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Contents

Part I
Educating Students in Sustainable Engineering (II)

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Trends in innovative product design and manufacture require a paradigm shift in traditional methodologies because they are becoming increasingly ineffective for applications built for sustainable futures. The well-known concept of sustainable development, which is based on sustained growth for environmental, economic and societal benefits, is brought into focus for highlighting the significance of product design and manufacture. The technological challenges posed by the need for implementing innovative design and manufacture call for a need for developing and implementing new educational and training programmes for next generation design and manufacturing engineers. We aim at tackling these challenges with a proposed new curriculum at five different levels. Perpetual material flow and multi life-cycle/multi-use self-healing materials, innovative product and process design and development are in the core of the proposed design for sustainability educational programmes.

Keywords: product design; manufacturing; sustainability; education; curriculum

This paper presents a new method for evaluating product designs at their early stage of development according to different criteria and a case-study-based project. The goal is to select among imprecisely defined design alternatives in a multicriteria context, as is required for taking into account sustainability considerations. Imprecision—the most dominant type of uncertainty during the early stages of design—is defined as designer's preferences for a range of values in the design variables; it can be modelled by fuzzy numbers. The project involves the analysis of three design concepts of a vacuum cleaner (paper bag, plastic bin with filters and plastic bin with cyclone). Using the proposed multicriteria decision method different End-of-Life (EOL) strategies for the three concepts are investigated from the viewpoint of four criteria (one economic and three environmental). Sensitivity analyses are performed to identify the parameters influencing the robustness of the decisions. The case study will show that the 'right' decision (i.e. the selection of the best design alternative) depends on the trade-off between criteria performances.

Keywords: life cycle design; strategic design; engineering design

There is a need to create an awareness of Life Cycle Engineering and EcoDesign in Engineering students. Topics covered in an LCE/EcoDesign course will create an awareness of environmental impacts, especially in other design course projects. This paper suggests that an awareness of product impact upon the environment must be created at an early stage in undergraduate education. Deciding what to include in an LCE/EcoDesign Course can be difficult because there are many different views on the subject. However, there are more similarities than differences. All LCE/EcoDesign Engineering courses have the ultimate objective of decreasing the environmental impact of a design. It has been observed that 70% of product costs are decided at the design stage. This can be extended to environmental impact, where it can be observed that, the design is correct, at the beginning, the environmental impact can be reduced by an estimated 70%. An LCE course does not need a high mathematical content and can give undergraduate students exposure to information that can be used in product design courses as they progress through university. The general content of such a course is suggested in this paper.

Keywords: life cycle; sustainable engineering; course content

A course in Life Cycle Assessment has engaged graduate students in engineering, forestry, business administration, and public policy at the University of Washington since 2003. The course pedagogy is project-based and supported by discussion-rich lectures that provide 'just-in-time' knowledge for student projects. Project feedback is provided through three interim reports, the first describing the goal and scope of their project, the second describing and presenting their inventory analysis and the third describing their impact characterization. The final report combines these three interim reports (with responses to instructor comments), and adds the student's interpretation of the results. Students are encouraged to select projects related to their graduate research, which has contributed not only to the student experience but also to an understanding of LCA in research labs throughout the university. Although student projects are limited in scope and by simplifying assumptions, computational nuances and all steps in the LCA process are implemented.

Keywords: Life Cycle Assessment; LCA; project-based learning

Most sustainability problems are system problems (for example, transport or food consumption) and almost insoluble without completely new ways of thinking. To address sustainability issues, which in broad terms are the key issues of our times, designers need to be able to understand design problems in context, envisage and describe better future systems and then design products that could be part of a new improved system.

This paper introduces a framework for the definition of sustainable design projects. The paper then uses this framework to describe the development and delivery of a sustainable design project to second year Product Design students whose programme of study spans the disciplines of engineering, the visual arts, business and psychology. The project was divided into a number of phases. In the first two phases students worked in teams to research and so build up a clear view of the context for a given problem area (for example, mobile phones); they then used this context as the basis for a definition of a vision of the future (10–15 years from now). Finally, each individual student defined a design brief for a product that might be a part of their team's envisaged future and developed designs that satisfied the brief.

