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COMPETENCE DEVELOPMENT IN AN INTERNATIONAL PRODUCT DESIGN COURSE

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

Introduction

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 on what engineers who will operate in this century should be. The main message of the report can be summarised as; *"... At the heart 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…".*

Two distinctive views on the development of these competences 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 possess and use. At that time, students were taught in a way which helped them to pass examinations rather then to solve successfully real life design problems. 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 which industrial and pedagogical requirements of competences students should have and how to obtain these in university engineering design courses. *[9]*, identified the three most important characteristics of competence namely, 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 need to be developed by industrial design engineering education, and grouped these as core and meta competences.
[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 personal competences are creativity, communication, integrative thinking, problem solving and learning from examples.
The importance of the above requirements was recognised by the organisers of the European Global Product Realisation (EGPR) course and hence, a holistic view of engineering design education has been adopted and followed in the course. In the most recent round of the course, students needed to respond to a brief set by Kesslers International of the UK, the industrial partner, a specialist design and manufacturing company, who wanted to design and build a Point of Purchase (POP) display for male grooming products that would have high profile commercial use by their client. This paper analyses the methods applied in the EGPR course and evaluates them against the views of engineering students, academics and the industrial partner involved in this year's project.

STRUCTURE OF THE EGPR COURSE

The EGPR course which started in February 2007 is the seventh in the series since its inception. There have been several publications on the development of the course and its implementation, for example *[Horvath et all, 2004]*. Each course had a different educational and research goal. The research focus of the 2007 EGPR was directed to 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.

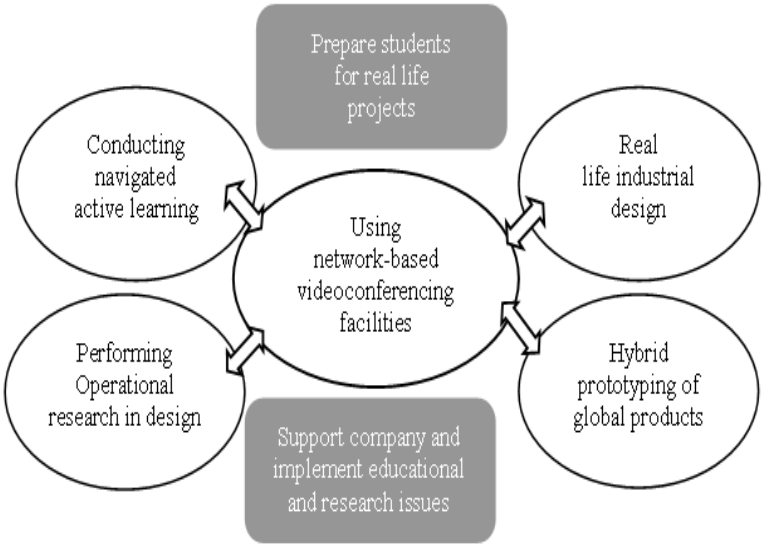

Figure 1 Main aims of the EGPR course

All courses to date offered not only conventional elements of design competence to be 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. The design teams are formed of couples from collaborating universities. As shown in *[6]* 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 results achieved of the basic pedagogical concepts, educational constructs, organizational framework, course content, and early experiences with previous EGPR courses have been reported in former publications by course organisers *[6]*. 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 the previous 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: CUL – City University London, United Kingdom;
DUT - Delft University of Technology, the Netherlands;
EPFL - Ecole Polytechnique Federale Lausanne, Switzerland;
UoL - University of Ljubljana, Slovenia
UoZ - University of Zagreb, Croatia

A comprehensive review of the research performed during the course in 2005 on the development of holistic design competences is reported in *[8]*. Based on their past experience and publications, the organisers of the course adopted the view that design competence is a combination of five capacities. These are knowledge, skills, capabilities, attitude, and experience, as shown in Figure 2. They are all strongly connected to provide the intelligence, knowledge basis, and problem solving capabilities required for solving real design problems.

