to facilitate education. Especially to support the mini-project of reuse we take a further step and make use of digital document sharing and instant messaging. Digital document sharing, e.g. drop-box, makes it possible for students to work together on documents in a shared environment and the lecturer can check the progress of each project-team. Instant messaging, e.g. twitter, makes it easy to communicate between students, project-teams and the lecturer. The advantage of this application is even greater if students and the lecturer work at different (international) locations.

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