1 EDUCATION OF NPD IN VIRTUAL MULTI-X ENVIRONMENTS

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Cost competitiveness, energy price, geographic dispersion of human, knowledge and material resources are forcing companies to outsource and spread the tasks among companies and partners all around the world. All these factors as well as emerging complexity of new products demand extreme flexibility and coordination of all participants in any innovation project. Therefore, multi-x (multi-disciplinary, -cultural, etc) teams, with team members on different geographical locations, work often on the same project. Social, cultural and professional differences amplified with a lack of eye-to-eye contact, demand special technical and social skills of all participants. These skills are of the same importance as professional knowledge, which is necessary for project realisation, and include the use of information and communication technologies (ICT), virtual-team work, decision making, team management, conflict management, etc. and especially their combined implementation in real projects. The latter is a skill, which should be taught and practiced on a case to achieve, and any educational institution, which is aiming to train competitive engineers, should implement this kind of work into educational process.

To provide students with the knowledge and practice of multi-x team work an international course called European Global Product Realization (E-GPR) was launched in school year 2001–2002. Its main goal is to provide a stimulating learning environment for students in several disciplines (i.e. design, mechanical engineering, PLM, electronics, etc.), where they can get experience in multi-x collaboration in new product development (NPD) and develop several aspects of design competences needed for their future professional practice.

Keywords: European Global Product Realization (E-GPR), Design Education, Virtual Team, Collaborative Design.

1. INTRODUCTION

In any production company there is a constant urge for a development of new products to withstand the emerging competition. The complexity of products, cost competitiveness and realization deadlines are forcing companies to modernize design-production processes, where the designer plays an important role from all the beginning of this process.[2] The traditional design methodology is not sufficient anymore, as it can not face and satisfy all the new design requirements within a reasonable design timeframe.[3] And if we check the flow of modern design-development process,[8] we can see that it is constantly iterative process on many levels. This demands multidisciplinary (or multi-x) skills of all participants of this process.[13] However, a collaborative design is emerging as a promising alternative to classical design approaches.[1] Various disciplines such as decision theory, social science, operation management, computer science etc. have been used to deal with the emerging collaborative design. Teams that are multi-disciplinary, multi-national and multi-cultural (multi-x) are being formed to enable an in-depth view on design problems. Several institutions (university, industry, government, society) are participating in the concept-to-market design process, making it even more complex.[4]

The multi-x nature of NPD teams demands participants which are not only professionals in their field (e.g. mechanical design, industrial design, etc) but should have other skills as well.[14] Good knowledge of common language, common technical language, skills in using common software, negotiation with clients, problem solving, interpersonal skills and project management are just some of them.[6,7,15]

Therefore, a modern design profession is no longer focused only on its narrow basic knowledge, but covers a wide range of social and technical disciplines as well as environmental issues.[5,16,17]

2. COURSE DESCRIPTION

The main goal of the E-GPR course is to give students a practical experience with a new product development (NPD) process. NPD is a complex multi-disciplinary process, usually with participants, knowledge and material geographically (often internationally) dispersed outside the company's site.

To simulate this situation, five European universities run the course of European Global Product Realisation (E-GPR), where each university provides its specific knowledge to the course. Students of Delft University of Technology are specialized in industrial design, Swiss Federal Institute of Technology provides knowledge of Micro-Engineering and Communication systems, members of University of Ljubljana and University of Zagreb are specialized in Mechanical Engineering, while City University of London provides mostly knowledge of Electrical engineering.

The course consists of lectures and case work on real industrial problem assigned by chosen company and university staff. Here, the problem is expected to be a demand for a new product, since the course covers the whole design-development chain from idea to the first prototype.[8] The company is expected to provide a full knowledge including some market research, material and financial as well as managing support, while it gets four or five working prototypes with full documentation covering the whole R&D process in return.

Lectures consist of general topics to equip students with necessary knowledge for active work in NPD process (IT technologies, how to work in virtual teams, modern trends in R&D processes, etc) as well as specific professional knowledge, which is yearly adapted to an assigned task work.

Since participants are dispersed in several different countries most of the communication between them is led over electronic communication channels, like internet communication tools. Using video-conferencing equipment, all the lectures are held on all universities simultaneously, providing active cooperation of all participants, regardless to the location of the course holder.

