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RETHINKING PRODUCT DEVELOPMENT EDUCATION STREAM WITHIN AN E-LEARNING ENVIRONMENT

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Introduction

Faculty of Mechanical Engineering and Naval Architecture has educated about 90% of master students in mechanical engineering and naval architecture in Croatia. Since the enrolment of the first generation of students back in 1919 faculty trained engineers to support the technological and economic development of society. It provides students with training in a wide range of engineering fields among whom the two: engineering design and energy and process engineering gain most interest of prospective students. Following the changes in engineering theory and practice the faculty constantly updated existing courses to keep alongside with the latest developments in technology and, where necessary, introduced new courses to meet the changes.

A new Product Development education stream has been introduced within the implementation of Bologna framework scheme fostered at the national level. The aim was to implement more reflective teaching and learning, moving the focus from a procedural approach to reflection and conversation for gaining understanding and perception. The resultant courses were created aiming for a comprehensive lifecycle perspective of the disciplinary knowledge as well as development of student competencies such as responsibility, creative thinking and group dialogue. Assessment was pursued by a combination of oral presentation and written and project based examination. E-learning support tools have been introduced with the new group of courses in order to enhance availability of courses' material and communication with teaching staff.

In this paper we will present e-learning implementation of one of the course from the new product development stream that has been awarded as the best e-learning course at University of Zagreb in 2013. The general conclusion to be drawn is that this type of learning was perceived as very different for the students compared to earlier courses enhancing engineering students' interest for product development, increasing understanding for noncore-engineering aspects of product development (innovation, eco design, ergonomic, etc.) motivate self-learning and increase students' communication and presentation capabilities.

Product development stream of courses

The new product development education stream was built based on the consideration about requirements for the modern engineers that are well documented in literature (Crawley et al., 2007, p.2; Dym et al., 2005) and are results of the discussions with Croatian and Slovenian industry. Especial important insights for new product development education stream were results of the several workshops on design education held during the series of the international design conferences DESIGN (http://www.designconference.org) from 2000 – 2012 in Cavtat, Croatia.

Engagement in all phases of product lifecycle, complexity and multidisciplinary approach, teamwork, creativity and innovation are recognised as the main descriptors of the working environment for the modern engineers. Therefore instead of the existing education o the engineering methods and tools, the focus of the new education approach has been moved toward the whole product development process including engineering, management and ethical issues (Figure 1).

In parallel to the product development methods stream, the courses related to the computer aided support of the product development methods have been also introduced and developed. The new product development group of courses have been further developed accordingly to the upper part of the Figure 1 into three courses:

- **Introduction to Product Development.** The goal of the course is to give an introduction to multidisciplinary aspects of product development and innovation. During this course students should familiarize themselves with basic terminology and methodology that could be used in product development projects. Practical problems should be considered in cooperation with companies in order to simulate real product development situations.
- **Engineering Design and Product Life Issues.** The course aims at creating an understanding of the activities of innovation and technical innovations. It helps the students to comprehend innovation techniques and be able to create innovative technical solutions by their use. The use of the techniques is focused on product life oriented design and product life systems by introducing different design for x methods (environment, ergonomics, manufacturing, safety, services, etc.).
- **Integrated Product Development.** The goal of the course is to learn principles of the project integration, experimentation and virtual development in order to consider product development in the light of the business strategy of the company. The central part of the course is product development project where students will develop the new and innovative product for different areas (health, environment, agriculture, etc.) and deliver full technical description for it in order to be ready for prototyping.

