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An innovative approach to teaching sustainable design and management

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Abstract

For many years the market leadership was driven by offering better price on more product functions and services. The world is currently shifting towards social responsibility thinking. This changes the market behaviour, and leads to more innovations, such as designing new product/service/system using re-usable parts, new electric motor concepts, or inventing new chemical production procedures generating less waste, and many more opportunities.

This paper introduces a research valorisation activity that aims at developing a program of training and coaching to prepare students and industry partners to this emerging innovation wave. The most outstanding particularity of this program is that it combines management and engineering aspects of sustainability in a form that empowers trainees to deploy sustainable approaches in practice. The particular target group of design engineers get equipped with fundamentally important sustainability knowledge enabling them to include sustainability considerations in their products and systems design. Eco-design is positioned as a key lever towards achieving sustainable product-service systems.

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1. Introduction

Sustainability has become a global megatrend under the pressure of the climate change, and increasingly stringent resource scarcity. Organisations should better act in a sustainable manner in order to preserve the environment, and, to be socially responsible, while still preserving their economic orientation.

In recent years, important global issues around energy security, unstable fuel prices, greenhouse gas emissions, as well as sustainable procurement, ethical trade, and corporate social responsibility (CSR), have led organisations increase their commitment to moving towards more sustainable products, services, processes, and associated business models. The most popular improvement vectors are in the area of carbon footprint and energy efficiency. The United Nations' Division for Sustainable Development confirms these tendencies in the report [1] by registering a steep increase in the number of companies certified to fulfil the environmental management and social responsibility standards ISO 14001 [2], and ISO 26000 [3] respectively. They also indicate an increase in the number of consumers feeling concerned by social and ecological issues. Revenue figures from fair-trade products have grown to 2.9 billion euros per year despite the recent economic troubles. The same report reveals that governments are also following the sustainability trend by highlighting sustainable procurement policies, both in developed and in developing countries.

The research valorisation work presented in this paper aims at contributing to filling an emerging gap in current education, and in professional training programs. This gap is located in teaching actionable key knowledge in the area of the sustainable design of organisations, products, services, and products. This teaching material is designed in a way that it can actually be applied successfully in both engineering and management activities in order to make them more sustainable. This paper presents the research objectives and approach that are underlying this training program design

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activity in section 2. Section 3 gives an overview of the trainings' main elements, while section 4 explains the training approach that has been chosen for their implementation. As a conclusion to this paper section 5 presents the upcoming activities to furthermore develop this training program.

2. Research Objectives and Approach

The larger context of the presented research valorisation activity is a collaborative work of a European project consortium including the following organisations:

- Denkstatt, Romania (coordinator);
- Bicero, Slovenia;
- EMIRAcle, Belgium and France;
- Grenoble INP, France;
- ISCN GmbH, Austria;
- Polytechnic University of Timisoara, Romania.

The main partners' goal is to develop and provide a training program, which combines both the management and engineering aspects of integrating sustainability in organisations, and in their products, services, and processes. It shall also deal with the assessment of an organisations' sustainability performance and provide a practical approach to setting up relevant programs, objectives, and targets in a strategic sustainable manner. Furthermore, the program shall be certified by the influential European Certification and Qualification Association ECQA. This certification provides numerous added values to the training:

- training architecture and modular ISO 17025 [4] compliant certification according to the European Qualification Framework EQF [5];
- assurance of a high quality level of the training materials and certification procedures;
- clear certification procedures for trainers and trainees;
- learning and exam portals provided and driven by the ECQA;
- sustainable and continuous development managed by a Job Role Committee composed of representatives from academia, and from industry;
- international promotion of the program.

The higher objective of this collaboration is to establish a new certifiable skill set around sustainability engineering and management on the European level. The training program therefore aims at addressing a wide range of target groups, as achieving sustainability requires the collaboration, and the interaction of several different stakeholder groups.

Responsible Managers and Directors of industrial, academic, and governmental organisations will be empowered to develop business strategies leveraging sustainability. They will learn how to successfully deploy them for a better sustainability performance, and for an improved corporate image.

