

ECO-DESIGN PERSPECTIVE IN THE ENGINEERING EDUCATION AT POZNAN UNIVERSITY OF TECHNOLOGY

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ABSTRACT

Designing of environmentally sound products is still a challenge in Poland. To reach this goal, a new type of engineers should be taught. At Poznan University of Technology, as a first technical higher education institution in Poland, pro-environmental courses including also eco-design issues, have been implemented.

Firstly, the introduction of environmental issues into the education of mechanical engineering students at the level of specialization, is shown. This process started with the elaboration of the desired professional profile of graduates and next the selection of the list of courses. The last step was launching the campaign to introduce the programme. For designers, taught also in the context of this specialization, some specific courses were proposed.

Secondly, the introduction into the study programme of another specialization, especially devoted to teaching future designers, the course called "Ecobalancing", is presented. The main goal of this course is to give instructions how to use the specific tools helpful in the eco-optimization of elements and objects in designing process.

Thirdly, the one-week initiative called "International summer school of solving technical problems in mechanics, material sciences and transportation" is shown. During this workshop the students, working in small groups, solve real technical design problems given by companies. In their design proposals they are strongly encouraged to take into consideration ecological aspects.

Keywords: ecology, ecobalancing, ecodesign

1 INTRODUCTION

Poznan University of Technology (PUT) is almost 90-year-old educational institution. It continues the tradition of the State Higher School of Mechanical Engineering, which was opened in Poznan in August 1919. In September 1945, the School received the name of Poznan School of Engineering and after ten years became Poznan University of Technology. At present, PUT is an autonomous technical university with nine faculties, with over one thousand academic staff doing research and running educational tasks for the nineteen thousand students. Two mechanical engineering faculties: Faculty of Mechanical Engineering and Management and Faculty of Machines and Transportation are actually operating in the structures of PUT.

The Faculty of Mechanical Engineering and Management has its roots in the above mentioned State Higher School of Mechanical Engineering. The present name of the faculty reflects the scope of the faculty research and education, which includes: machines and structures, material processing technologies, applied mechanics, material

science and engineering, computer aided engineering, machinery diagnostics, sustainability in engineering management and production engineering.

The Faculty of Machines and Transportation was founded in 1953 in PUT, as a Faculty of Agricultural Engineering. The development of new profiles of study resulted in renaming the faculty in 2000. The main scientific and educational areas are: vehicles and food processing machines, maintenance of machines, optimization of engine thermal processes, new environmentally friendly solutions in internal combustion engines, virtual modeling of mechanical systems, Life Cycle Assessment of technical objects, logistics, CAD systems and advanced gas combustion systems.

This paper is devoted to showing the introduction of a new syllabus elements focused on ecodesign issues (on the broader environmental background) in the education area of mechanical engineering at Poznan University of Technology. The three different activities are shown in the paper.

2 ESTABLISHING ECO-ENGINEERING SPECIALIZATION AND THE MAIN CONTENT OF THE PROGRAMME OF ECO-ENGINEERING

The concept of sustainable development does not only refer to environmental issues, but also includes a wide range of important policy areas, containing links to world's development. Keeping it all in mind, the representatives of the two described above mechanical engineering faculties at PUT, working on the areas closely related to problems of sustainable development, joined their efforts to cooperate on the project leading to establish a specialization called "Eco-Engineering". The shared concept was to introduce broad scope of environmental issues into the education of mechanical engineering students.

Boks et al. [1], Jeswiet [2] and Nobels et al. [3] give the examples that universities offer one or more courses, which are focused on sustainability issues, especially eco-design. The scope of engagement in introducing these important aspects varies. Especially Boks et al. [1] show the broader attitude towards placing environmental issues in design education, with the aim of creating awareness among students about the role played by sustainability in industrial product development processes. The focus on design (eco-design) issues in education one can find in papers of Selva and Carulli [4] and Holmlid and Arvola [5].