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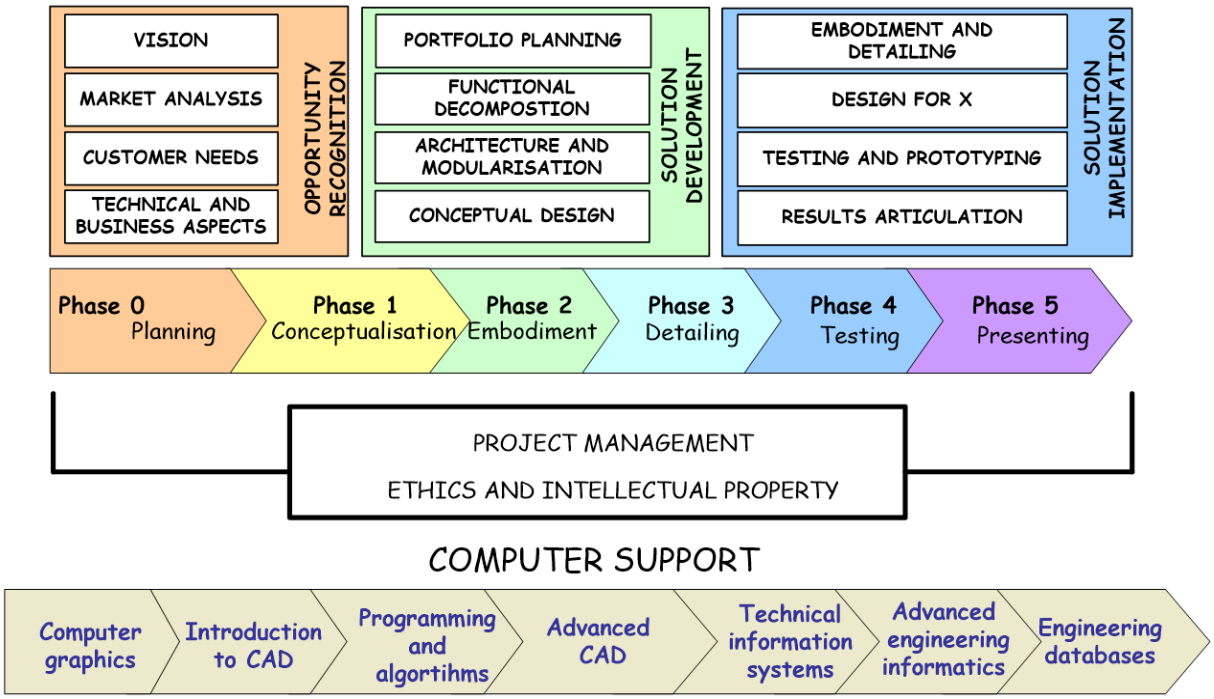

Figure 1. Educational model of Product Development Process accordingly to Ulrich & Eppinger (2004, p.7)

Pedagogical-didactic approach applied

Pedagogical –didactic approach that has been used for the development of the whole stream is based on the learning by practicing as is defined within CDIO (conceive, design, implement, operate) framework (Pahl et al., 2007) for future engineering design students. The approach is realised as combination of the classical lectures in the classrooms including real world examples analysis, self-learning by using different types of resources and activities, simulation tasks based on the gained knowledge during the exercises and self-preparation for the final examination. The key interactive elements of the courses stream are synchronous and asynchronous discussions as the main medium for knowledge and information exchange between teachers students.

Two main types of subject matter acquisition applied in courses are:

- Classical acquisition that includes learning activities in classrooms and laboratory like lectures, practical exercises for individual and teamwork based problem solving.
- On-line acquisition that includes access to the learning resources divided by didactical units, materials for self-learning that includes advance topics in the form of the articles and video materials, self-assessment quizzes individually created for each student and tools for information and knowledge sharing (discussion forums, wikis, on-line dictionaries, etc.).

Accordingly, didactical model that is applied for stream of courses is combining classical group learning and self-learning in order to enable for each student maximal flexibility and

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autonomy in learning process participation. The key idea of the courses development is to additional emphasise active role of students in knowledge exchange process undergoing during the courses execution. For each course the expected learning outcomes have been defined as a starting point for course structure development (Table 1). In order to support that, the learning process in the course stream is designed to enable gradual learning by experience, based on individual problem based tasks in the beginning of the first course up to project based team learning at the end of the last.

Table 1: Learning outcomes of course stream

Introduction to Product Development	Engineering Design and Product Life Issues	Integrated Product Development
To be able to understand the technical and business aspects of the product development process.	To be skilled in practice of defining and solving engineering problems.	To be skilled in market analysis and recognition the opportunity for new product development.
To be skilled in implementation of gathering data from customers and establish technical specification.	To be able to understand human behaviour in product lifecycle.	To be skilled in patent search and innovative problem solving.
To be skilled in creating product functional decomposition.	To be able to understand manufacturing and assembling issues for product development.	To be skilled in modelling the product in conceptual phases of the product development using standard languages and tools.
To be able to participate in engineering problem solving.	To be able to understand environmental effects in the product life cycle.	To be skilled in embodiment and detailed design of the new product.
To be able to understand the principles behind product modularisation	To be able to understand ergonomic aspects in product lifecycle.	To be able to plan simulation and experimentation of the solution in each phase.
To be able to understand ethical and intellectual property issues in product development	To be able to understand safety issues in product lifecycle.	To be able to articulate and present results of the development project.
	To be skilled in implementation of product-service systems.	