Designers and Managers of products, services, and/or processes will learn essential multi-dimensional sustainability principles, as well as how to take these principles into account in their daily creative work. They will understand that sustainability should be integrated consistently into products, services, and processes by designing from the very earliest phases onwards. Therefore, the designers and managers have significant roles in achieving their organisations' sustainability performance objectives. The training teaches them practical methods and tools to support them in fulfilling these roles.

Master and PhD Students as future young employees in industry and academia should be able to assume key roles in fostering and implementing a sustainability mindset in an organisation. They are increasingly expected to understand sustainability methods and tools, as well as being able to apply those methods and tools in real-life industry and research projects. The training program is therefore designed to be complementary to their studies. It addresses both managerial and practical sustainability topics in a concise and applicable form. This will give them a broad – yet practical – basis to build upon when assuming their future professional positions.

The training development process goes through the following main stages:

- need-analysis for the training in all the participating partner countries;
- development of an EQF-compliant skill card largely based on the results of the needs-analyses;
- development of e-learning enabled training materials in English language for all the skill elements of the skill card;
- several pilot training loops all over Europe, and subsequent improvement of both the skill card, and the training materials;
- translation of the training materials in all the languages represented in the consortium;
- deployment of the training in the e-learning environment of the ECQA;
- development and deployment of a pool of test questions and competence recognition criteria for certification;
- foundation of an expert committee ensuring the continuous improvement of all project outcomes, as well as supporting the decisions about the certification of prior competencies, and the contracting of education and training organisations.

The whole process will last two years. It has been halfway run through at the time of writing this paper. The results of the need-analysis have been published in [6]. This paper focusses on the identified key subjects that are currently being elaborated in the form of e-learning enabled training materials.

3. Training Program Design

This section explains the main subjects covered in the training program resulting from our research so far.

3.1. Understanding sustainability leadership

To begin with, the program devotes several training elements to shape an understanding of sustainability in the context of different types of organisations, standards, and, regulations that have been developed around it.

Sustainability has become a keyword (or 'buzzword') for product development in several sectors. In this training context the term sustainability should be associated with the notion of the environment. It thereby covers the intersection between challenges, requirements, and constraints imposed by the three dimensions of the environment: society, ecology, and economy (see Fig. 1).

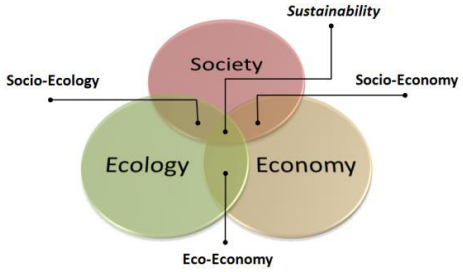

Fig.1. The dimensions of sustainability considered in this research

It is mandatory to ensure that sustainability covers the three main areas shown in Fig. 1. Those areas make up our environment. The concept of environment is defined as "*The surroundings or conditions in which a person, animal, or plant lives or operates"* [7]. Sustainability is very often reduced to the economic factor only, and often considered for achieving a sustainable profit growth. In the presented training sustainable design fully considers the three areas, including their overlapping regions.

The Bruntland Commission defined in 1987 sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [8]. To achieve sustainable production and consumption, societies have to drastically reduce their consumption of raw material and energy. Accordingly, sustainable design or eco-design denotes product/services/system/process design activities that strongly integrate sustainability considerations into the design process.

The proactive management of environmental aspects converges with enterprise risk management, corporate governance, operational, financial practices, and performance. Therefore international standards are becoming increasingly important for organisations to work with, towards common and comparable environmental management practices. The sustainability standard compliance supports their commitment and performance to the integration of sustainability in their organisations, products, and services. The program explains the scope and key benefits of the ISO standard families 14001 [2], 26000 [3], 31001 [9], 50001 [10].

3.2. Resource Efficiency and Cleaner Production (RECP) methodology

As a first methodological approach towards taking into account rather fundamental sustainability issues in industrial organisations, the training introduces a program jointly driven by the UNIDO and the UNEP to advance sustainable industrial development, consumption, and production in developing and transition countries. Specifically, their joint Program on Resource Efficiency and Cleaner Production (RECP) aims to improve resource efficiency and environmental performance of organisation, such as private businesses [11]. This program is based on achievements and on lessons learnt from National Cleaner Production Centres (NCPCs) established since 1994. Activities are underway in over 40 countries. Cleaner Production (CP) is therefore on the agenda of industry and government. Trained technical staff foster the implementation of CP options and policy changes. The current RECP Program provides for the first time a strategic and coherent framework for up-scaling and mainstreaming activities and results of NCPCs, nationally, regionally, and globally.

