TEACHING AN ENGINEERING DESIGN COURSE IN AN INTERDISCIPLINARY INTERNATIONAL ACADEMIC VIRTUAL ENVIRONMENT

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ABSTRACT
The European Global Product Realisation (EGPR) course is designed to bring knowledge and skills in engineering education and to develop student's competences for industrial collaboration and realisation. To connect undergraduate learning with real life experience, an academic virtual enterprise has been created between Kesslers International, a UK based company, and final year university students from 5 countries, namely: the United Kingdom, The Netherlands, Switzerland, Slovenia and Croatia. Mixed international design teams use the most modern technologies and methods to develop concepts and prototypes of products for the core company, aimed to fulfil requirements of a global market.
This paper reviews the main aspects and impact of EGPR on undergraduate education at City University and the fulfilment of the four major requirements of UK industry for the education of engineers in the 21st century, namely: basic knowledge; skills; attitudes and; group work.
It further outlines what are the expectations from the course and how the undergraduate students from different universities, disciplines and backgrounds have combined theory and practice to achieve educational goals and produce an outcome which brings innovation and know-how to industry. The effects of the use of e-learning and videoconferencing systems in the realisation of the project are discussed.

Keywords: Academic virtual enterprise, educating engineers for industry, interdisciplinary design, engineering design competences, education and research

1 INTRODUCTION

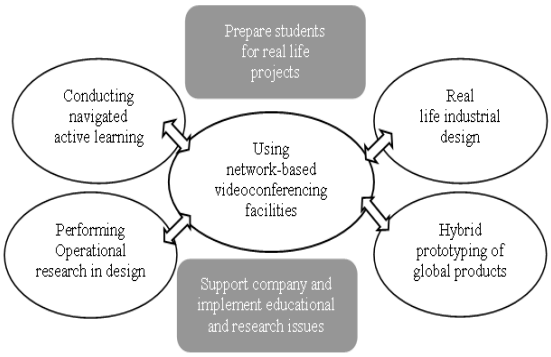
Two distinctive views on the development of engineering design competence can be identified. The first, often referred to as the reductionist view, assumes that design competence is nothing other than a set of basic design abilities typically addressed individually. The opposite is the holistic view, which sees design competence as a synergetic construct of generic human capacities, as explained by *[8]*. Various authors argue that design competences are built in different contexts, *[2]*. In the past, the emphasis was put on getting basic knowledge for a designer to posses and use. At that time, students were taught in a way which helped them to pass examinations rather then to solve real life design problems with success. Recently, however, design problem solving capabilities have been given growing attention and various aspects of design

competence have been investigated and addressed. Many authors analysed industrial and pedagogical requirements of competences that students should have and how to obtain these in university engineering design courses. *[9]*, identified the three most important characteristics of competence, contextual, behavioural and problem oriented. They argue that there is no universal deliverable for engineering design education but rather that specific design know-how should be conveyed to students depending on the goals, content and form of a design.
The presence of competence can generally be observed in terms of its operation to enable design problem solving. For instance, *[4]*, put these in categories such as teamwork, information gathering, problem definition, idea generation, evaluation and decision making, implementation, and communication. They claim that these need to be developed by introductory design courses and suggest that other competences are to be addressed in higher design courses to suit specific disciplines. In all cases, knowledge remains important, but it is more often considered as an element of engineering design know-how, rather than as the only goal of design education. *[10]*, identified nine competences that are requested to be developed by industrial design engineering education, and grouped these as core and meta competences.
Horvath *[8]*, analysed the connection between personal know how and that contained in a community of professionals. *[1]* concluded that communal competences are becoming more important for industry nowadays. Typically, communal competences are multi-disciplinary collaboration, dislocated communication, balanced comprehension, and resource sharing, while the personal competences are creativity, communication, integrative thinking, problem solving, learning from examples.
In this rapidly changing world, the future of many companies depends on globalisation of design, manufacturing, servicing and sales. A study published in March 2006 *[5]*, outlines an industrial view. The main message of the report can be summarised as; *"... At the heart lie the defining and enabling skills that form the core competencies of the engineering graduate... Three roles are identified. Firstly the role of engineer as specialist ... Secondly, the engineer as integrator reflects the need for graduates who can operate and manage across boundaries, be they technical or organisational, in a complex business environment. Thirdly,...the critical role engineering graduates must play is providing the creativity, innovation, and leadership needed to guide the industry to a successful future. This is a vision of the future that underlines the vital importance of undergraduate engineering education to the UK engineering industry..."*.
The organisers of the EGPR course recognised the importance of above requirements and hence, the holistic view of engineering design education has been adopted and followed in the course. This year students need to respond to the brief set by the project's industrial partner, specialist design and manufacturing company Kesslers International: to design and build a Point Of Purchase (POP) display for male grooming products that will see high profile commercial use by their client. This paper analyses the methods applied in the EGPR course and evaluates these against the views of engineering students, academics and the industrial partner involved in this year's project.