In addition to developing design skills and knowledge, the project allowed students to gain first-hand experience of challenges to be addressed in the realization of sustainable products. A key challenge demonstrated through the project was that the future will be about understanding product design in as wide a sense as possible; it is this context, and the derived understanding that comes from design research, that will be key in the future.

Keywords: sustainable design; product design; interdisciplinary teams

In order for society to achieve a sustainable future, engineers must equally consider issues of the environment, society, and economy. For years engineering education has taken a behaviourist approach, assuming a student's mind is an empty slate that needs to be filled with a finite amount of knowledge, transmitted from teacher to student. Here we demonstrate how a team of engineering and public policy students can construct their own knowledge while developing sustainable construction materials that could be used in the developing world. Our education model is assessed by several direct and indirect methods; including evaluation of course deliverables, student surveys and comparison to more traditional design projects.

Keywords: constructivist education; engineering; social science; public policy; sustainable development; pozzolan; cement; developing world

The paper addresses sustainability within the context of an undergraduate research project located outside Yogyakarta, Indonesia that involved students from the Purdue School of Engineering and Technology (IUPUI). The project focused on the architecture and sustainable building practices of this far eastern region of the world and in particular a shop house located in the art market. This paper discusses how the conceptual design of this shop house was created under the direction of sound, local, sustainable building practices that were obtained from survey data distributed to Indonesian designers.

Keywords: architecture; sustainable; international; architectural education; livelihoods; Indonesia

A wide variety of engineering students and professionals are interested in sustainability issues, but do not come from environmental backgrounds. As a result, courses designed for such students must strike a balance between providing useful environmental and sustainability knowledge and yet remain appropriate for those coming from a non-environmental background. This paper outlines such a course that has been taught and refined for the last three years in the Faculty of Engineering, University of Windsor, to a mixed class of civil, mechanical, environmental and industrial engineering graduate students. The paper provides examples and descriptions of what was done in the class and their effectiveness for teaching sustainability, as well as what difficulties were encountered.

Keywords: Education; engineering; environment; graduate course; professional development; sustainability

Industrial processes have different levels of impact on the environment and there is a need to foster knowledge of the environmental consequences of industrial activities. One of the ways of achieving this is by the application of the concepts of industrial ecology (a multidisciplinary research approach) to industry's day-to-day activities. Another possible way of pursuing this goal is to use environmental education as a tool for increasing awareness with regard to the social, political and economic relevance of, as well as the need for, environmentally sound industrial methods. Technical universities in the Baltic Sea region, under the framework of the BALTECH consortium, have decided to develop and implement a new MSc Programme in Environmental Management and Cleaner Production, based on an integrated approach to industrial ecology towards current and long term/strategic environmental goals. The programme focuses on technologies and concepts in environmental planning and management for sustainable industrial development. The programme began at Kaunas University of Technology in September 2002. The Institute of Environmental Engineering (APINI), which is the main organisation responsible for the Environmental Management and Cleaner Production MSc programme in Kaunas University of Technology, treats the multidisciplinary approach as the main priority in the design of curricular models and views it as a strategic device in training graduates who will succeed in the labour market. This paper outlines a new educational model that provides students with both a systemic perspective and a more technical attitude for handling environmental multidimensionality.