The span of study in engineering leading to a master degree in Poznan University of Technology is planned in total for 5 years, in frames of so called fields (directions) of study [6, 7] which, after three years of joint study programme, split into several so called specializations. New specialization, called Eco-Engineering, was placed within the framework of the field of study: Management and Engineering of Production, at the Faculty of Mechanical Engineering and Management. Eco-Engineering is one of 4 specializations, with a 2-year program of study, and starts with the shared level of knowledge and skills offered to every student of an above-mentioned field of study.

This shared 3 year program of study consists of several groups of subjects, such as: Humanities, with 390 teaching hours span; Sciences with elements of mathematics, physics and chemistry with the span of 300 teaching hours; Foundation of Economy and Management with 195 hours of classes. It gives in total 885 hours of basic subjects, and on that background it is delivered the basis of Engineering Education at 660 teaching hours, consisting of the elements of mechanical engineering, strengths of materials, machine design and automation, manufacturing technology, manufacturing systems and processes, metrology, ecology, systems engineering, engineering applications of information technology: CAD, CAM, CAE.

The next group of subjects is focused on production engineering and management, with 375 hours of teaching, and encompasses all subjects related to engineering accounting, management and marketing.

The last portion of base engineering education (825 hours) provides students of previous engineering subjects with more advanced knowledge and skills, including some new ones, such as Total Quality Management and logistics.

Graduates of the Eco-Engineering specialization are being prepared to solve interdisciplinary engineering problems oriented towards ecological aspects.

In the Eco-Engineering specialization, the study programme encompasses two groups of courses: core and optional ones [6]. The programme for diploma profile “Eco-Engineering” is presented in Table 1, showing both diploma profiles of Eco-engineering courses.

Table 1 Eco-Engineering courses [6, 7]

Core courses	Optional courses	
	Eco-Engineering profile	Engineering of Recycling profile
<ul style="list-style-type: none"> • Ecology and sustainable development, • Legal and economical aspects of environmental protection, • Ecobalancing of objects and processes, • Life cycle management, • Eco-transportation and eco-logistics, • Technological processes of recycling, • Recycling in design of products, • Designing of environment friendly technical objects 	<ul style="list-style-type: none"> • Environment management and eco-economy, • Environmental reports, • Environmental declarations, • Ecotechnology of water and wastewater, • Problems of cogeneration of energy, • Low-energy buildings and so called passive buildings, • Inventics and innovation theory, • Town planning vibroacoustics, • Engineering of ecoproducts, • Management of flow and services, • Zero-emissions technologies, • Informatic tools used in ecobalancing 	<ul style="list-style-type: none"> • Legal bases and systems of recycling, • Logistics of recycling, • Engineering of repairs, regenerations and modernizations, • Recycling of special materials, • Technological properties of polymeric recyclates, • Methods of examining of metals and plastics, • Health aspects of recycling

In the last academic year the students worked on their diploma theses. The range of topics was broad, and often involved complex technical problems. Some examples of the subjects of diploma theses are presented below:

- Methodology and sustainable environmental development indicators (ESI) of major mechanical technologies.
- Laboratory model of Savonius turbine – design and research; this diploma work was about design and construction of lab stand model of Savonius vertical axe wind turbine and the graduate designed, produced and examined with success the model

of the turbine, which now serves for the student courses in the laboratory of vibroacoustics.

- Energetic and material balance of functioning of car repair/service station.
- Analysis of usefulness of selected software tools for the purposes of eco-balancing of technical objects; this diploma work was devoted to analyze the usefulness of different software tools for ecobalancing of technical objects.

Generally, education process leads to prepare future engineers of Eco-Engineering for independent and creative work with all aspects of complex technical and organizational problems. The syllabus assures a combination of theoretical and professional knowledge in design of structures and technological processes, on the basis of general and specialized disciplines:

- general disciplines play an important role in the educational process, allowing students to gain necessary skills in theoretical analysis and synthesis of phenomena and processes in technical systems,
- specialized courses contribute, in turn, to a mechanical engineer's professional skills and knowledge.

The graduate of Eco-Engineering gains the ability of identifying ecological potential of existing and created technical objects, technologies and skills, in order to apply this knowledge to designing and managing objects and processes. Students will widen their horizons in following issues: recycling of technical objects, environment-friendly drives, material and energy efficient technologies, pro-ecological infrastructure of production, environment-friendly materials, eco-products, LCA analyses of technical objects and processes.