2 STRUCTURE OF THE EGPR COURSE

The EGPR course which started in February 2007 is the seventh in the series of courses. The research focus is directed on the integration of undergraduate education and industrial research. The educational focus this year is on design integrated research for customer oriented products while, from the industrial point of view, the emphasis is on

the fulfilment of customer requirements in the fashion and beauty industry. In all to date courses, no only have the conventional elements of design competence been considered, but also those which are essential for future professional practice in virtual enterprises. The course is conducted completely through internet based video conferencing systems and the design teams are formed of couples from collaborating universities.



As shown in Figure 1 the aim of the course is to prepare engineering and design students for real life design projects as well as to support the industrial partner.

The basic pedagogical concepts, educational constructs, organizational framework, course content, achieved results of, and early experiences with the previous EGPR courses have been reported in former publications by course organisers *[6]* and *[7]*. The list of universities and companies who took part in the courses as participants, and the educational and research goals are summarized in Table 1. Interested readers are advised to refer to papers and articles such as *[3]* and *[7]* for specific details.

Table 1 Educational and Research goals of some EGPR courses

Year	University participants	Core company	Educational focus	Research focus
2002	UoL, EPFL, and DUT	LIV Postojna, Slovenia	Redesigning and prototyping for global market	Dislocated cooperation in academic virtual enterprise
2003	DUT, UoL, and EPFL	De Vlamboog BV, the Netherlands	Conceptualization and prototyping product for a core company	Project oriented learning in virtual environment
2004	EPFL, UoL, UoZ, and DUT	De Vlamboog BV, the Netherlands	Combining operational research and product conceptualization	Navigation of active learning
2005	EPFL,UoL,UoZ CUL, and DUT	AVIDOR, Switzerland	Human- and environment-centred product development	Development of holistic design competence
2006	EPFL, UoL, UoZ, CUL, and DUT	NIKO, Slovenia	Human centred product development for specific market	Design for the bottom of the pyramid
2007	EPFL, UoL, UoZ, CUL, and DUT	Kesslers International, UK	Design integrated research for customer oriented products	Integrating undergraduate education and industrial research
Abbreviations: EPFL - Ecole Polytechnique Federale Lausanne, Switzerland; CUL – City University London, United Kingdom; DUT - Delft University of Technology, the Netherlands; UoL - University of Ljubljana, Slovenia, UoZ - University of Zagreb, Croatia				

A comprehensive review of the research performed during the course in 2005 on development of holistic design competences is reported in *[8]*. Based on past

experiences and information from literature, it appeared that the design competence is a combination of five capacities. These are knowledge, skills, capabilities, attitude, and experience. They are all strongly connected to provide the intelligence, knowledge basis, and problem solving resources required for design competence. Design knowledge relates to all subjects required for problem solving, which may be related to and/or independent of the problem at hand. Design skills are learned abilities to perform a design action or execute a process. Both of these result from experience. Design capabilities are required to perform a function; attitude is a way of thinking, while the experiences are actual observations of solving practical problems. All five capacities should be equally emphasised in the educational programs in order to develop design competences for future engineers and designers.

3 RESEARCH METHODOLOGY

In order to explore the effects of the EGPR course at City University, two sets of questionnaires were prepared for participants in the course. The first was released during the first project review at the time students presented findings of the operational research. Being prepared in the early phase of the project, this paper reveals only the expectations from the course. The second questionnaire will be released at the end of the course and the final findings will be published consequently.

The questions that the students were asked fall in three categories; i) relevance of the course to industry and education ii) competencies that they were hoping to gain and iii) preference in the use of communication tools and working in groups.

Academics and organisers of the EGPR course, commented three aspects of the course, i) how closely they considered the course to be connected to industry and other courses at the University, ii) what competencies they expected students to gain and iii) how much engineering content they expected this particular course would have.

The industrial partner was asked to give a view on i) the relevance of the proposed project to academia and industry, ii) skills they as employers would like to see in students, and iii) benefits they expect to have from the project.

A total number of 17 students, 8 staff members and 2 company members took part and answered the research questionnaire.