Keywords: curriculum development; environmental knowledge; awareness and actions; sustainable development; multidisciplinary research

Undergraduate engineering students have an important role to play in curbing greenhouse gas emissions and global warming. This paper tackles the societal concern of carbon dioxide emissions from power plants by introducing a simple junior or senior-level experiment that illustrates the phenomenon of gas adsorption as a tool for carbon dioxide separation from a gas stream that simulates power plant flue gas emissions. The experiment familiarizes chemical and environmental engineering students with the characteristics of gas separation by adsorption with activated alumina, zeolite 13X, and soda lime, while highlighting its potential for carbon dioxide reduction at ambient conditions and at a relevant concentration (partial pressure) of carbon dioxide. This should be of interest to faculty who teach unit operations-type laboratory courses; they will find it an excellent 'sustainable engineering' hands-on addendum to traditional curricula.

Keywords: carbon dioxide sequestration; gas adsorption; mass transfer; unit operations experiment

Developing in students a deep understanding of the concept of sustainability, and how it applies to engineering, is a difficult task. Here we introduce a novel framework for developing online roleplay simulations for teaching sustainability principles to engineering students, based on a systems model of sustainability. Application of the framework is illustrated with a case study, the Mekong e-Sim, which is an online roleplay simulation set around proposed development issues in the Mekong region of South-East Asia. In 2005, the e-Sim was centred on public inquiries into two proposed development issues, including the Nam Theun II hydropower dam in Laos and the proposed Lancang project in China. The latter includes the blasting of rapids to improve river navigation and the construction of a large hydropower dam. The recommendations in relation to the proposed developments were to proceed with the Nam Theun II dam, but that approval of the Lancang project was unlikely. An evaluation of the 2005 Mekong e-Sim revealed that there was a high degree of interaction between roles about the social, environmental and economic issues surrounding the two proposed hydropower projects, and that the e-Sim was able to develop (i) awareness of the complexity of, and need for, sustainable development, (ii) the ability to see engineering issues from multiple perspectives, (iii) an understanding of the political, social, economic and scientific dimensions of engineering decision-making and (iv) a better understanding of the meaning of sustainable development.

Keywords: online roleplay simulation (e-sim); generic skills; sustainable development; Mekong e-Sim; environmental engineering

ED-WAVE is an electronic learning tool created under the Asia-Link Programme, a programme dedicated to the promotion of regional and multilateral networking between higher education institutions in European Union (EU) member states and South-East Asia and China. ED-WAVE has been developed by a consortium of three Asian and three European universities. It is an innovative product of high interdisciplinary action providing theoretical information, worked out examples, computer graphics, case study database and case base reasoning in the field of wastewater treatment and water reclamation. ED-WAVE aims also to provide a sustainable platform for ongoing learning on technologies improving water quality and efficiency by exposing the target groups to real-life applications through virtual industrial and municipal environments. The target groups involve students at undergraduate and graduate level, educators and young professionals working in water and related industries. The tool is going to be used in select courses in each institution as part of curriculum development.

Keywords: educational software; environmental engineering education; wastewater technologies; wastewater treatment animations

Part II

Contributions in: Engineering Education Research, Engineering Design, Power Electronics, Chemical Engineering, Biomedical Engineering, and Microelectronics

Student-centred as well as lifelong learning, require vastly different study skills than those needed to succeed in today's mainly lecture-based engineering classes. This paper presents the result of a survey that assessed the study skills of engineering freshmen. Because surveys do not capture how students actually use their study skills, this study was carried out to discover some facts related to time management. Data collected from 295 students taking Chemistry 101 focused on 30 online homework sets. It was used to search for patterns in the routine that students develop while entering answers as many times as they desired. The aim of the effort was to assess if it could be possible to monitor student habits whilst supporting them, to recognize and overcome detrimental time-management skills early in their college career. The result of the data analysis did point to the fact that procrastinators who achieved poor final grades in chemistry can be identified based on their homework submission patterns. Furthermore, it confirmed the common belief that A students tend to finish their homework earlier and, in this case, also use fewer entries to complete when compared to C and D students.