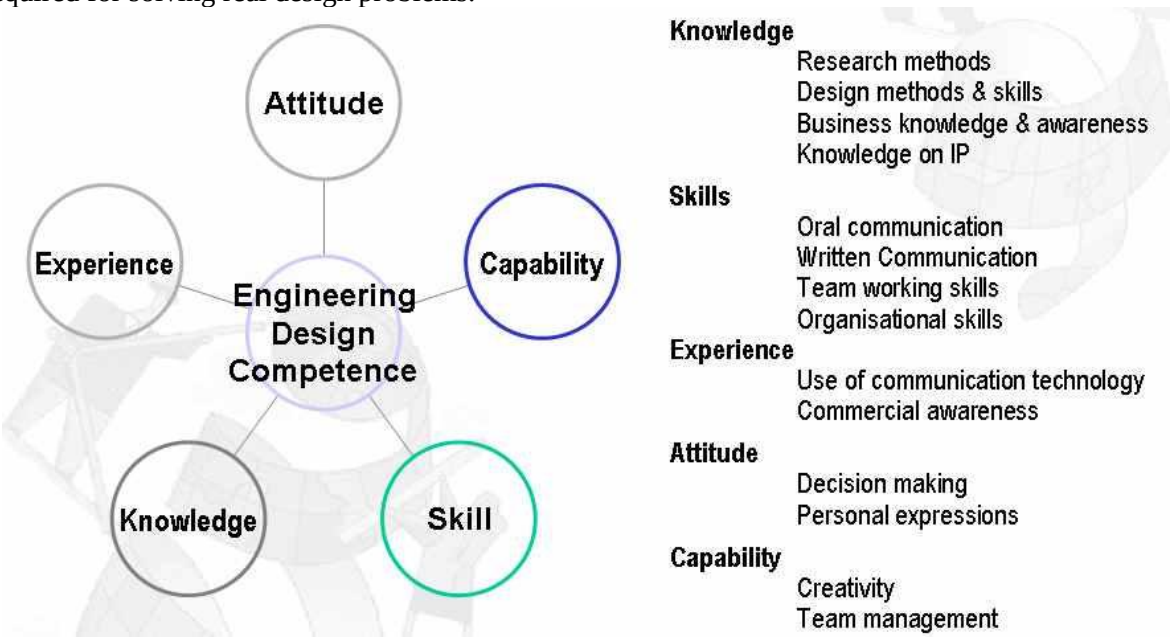

Figure 2 Engineering Design Competence

Design knowledge relates to all subjects required for problem solving, which may be either related to or independent *on* 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 experiences are gained through actual observations of solving practical problems. All five capacities should be equally emphasised in the educational programs in order to develop design competence in future engineers and designers.

RESEARCH METHODOLOGY

In order to explore the effects of the EGPR course on education at City University and to gain the opinion of students and staff from other universities, two sets of questionnaires were prepared for participants in the course. The first was released during the first project review at the time the students presented findings of their operational research. Therefore the results of the first questionnaire reveal their expectations from the course. The second questionnaire was released at the end of the course and outlined the effects of the course. In this paper the results of both questionnaires are compared and discussed..

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

Academics and organisers of the EGPR course, commented on three aspects of the course, namely:

i) how closely they considered the course to be connected to industry and other courses at the University,
ii) ii) what competencies they thought students gained the most and
iii) iii) how much engineering content this particular course had, taking into account that the subject of design was a display for the fashion industry.

The industrial partner was asked to give a view on

i) the relevance of the proposed project to academia and industry,
ii) the skills they, as employers, would like to see in students, and
iii) the benefits they had gained from the project.

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

EVALUATION OF THE RESULTS

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.

The academics thought that the project has a good balance of understanding customer requirements and applying engineering principles, while still combining a reasonable amount of traditional design. They commented that students might not have fully realised the level of engineering and the design requirements and that the engineering content could be better planned. However the amount of engineering was not predetermined and the individual groups defined the amount/level of engineering themselves. All felt that the project was very unique and felt that it might be the first step towards possible means of learning in the future. The staff felt that, while the application of the problem came as a surprise, the final solutions required substantial engineering. This was even more evident during the workshop which appeared to be very successful and produced four very good prototypes. The designs of some of the prototypes are shown in Figure 3. The prototypes manufactured, tested and presented at the final workshop are shown in Figure 4.