The training focusses on the following RECP aspects:

- Water Efficiency Management;
- Energy Efficiency Management;
- Materials & Waste Management.

3.3. Life-Cycle approaches and eco-design

Sustainability of products and services does not happen by itself; it has to be proactively taken into account in their design. In more technical terms: it has to be "engineered" using methods of integrated engineering design [12]. Hereby, the notion of the product/system life cycle plays a central role. In integrated design the product/system life-cycle comprises all phases that the product/system goes through from the idea to its end-of-life and revival. The principal stages that a product or system typically runs through in its life-cycle are design, manufacturing, distribution, customisation, and the end-of-life. In integrated design closed life-cycle should be preferred. Integrated design targets a "cradle to cradle" approach that goes beyond the often-cited notion of "from cradle to grave".

Taking into account life-cycle issues in integrated product/system design requires developing systematic methods. The Life Cycle Engineering (LCE) approach offers a set of method which are able to optimise a product from an integrated technical, ecological and economic point of view. It is a management practice approach that aims at combining relevant information in one decision support tool. Its objective is to chart an optimum life-cycle for a manufactured product. LCE connects different angles from which one should look at new developments and in particular, it involves technical, costing and ecological points of view.

There is an increasing demand in assessing and reducing the ecological impacts of products. Complex products such as automobiles need effective methodologies and tools to evaluate their environmental impacts without neglecting the technical and cost implications. The consequences of developing new products and services need to be analysed. Companies need to have relevant methods, and powerful tools. Life Cycle Engineering is also an approach that promotes assessing the environmental impacts in conjunction with economic impacts under consideration of technical boundary conditions. The scope of the assessment is usually the whole product life-cycle, including the production, use phase and end of life stages:

- The environmental impacts are assessed according to the ecological (or environmental) Life Cycle Assessment (LCA). It is a quantified multi-criteria and multi-stage impact assessment (ISO 14040 – 44).
- The economic impacts are assessed according to the Life Cycle Costing (LCC) approach.
- Technical boundary conditions are taken into account providing some limitations on the model, thus verifying the technical feasibility. In practice, to be reliable the LCA and the LCC should share the same boundary.

Life Cycle Engineering increasingly aims at providing a complete system of support tools for the product/system life-cycle. The economic objectives of LCE are adding value extension of business areas, reduction of fixed cost, and increase the profitability of products and services.

Life Cycle Assessment (LCA) is a technique for assessing the potential environmental aspects and potential aspects associated with a product (or service) [13], by:

- defining the goal and scope of the study,
- compiling an inventory of the included inputs and outputs material and energy flows (within the scope),
- evaluating the potential environmental impacts associated with those inputs and outputs (using appropriate calculation methods), and
- interpreting the life cycle impact results regarding the objectives of the study.

When conducting a LCA, the environmental impact of the design/development stage is usually excluded, since it is often assumed not to contribute significantly. It is obvious that the decisions made in the design/development stage highly influence the environmental impacts of the product during its life-cycle stage. The design of a product strongly predetermines its behaviour in the subsequent phases (e.g., the design of an automobile more or less determines the fuel consumption and emissions per kilometre driven in the use phase and has a high influence on the feasible recycling options in the end-of-life phase).

The high interdependency between design/development and the other life-cycle stages is vital to understand to practice eco-design. If the main aim of conducting a life cycle assessment is to address recommendations to product designers to improve the environmental performance of goods and services. The life cycle study should therefore be carried out as early as possible in the design process, as well as concurrently to the other design procedures. This approach is applied analogously to the designing or to the improvement of a process within a life-cycle of a product, especially if several interactions with other processes or life-cycle stages are occurring (mainly the case).

Life Cycle Costing (LCC), also called Whole Life Costing, is a technique to establish the total cost of ownership. It is a structured approach that addresses all the elements of this cost and can be used to produce a spent profile of the product or service over its anticipated life-span. The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options. The accuracy of LCC analysis diminishes as it projects further into the future, so it is most valuable as a comparative tool when long term assumptions apply to all the options and consequently have the same impact. The life cycle cost of an item is the sum of all funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life.