Keywords: Student-centred; lifelong learning; lecture-based; freshmen; survey; time management; chemistry; submission patterns

This paper discusses how the use of virtual reality technology impacts student learning and faculty teaching methods, both individually and collectively. Experiences concerning implementation and interactions between instructors and students are presented. Surveys were conducted to collect students' responses concerning the use of VR in design and graphics classrooms. Students noted that the use of VR offers advantages over other learning methods. Students' spatial skills were significantly improved after a semester of virtual reality-based instruction. Some challenges in implementing virtual reality in classrooms are also discussed.

Keywords: virtual reality; visualization; design and graphics

With the advent of information and communication technologies (ICTs) learning strategies and methods have changed. Academics and students are also changing the way they teach and learn in an effort to adapt to these new methods. The aim of this paper is to compare students' perception of traditional vs. blended learning methods in the Industrial Plants course, which is part of the Degree in Industrial Engineering and Scheduling taught at the Technical University of Catalonia (UPC). A questionnaire was developed and given out to 163 students enrolled in the course, over a period of two academic years (2004–2005 and 2005–2006). The findings of this study provide practical guidelines for the implementation of new teaching methods.

Keywords: blended learning; learning methods; assessment

Virtual and distance laboratories extend the application area of the web. This leads to an openly integrated environment which facilitates the sharing of not only educational material but also hardware and software resources. This paper investigates distance learning with particular attention to experimental work. DelftWebLab provides the user with a practical experience in Power Electronic education. It was designed based on cutting-edge ideas and had clear targets.

Keywords: distance education; power electronics

Being a student is usually followed by working in industry and the transition from one to the other may be challenging. In our research, we conduct a lengthy survey and ask chemical engineers, who have graduated from university in the past 10 years, to evaluate the education they received in respect of expectations in industry. We received 200 replies and quantitatively analysed the results. With information from the survey, we turned our attention to our education system and the curriculum, suggesting some changes accordingly. Our goal with this work is to propose a system that prepares students for what they might encounter in industry. Also, we would like to suggest ways to give them better exposure to industrial applications, needs and most recent developments through industry-related coursework. As a result, our ultimate aim is to find ways to reconnect the tenuous ties between university and industry and to intensify the exchange between chemical and related (pharmaceutical, biotechnology, etc) industries, which, in the long run, will result in mutual benefit for both academia and students.

Keywords: Chemical engineering education; industry-university collaboration; curriculum change

Biomedical signal processing and analysis is a field of great importance in current medical practice. MATLAB is the most commonly used software tool for biomedical signal processing, visualization, editing, etc. This paper presents an initiative to teach Doppler ultrasound blood flow signal analysis to biomedical engineering students. The approach was based on illustrative applications that highlight the performance characteristics of the signal processing methods (classical, model-based, eigenvector and time-frequency methods). Following a brief description of the signal processing methods, applications of the methods to the Doppler signals obtained from the internal carotid artery and ophthalmic artery were done by means of a series of MATLAB functions. The functions involved in signal processing and wavelet toolboxes of MATLAB can be used to analyse the signal under study. The author suggests that the use of MATLAB exercises will assist students in gaining a better understanding of the various signal processing methods in blood flow investigations.

Keywords: Doppler ultrasound blood flow signal; signal processing methods; MATLAB toolboxes

*This paper is an overview of the activities performed in the framework of the European IST project EuNICE-Test (**Eu**ropean **N**etwork for **I**nitial and **C**ontinuing **E**ducation in VLSI/SOC **Test**ing) using remote automatic test equipment (ATE)), addressing the shortage of skills in the microelectronics industry in the field of electronic testing. The project was based on the experience of the common test resource centre (CRTC) for French universities. In the framework of the EuNICE-Test project, the existing network expanded to 4 new academic centres: Universitat Politècnica de Catalunya, Spain, Politecnico di Torino, Italy, University of Stuttgart, Germany and Jozef Stefan Institute Ljubljana, Slovenia. Assessments of the results achieved are presented as well as course topics and possible future extensions.*

Keywords: microelectronic circuit test; remote on-line test; digital test; mixed-signal test; memory test, automatic test equipment; test education.