The relevance to industry was also justified by the industrial partner, Kesslers International, who thought that the course teaches engineering and design with a focus on building relations with the consumers. In the first questionnaire, they outlined that the course gives a chance to bring leading edge engineering techniques into an industrial field. They had not worked as an industrial partner in

academia before but thought that the partnership between academia and industry was 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 hoped to gain with the completion of this project. In the final questionnaire it was outlined that the research of the market and the product was good but that more emphasis could have put on the research of the company especially in the use of the manufacturing resources and the process. They felt the designs were innovative and motivating and appreciated the contributions from both the students and the academics. It was also discovered that communication between the academic and industrial sides of the enterprise could have been better and in that respect two way educational and practical aspects could have brought more benefit. In their opinion engineers working in a company are the ones who could have the most benefit from such an exercise.

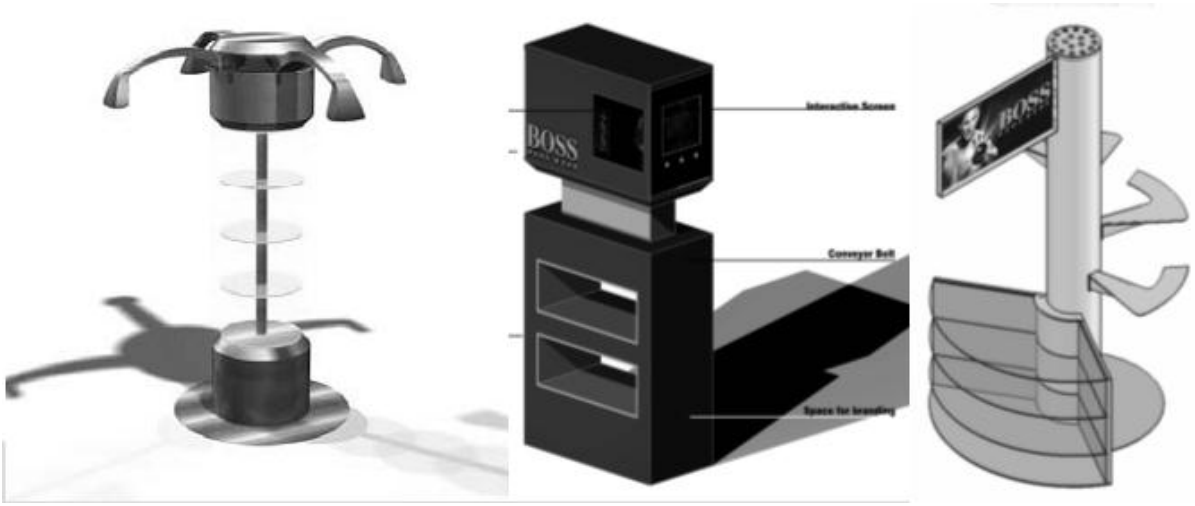

Figure 3 Designs of some of the prototypes

Figure 4 Manufactured prototypes presented at the final workshop

Competences gained in the course

Since the questionnaire concentrated on competences that students were hoping to achieve and that they obtained during the course, in all the following diagrams, the light grey bars represent the percentage of student replies to the first questionnaire while the dark bars represent the percentage of student replies at the end of the course.

In the summary of the first questionnaire, 29% students expressed their hope to substantially increase their design skills while 41% hoped to slightly improve it. This is reflected in the fact that 35% of the students felt that they hoped to slightly improve their creativity through their participation in the project. 53% of students hoped that they would slightly improve their organisational skills while 47% thought that the improvement would be substantial. 53% and 71%, respectively, of the students hoped to slightly improve their oral and written communication skills respectively. 35% expected to substantially improve their oral skills while 18% were looking forward to substantially improve on their writing skills.

Figure 5 shows the four main categories of knowledge and skills that the students were evaluating. The biggest gain in this category was in understanding business issues and intellectual property issues.