4 EVALUATION OF THE RESULTS

4.1 Relevance of the EGPR course to industry

29% of students thought it was very relevant, 59% said the project was relevant, while one student (6%) thought it has little relevance to industry.

Academics thought that the project has a good balance of understanding customer requirements and applying engineering principles, still combining a reasonable amount of traditional design. They commented that students might not have fully realised the engineering and design aspects and the design and productivity constraints this early the research phase of the project. They defined the project as very unique and felt that it might be the first step towards possible means of learning in the future.

The relevance to industry was also justified by the industrial partner, Kesslers International, who thought the course teaches engineering and design with a focus on building relation to consumers. In their opinion it gives a chance to bring leading edge engineering techniques into an industrial field. They have not worked as an industrial partner in academia before. In their view the partnership between academia and industry is very important. The chance of getting innovations from bright students and helping to increase the market share was stated as one of the reasons the company become

involved in the EGPR. Innovation, creativity and a fresh perspective are the three main aspects the company hopes to gain with the completion of this project.

4.2 Competences expected to be gained in the course

29% students expressed their hope to substantially increase their design skills while 41% hope to slightly improve it. This is reflected in the fact that 35% of the students felt that they hope to slightly improve their creativity through their participation in the project. 53% of students hope that they will slightly improve their organisational skills while 47% thought that the improvement will be substantial.

The basic intention of a project like this is to increase the team working abilities and communication skills of students. All staff members agreed with this and so did 88% of the students. Only two students thought that they had just slightly increased their team working skills so far. This might have been either due to their reduced involvement and commitment to the project or just because of the nature of the research phase. If Kesslers, as a company, were looking to employ a graduate, they would look highly for team working, communication and design skills.

53% and 71% of the students hope to slightly improve their oral and written communication skills respectively. 35% expect to substantially improve their oral skills while 18% are looking forward to substantially improve on their written skills.

The competences students hope to gain, the staff felt the students should gain and those Kesslers as an employer seek in a graduate were the same and are as follows: i) Team working and communication skills, iii) Decision making experience , iv) Organisational skills and attitudes and v) Time management capability. The competences rated the least expected to be gained during the project were design creativity and legal competences.

4.3 Use of communication tools and other benefits expected from the course

To get an overview of the types and frequency of use of communication tools the following table summarises the main findings. The first four tools enable real time student communication while the remaining two are for file sharing.

Table 2 Communication tools used and frequency of use

	Video conferencing	Net Meeting	Breeze	msn	Black board	E-mail
Never	6%	41%	41%	29%	5%	0%
Every Day	0%	0%	0%	24%	18%	59%
Once a week	24%	24%	12%	6%	12%	0%
Twice a week	59%	29%	12%	6%	18%	6%
More times a week	11%	0%	29%	35%	41%	35%
Other	0%	6%	6%	0%	6%	0%

47% of the students felt that they would work better in a team if they met physically while another 47% thought they would work equally well in a virtual enterprise. Only one student felt that the work in a virtual team is more convenient. Five of the student respondents emphasised that they prefer working with team members they meet physically as they are more able to understand their reactions to any suggestions or problems through their use of body language. Such language and emotions are often hard to pick up when meeting through video conferencing. This is also due to the time delay in response time but also to the time constraints of team members during their meeting times. Nevertheless, one respondent who felt that he/she works better in a virtual team emphasised that this is due to the fact that the commitment levels of all virtual team members are higher than members who meet face to face.

5 CONCLUSIONS

The preliminary results indicate that the EGPR course seems to be helping students to understand team working environment: Communication; Coordination and Cooperation as this is recognised by all participants in the course as the most important benefit.

All participants with the exception of one student found this year's project relevant to real life industry experience. In regards to this, it seems that the cultural diversity in the design teams is emphasised by the use of different design processes and the different levels of design education and experience at different universities. Since information technology was the only means of communication the challenge was to get the inexperienced users to build a level of trust and confidence within the teams and their relationship with their industrial partner. This challenge seems to have led to a better understanding of different cultural and work ethics that apply in each country and was highly appreciated by all the participating students.

Moreover, a project like this is likely to offer commercial awareness and an insight into the aims, structure and management of a business in order to make it collaborative and to survive in a global competitive market.

Distributed problem solving is found to be novel approach for most of the students participating in the course. They had to agree and follow a common methodology which sometimes takes them out of their 'comfort zone'. However, although half of the students preferred working in physical rather then virtual teams, creativity and motivation are still very much stimulated. There is a high level of willingness by members to invest a substantial amount of time – more than the required as set by the course outline - to realise the successful completion of the project.

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