3 ECO-DESIGN IN VIRTUAL MECHANICAL ENGINEERING

Department of Machine Design Methods at Faculty of Machines and Transportation is focusing on engineering methods for object oriented design and processes. Methods of concurrent design are developed with detailed techniques of DfX, oriented towards manufacturing and assembling, costs and recycling. It is also research done in the field of virtual modeling of mechanical systems with the support of finite element analysis of structural and thermal problems, computational fluid dynamics, aeroelasticity, fluid structure interactions etc.

In the educational programme of specialization devoted to teaching future designers, called Virtual Mechanical Engineering, the course, called "Ecobalancing", was introduced. The main goal of this course is to give instructions how to use the specific tools devoted for eco-optimization of elements and objects in designing process.

Among specific topics oriented on ecobalancing, in the designing processes are discussed:

- assumptions of designing of new products and technologies, based on environmental costs in the whole life cycle,
- the place of ecodesigning in the modernization of existing objects,
- ecodesigning methods and applied tools,
- risk and hazard optimization,
- Life Cycle Assessment and Life Cycle Management application in the designing,
- key spots of decision making,
- environmental evaluation of designing solution using calculation tools.

Additionally following aspects of ecolabelling are also put into the programme of ecobalancing for the students interested in designing of technical objects:

- environmental image of the product,
- characterization of environmental impacts generated in the life cycle of the product,
- legal regulations in the area of ecolabelling,
- conditions of environmental label application in relation to different categories of the objects,
- sales of the ecoproduct,
- environmental information handling for the need of ecolabelling,
- guidelines of the ecolabelling for the enterprises.

4 ECO-DESIGN IN INTERNATIONAL SUMMER SCHOOL

The generation, exploitation and diffusion of knowledge are fundamental to economic growth, development and the well being of nations. On the other hand there is observed a societies' demand for sustainable development and high quality of products and services. With this perspective it is essential to provide an education to perform research in technology, which meets all those expectations [8]. Central to this is the necessity of creating and implementing the innovations. Over time, the nature and landscape of innovation has changed but the need of innovation is constantly increasing.

Specific form of eco and innovation education at the Faculty of Machines and Transportation is one-week initiative called "International summer school of solving technical problems in mechanics, material sciences and transportation" (ISS). As a one-week workshop it is organized in September and gathers students from Poland and abroad, companies representing different branches of industry and the university staff. Students working in small groups solve mainly real technical design problems, given by companies. Better understanding of the subject is supported by the visits in companies, where students consult the practical aspects of their solutions. The university staff in form of consultations provides the methodological background of projects. In the final presentations the students' potential can be seen in their design proposals, which are very often highly creative. ISS as a teaching tool plays a significant role in design education process for graduate students in Poznan University of Technology. Other interesting parties, also profiting from ISS, are of course companies and university.

5 CONCLUDING REMARKS

The conclusions concerning the three eco-design education approaches described above are as follows:

1. It was done the first step in Poland dealing with introduction of eco-design elements into the technical university curriculum. All these three forms were accepted by students in PUT.
2. The interest of students to study eco-engineering confirm the need for education of newly profiled engineers, who can face the challenges of eco-business. Eco-Engineering specialization is chosen each year by at least 10 students, among many other possibilities.
3. Ecobalancing started to be the introduction to eco-designing at Virtual Mechanical Engineering specialization, giving the students the tool for choosing environmental friendly solutions in designing process. This tool is widely used by graduates,
4. International Summer School attracts each year some 40-50 students from Poland and abroad, giving them the chance to solve the technical problems with the use of modern methods, including environmental issues. The reasons of success are as follows: students find ISS as a good opportunity to familiarize with practical

problems, use their knowledge and start to use their creativity by solving real design problems. This is a competence training for them, leading to even patented solutions. The solved projects are often an inspiration and motivation for students to their master or even doctoral thesis.

5. To sum up, the different forms of introduction of eco-design issues to the curriculum in PUT is the opportunity to enlarge significantly the circle of students to be acquainted with these environmental issues.

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