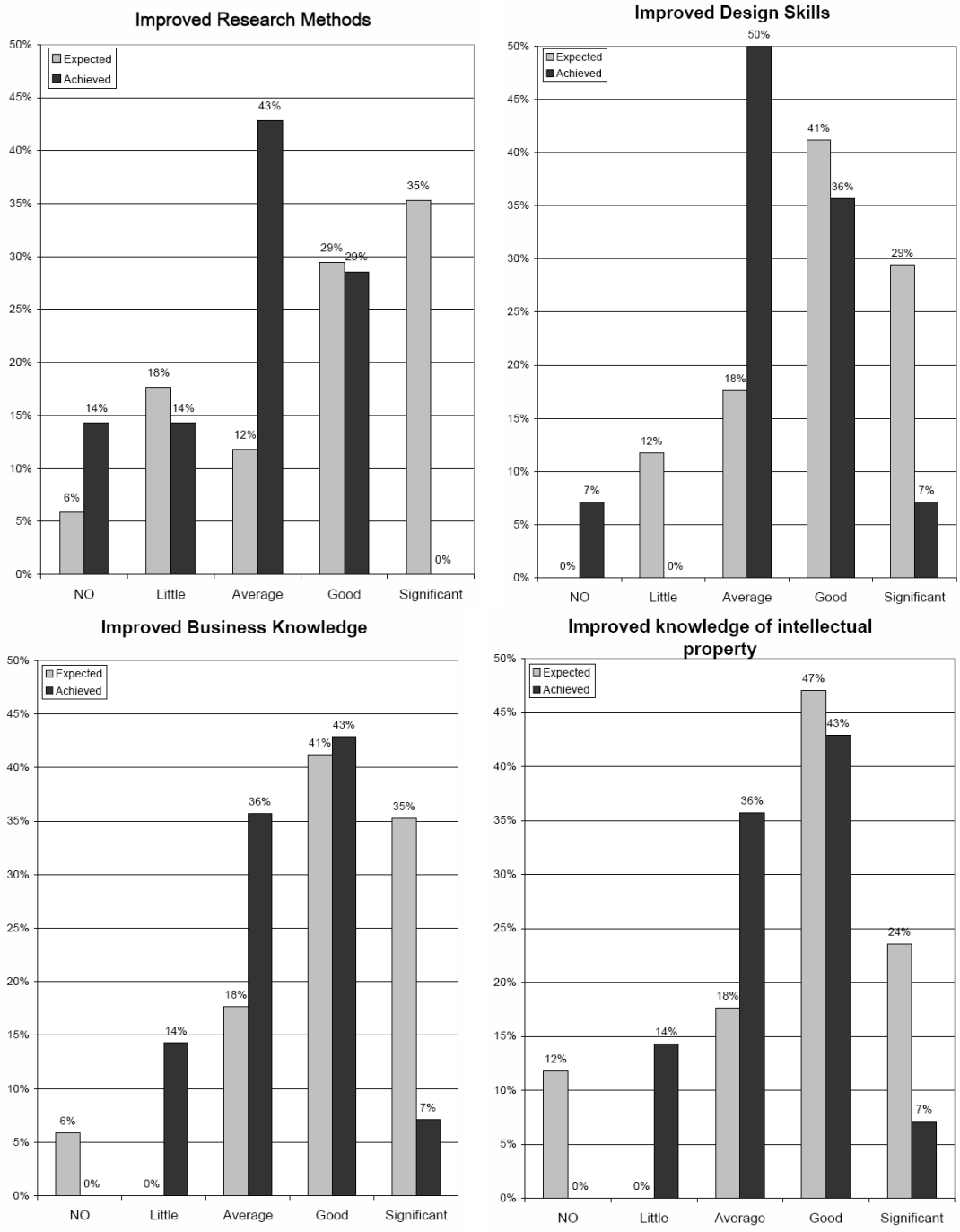

Figure 5 Level of different types of knowledge students gained from the project

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.