Product Structure Assessment (ProSA) is used to assess a product's features in terms of disassembly, recycling and reuse from the viewpoint of cost optimisation. It gives the inputs for calculating the end-of-life costs related to these activities.

In terms of tools that support LCE, there are four general classes of information technology (IT) systems in modern enterprise infrastructures:

- SCM (Supply Chain Management) – for the management of the supply chain;
- CRM (Customer Relationships Management) – the systems that store information about the history of customers' interaction with the company (business offers, purchases, services, etc.);
- PPC (Production Planning and Control) – for the management of manufacturing system (purchases, orders, production planning and scheduling);
- PLM (Product Lifecycle Management) – the class of IT systems that collect and manage the data that emerges during product life-cycle.

All the mentioned methods and tools form an integral part of the training program. Their theory is explained concisely, while their practical application is shown using real-world case studies.

3.4. Deployment of eco-design and sustainability

Knowing about the necessity for sustainability thinking and acting form the necessary basis are mandatory for successfully implementing sustainability in an organisation. Mastering methods and tools for doing so are also indispensable. This implementation is typically a process that covers several stages of maturity. It reaches from opposition and ignorance, over risk and cost considerations, towards realising competitive advantages thanks to sustainability, and finally the total transformation in order to re-interpret the nature of the organisation to an integral self-renewing element of the whole society and its ecological context [14]. Organisation leaders have to realise the added value of investing time and effort into leading their organisations through these different stages of sustainability deployment, and they have to be ready to face the risks associated with the transformation process.

A survey published in July 2007 by McKinsey & Company of CEOs that have signed up for the UN Global Compact identified a broad range of areas where CEOs were having problems in driving greater responsibility and sustainability [15]. The survey found that more than 90 per cent of the CEOs said they were doing more than they did five years ago to incorporate environmental, social and governance issues into their strategy and operations. 72 per cent of them said they thought corporate responsibility should be embedded

fully into strategy and operations through their firms. However, only 50 per cent actually did so. Although 59 per cent of them said corporate responsibility should be embedded into their global supply chains, only 27 per cent of them thought they were doing it. The problem areas identified by the CEOs included board oversight, stakeholder engagement and linking sustainability issues thoroughly into business purpose and strategy. The survey found that these committed CEOs regarded competing strategic priorities as the biggest barrier to implementing a systemic approach to sustainability across their companies. The complexity of implementing these issues across different business functions also posed problems, as did the lack of recognition from financial markets.

The training deals with approaches that facilitate the transformation process. One key lever of introducing sustainable design and thinking into a business organisation is to make sustainability an engine of innovation of products, services, and processes [16]. While nowadays in many organisations sustainability measures are still considered as a "necessary must", sustainability leaders have understood turning sustainability into a competitive advantage rather than an additional burden. The training elaborates several examples from different sectors to point this out.

Another key lever for sustainable value creation by innovation is linked to the paradigm of Service Innovation. Industrial Product-Service Systems (IPS²), or simply Product-Service Systems (PSS), focus on maximising value creation by complete and integrated solutions consisting of added-value services enabled by and co-designed with products [17,18]. PSS design offers the opportunity of integrating business model design and eco-design, which thereby both converge in a life cycle approach. This approach integrates service delivery and the co-creation process together to support value creation and sustainability from the points of view that each stakeholder group involved in the product/service system life cycle has. The focus is thus on the creation of value all through the life cycle rather on profit generation for the producers and vendors [19]. The training largely elaborates on this aspect, and explains numerous practical case studies.

3.5. Social responsibility

Corporate social responsibility (CSR) refers to companies taking responsibility for their impact on society. CSR is defined by the European Commission as "the responsibility of enterprises for their impacts on society" [20]. The Commission encourages that enterprises "should have in place a process to integrate social, environmental, ethical human rights and consumer concerns into their business operations and core strategy in close collaboration with their stakeholders" [20]. As evidence suggests, CSR is increasingly important to the competitiveness of enterprises. It can bring benefits in terms of risk management, cost savings, access to capital, customer relationships, human resource management, and innovation capacity.