Engineering design and product life issues course

The courses stream is realised as set of the e-courses within Moodle LMS environment. The main motivation for application of the e-leaning methods in course stream was to increase the quality and efficiency of teaching by features that enable combination of the classical teaching methods and information technology. Specifically, the *Engineering design and product life issues* course was developed to enable active role of teachers and students in learning process and support both roles during the course execution. The e-course is divided in 15 thematic

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units (represented by cloud of keywords shown at Figure 2) that are supported by different interactive tools available within the environment.

Figure 2. Engineering design and product life issues keywords

The content and activities within each thematic unit is structured in progressive learning modules with following internal structure supported by different interactive tools:

- Resources with theoretical background with application to the examples acquired from real world.
- Self-assessment activity for students to assess current level of unit understanding and a feedback.
- Task (individual or teamwork) for practical application of the acquired knowledge and practicing learned methods and tools. For one of the unit, task is to disassembly real product in order to analyse requirements form the last phase of the product life related to recycling and propose redesigned solution for improvement of that phase (Figure 3).

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Figure 3. Students and teachers during disassembling exercise

Main tool for supporting interactive discussion during the course is forum. There are several different forums implemented: general forum for news related to the course execution, team based forums for group activities during the exercises, and discussion forums for "*those who would like to learn more*". Discussion forums are focused to the additional themes not included in 15 thematic units and enable students to extend their knowledge in topics like future of engineering design, design thinking or design solutions inspired by nature. They are provided with additional resources, and requested to submit essay based feedback on the topic that is evaluated by other students.

In order to additionally explain main concepts within the course, wiki based dictionary of the main concepts is provided and available for upgrade, as well as list of the famous mechanical engineers. These activities are voluntary with the goal to extend general level of technical culture among the students, and are very well accepted by students. Additional wiki is set up to provide general course info including rules of engagement, individual and team work, explanation of the grading scheme and links to the relevant web sites and literature. Calendar is used for announcing all important deadlines during the course execution.

Students' feedback is enabled by means of the evaluation form which enables them to assess content and methods applied in the course, quality of the learning resources, examination process and teachers.

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Discussion

Feedback after implementation of the all described features was very positive. Since the course was updated from the academic year to the academic year, it is reasonable to believe that it has reached the optimal ratio of what is offered to the participant in contrast to the requested results from them. During the first years of implementation students complained sometimes about amount of the different resources and activities that were necessary to process in order to pass the course. They needed some time to adapt to the extra activities that are not usually part of the engineering curriculum. Based on those suggestions, the course was tailored to the current extent.

Access statistic during the last execution year (2012/13) is showing that during the period observed was recorded more than 15,000 individual actions on different resources and activities conducted by 50 users. Transformed into the language of weekly actions, each user participated in about 300 actions in e-learning environment per week only for that course. This confirms continuous execution of the learning process during the whole period, partially influenced by intentional causal planned sequences of teaching activities. Discussion forums itself attracted more than 600 activities by half of the all involved users. Even the self-assessment activities were not additionally graded they were regularly used by 75% of the students that described them as especially important for understanding the each learning unit.

90% of the students that provided the feedback by anonymous survey described the teaching methods and learning resources as satisfactory and appropriate. 70% of them confirmed that they spent about 120 hours (4 ECTS equivalent) in order to successfully pass the course. 80% of them are satisfied with overall learning process and course as a whole. They particularly liked integration between the classical learning and practical task with diversity of the online resources and learning activities.

Conclusion

The implementation of new course stream on product development significantly differs from traditional engineering education that was practice before at our institution. Although students and teachers have been satisfied with the outcomes the main features of the product development students' education are still hard to address with e-learning technology. From our experience, one of the most important one is related to the practical work on analysis of the real products from different perspectives that is usually conducted in workshops. The similar issues are related to the laboratory focused work and experimentation. Learning by doing like for example during disassembling phase at end of product life cycle develops specific skills and experience that are hard to replace in virtual environment. Besides that, different aspects of the product development process are supported by different engineering software tools that are hard to integrate with LMS. Somehow those problems may be considered as the core of engineering education and leave the space for the future research in the area.

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