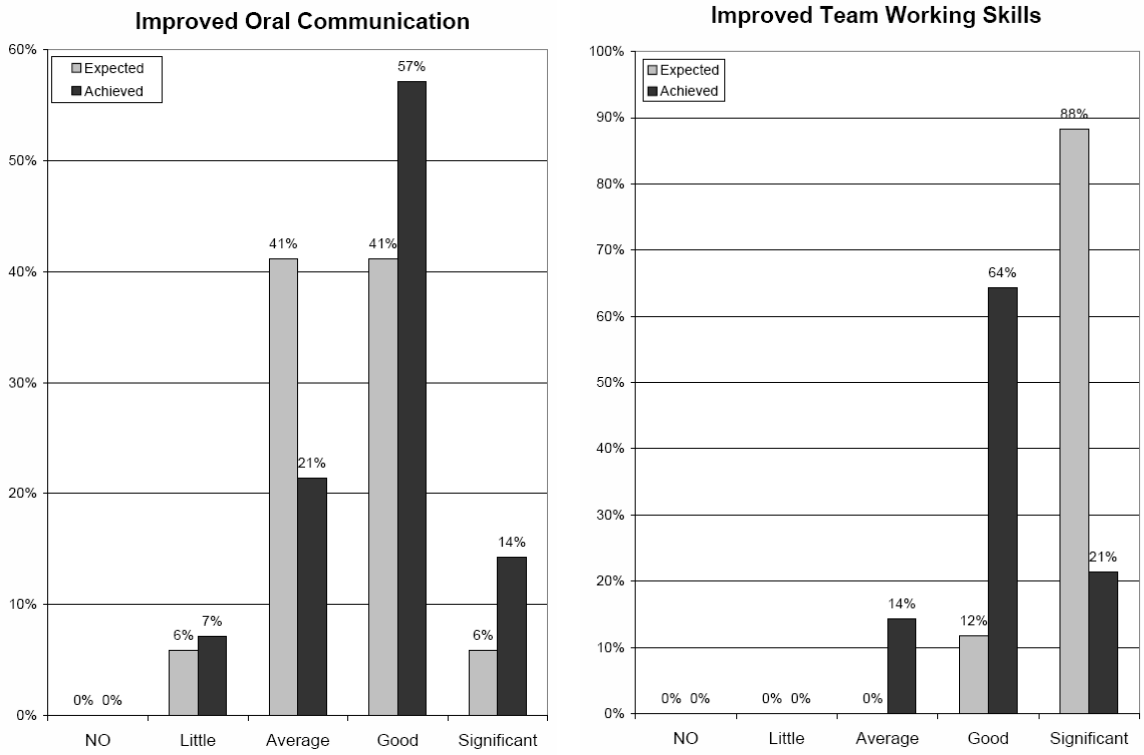

Figure 6 Students review of skills - communication and team work experience

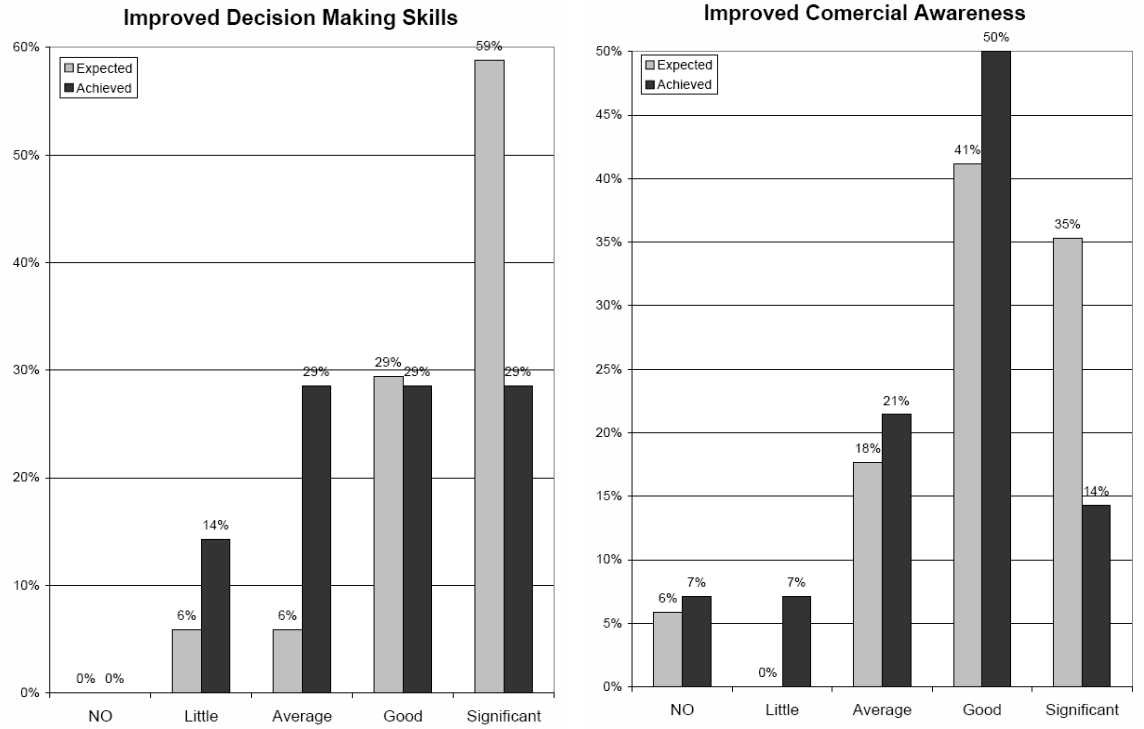

Figure 7 Students judgement about attitude and capabilities gained in the project

If Kesslers, as a company, were looking to employ a graduate, they would look mainly for team working, communication and design skills. As shown in Figure 6, the students felt that both communication and team working skills were improved during the course. At the end of the course the students realised that working in virtual design teams is not that easy and that some skills could have been improved should the project have had one more 'face-to-face' meeting at the beginning of the course. That is the reason for most of the students believing that they improved their team working skills substantially by one grade lower than they expected at the beginning.