The training explains CSR and its principal challenges, however it particularly focusses on stakeholder involvement, communication challenges for sustainability, as well as social impact assessment.

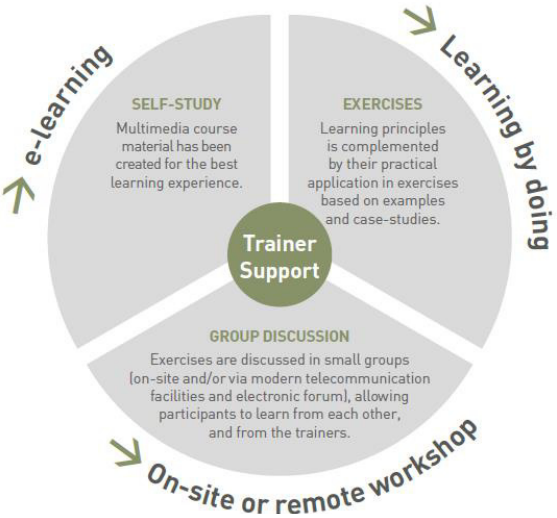

Fig. 2. The training approach

4. Training Approach

Figure 2 shows the training approach applied in the training program. Students study the training material per unit within an e-learning environment. They can contact trainers for questions comments, etc. via the forum which are associated with each learning element of a particular learning unit. As the training material is strictly focused on principles and core messages, students then have to do practical exercises in order to show that they understand these principles, and that they are able to apply them. Exercises are also done as homework, and must be uploaded to the respective discussion forums, where they will be commented by trainers, and other course participants.

In order to explain exercises and trainer comments, students are put together in groups of up to eight participants, who meet via telecommunication facilities with trainers. After a summary-style introduction to the studied learning units done by the trainers, every student is asked to explain his/her exercise. Trainers and other students comment on this explanations and ask questions. This facilitates knowledge and experience exchange among the entire group. After this on-line discussion session, students are obliged to upload an improved version of their exercises.

The complete training process can also happen on-site, *i.e.*, in the form of training seminars given in classical form as classroom sessions. The complete training program can be delivered in five to ten seminar days, mainly depending on the amount and level of detail of exercises. There can also be mixture of both, *e.g.,* the exercise discussion sessions could be done on-site rather than remotely. Thanks to the modularity of the training units it is possible to tailor session schedules to specific needs while still enabling an independent and neutral certification by the ECQA.

5. Conclusion

For many years the leadership on the market has been driven by offering more functions and services at a better price for maximum financial profit. Under the increasing pressure of global social and ecological challenges, the economic world is undergoing a shift in thinking towards assuming social responsibility by the environmentally responsible design of products and services for their entire life cycles. This shift is changing the market behaviour, confronting organisations with new challenges in terms of value understanding and value creation through innovative product-service systems and business models [21].

Education and professional training for knowledge and awareness creation is an important lever to facilitate fundamental shifts in thinking in organisations. The work presented in this paper aims at filling a gap in existing environmental sustainability education and training programs in terms of covering both the "why's" and "how's" to contribute to a more sustainable behaviour and performance by the very design of both organisations and systems of products, services, and processes.

The chosen approach is based on an e-learning enabled training program designed in a way that it can be used both in academic and professional training environments, be continually extended and nonetheless certified on a European level. The training program is practically oriented, considering for all technical elements exercises and best practice examples besides theoretical inputs. The concept of sustainable value creation thanks to the integrated design of product-service systems with the total incorporation of environmental sustainability considerations in all design steps and activities takes a central position in this program. However, teaching a design concept without also addressing approaches towards creating the necessary management attention and support, would not be sufficient for a training that claims to facilitate the future leaders in sustainability. Therefore, a considerable part of the training is dedicated to managerial approaches towards capturing the added value of acting environmentally responsible in heavily competitive economic environments.

With the competencies reached by the trainees with different responsibilities in organisations it is expected that the paradigm shift towards designing product-service systems and their associated processes with sustainable value creation as a fully integrated design objective will be facilitated. The most competitive organisations will be those who integrate concrete social and environmental performance objectives in their business strategy and drive innovation on their basis.

The future research activities linked to this new training program include an exhaustive assessment of trainings delivered to different target groups and in different countries over the next two years, as well as the implementing of a continuous improvement cycle during the same period.

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