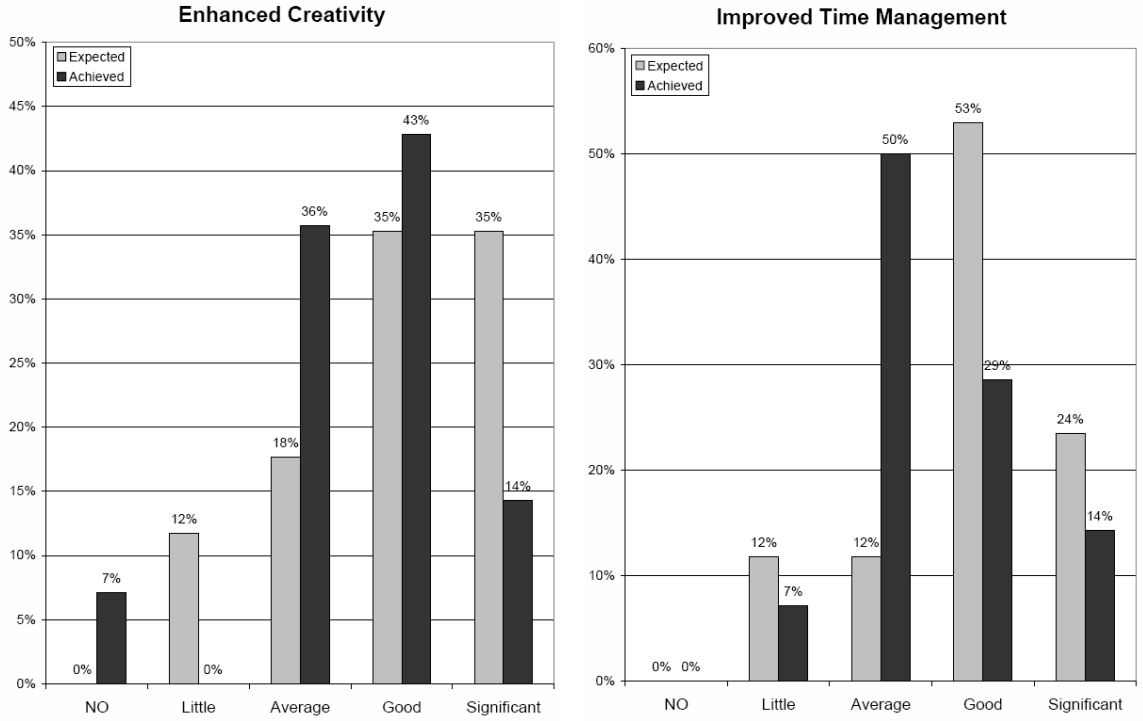

Figure 8 The review of creativity and management capabilities

As shown in Figure 7 and Figure 8, students felt that their expectations on improving creativity and commercial awareness were exceeded while decision making and management skills were not improved to the extent that they were hoping for.

The competences the students hoped to gain, the staff felt the students should gain and those at Kesslers, as an employer, sought in a graduate were the same and are as follows:

i) Team working and communication skills,
ii) Decision making experience,
iii) Organisational skills and attitudes and
iv) Time management capability.

The competences rated the least expected to be gained during the project were design creativity and legal competences. It appeared that at the end of the course Team working was improved and awareness of it was increased. However, the second place at the end of the course belonged to creativity and awareness of the IP issues of design.

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.

Figure 9 (right) shows that students gained experience in the use of communication technology but not to such an extent as they were hoping. On the other hand, they felt that they improved their organisational skills, as shown in Figure 9 (left), despite the fact that 47% of the students felt at the

beginning 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 the 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.

Table 2 Communication tools used and frequency of use

	Video conferencing	Net Meeting	Breeze	msn	Blackboard	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%

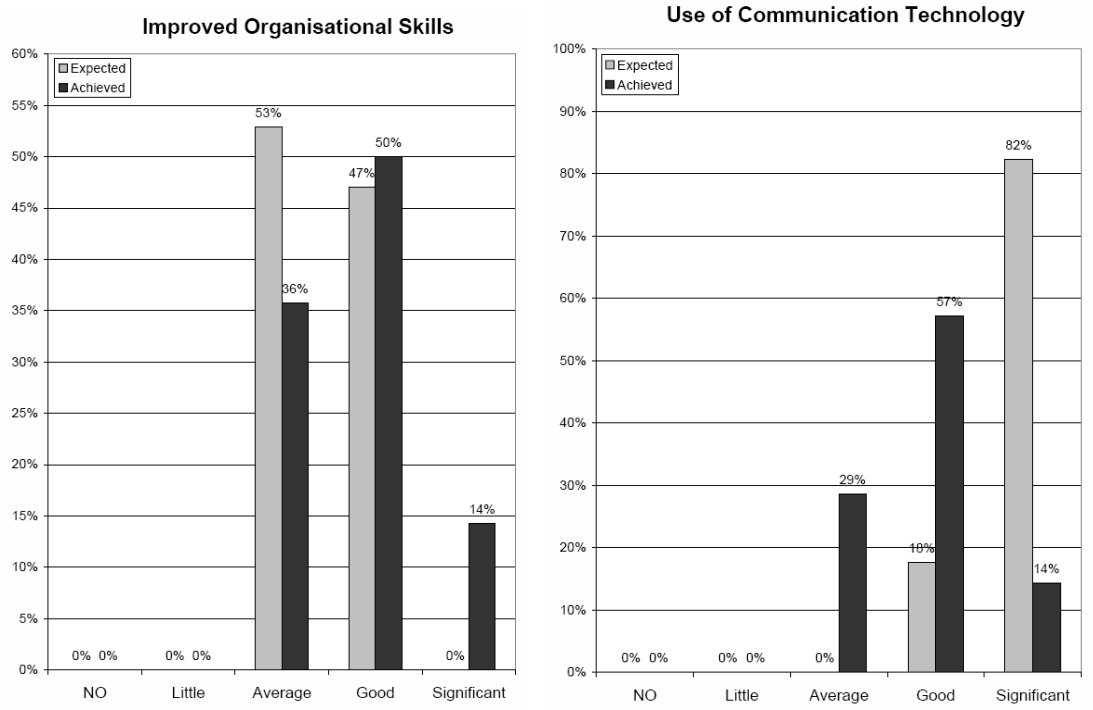

Figure 9 Organisational capabilities (left) and improvements in the use of communication technology

Conclusions

The results collected from students who attended the EGPR course indicate that they significantly improved communication, coordination and cooperation in their teams. All students thought that the highest benefit of the course is in improving oral communication skills and team working capabilities. On the other hand, students felt that they did not gain much or improved only slightly the 'traditional' knowledge and skills, such as research methods, design methods and decision making. Taking into account that this is the last product design project in their undergraduate education, students are expected to have developed these skills already in previous courses. Therefore, the aims of this course

were on integration, breaking boundaries and development of attitudes and experience and not in teaching basic design principles.
All the 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.
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. Intellectual property is regarded as an important factor in decision making and orientation to industry.
Distributed problem solving was found to be a novel means of collaboration for most of the students participating in the course. They had to agree and follow a common methodology which sometimes took them out of their 'comfort zone'. However, although half of the students preferred working in physical rather then virtual teams, creativity and motivation was still very much stimulated. There was 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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