The whole course is limited with one school semester and it starts with team formation (see Figure 1). In the first E-GPR year teams were formed by brokerage system, but in next courses this system was replaced with preliminary assignment of participants to the teams, considering their skills and geographic position. This was done for several reasons: brokerage system takes more time than preliminary assignment; school semesters begin at different time at each university, which demands several brokerage meetings; professional, cultural and geographical dispersion of participants is uncertain; Brokerage system often based mostly on subjective personal opinion about other participants which should be reduced or avoided in professional working teams.

Out of Figure 1 it can be seen, that the E-GPR project starts before the beginning of the course. A few months before the beginning of the course semester universities staff choose a company and discuss the details about the project with company representatives. In this time also a demand for a new global product is recognized. If we compare the flow diagram of Figure 1 with a modern design-development process scheme,[8] it is obvious that the E-GPR project follows the whole D&D process, where the first loop of this process (i.e. problem recognition, problem definition and definition of design goals) is

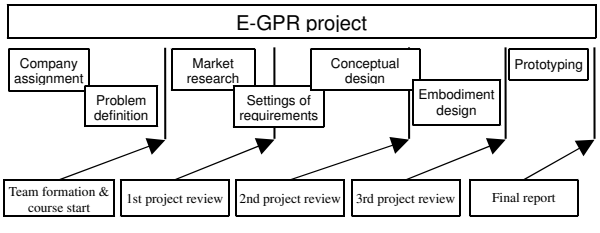

Figure 1. Phases of E-GPR project and important realization milestones.

started already by company representatives and educational staff. When the course begins and teams are formed, the whole process is taken over by student participants.

The process is very multidisciplinary and covers marketing, design and development phases. Although the participants have different professional background and their contribution to the course follows their profession, they should all understand all these phases of the NPD process, their mechanisms and importance.

Each team is guided by a coach who is a member of university staff, but experience shows that during the working process teams often chooses an informal manager among team members, who guides and coordinates the whole process. It is also common that different members are managing different phases of the course, according to their professional skills.

As in all industrial cases there is a constant lack of time, also an E-GPR course is set with several strict deadlines, when predefined results should be presented. Therefore coaches constantly control the progress of work by regular meetings with their teams, while there are also 4 official presentations of their work (see Figure 1) — three project reviews and a final presentation with belonging reports.

In the last phase of E-GPR course the members finally meet each other in person. This happens in the week of the final workshop, which takes place in a town of a host university, usually in the last week of May or first week of June. At that time the prototypes are detailed, finished and the results are presented to the professional public and media. Besides work this is also the opportunity for intensive social meeting of all participants of the course.

3. RESULTS

The results of E-GPR course are monitored in several different ways. During each course, the progress of work is controlled by staff and company representatives through interviews with participants and three project reports. The final evaluation of each team's work was done on basis of final presentations and reports (see Figure 1). Each year, students, staff and company representatives filled in different questionnaires to monitor several aspects of E-GPR project.

Some of the unrefined results of questionnaire regarding creativity of NPD process of E-GPR course are shown in Figure 2. The first diagram of Figure 2 reveals the answer to the question of how effective the team's overall creative process was in leading to promising creative results. It is clear that students were mostly satisfied with the results of creative work in their teams, although the project work was mostly parceled out to individual team members (Figure 2 (b)), but which we do not take as a disadvantage [12]. Since teams used many of numerous group creativity methods (e.g. brainstorming, morphologic analysis, etc) during their NPD meetings, we do not expect direct correlation of above results, in spite of individuality of realization work. However, the creativity process can continue also during that phase, using other creativity methods (check lists, flowcharts, etc).

One of the necessary conditions to achieve and maintain high team creativity is the trust among all team members. Trust building is a long and difficult process of socializing. Socializing in virtual teams is very important and even more complicated as there is no personal contact between team members, so it is done mostly by exchange of personal or non-professional information, such as hobbies, movies, activities, etc.[9–11]

Figure 3 shows the rate and structure of informal information shared among team members (columns) as well as students' estimation of trust among them. If we compare the results, we can notice congruity of the results. The trust among the members is relatively strong, although some people didn't want to share their intimate part of life (personal issues, crisis and things of interest), but there was a lot of impersonal non-professional communication among participants, which also served for socializing and trust building.

The access to necessary information and ability for its selection and interpretation is fundamental for any successful development work. Therefore we asked participants to evaluate the importance of eight different information profiles in NPD process during the E-GPR course. The importance of different information profiles changes during different development phases, so the results give only the global look on the NPD process.

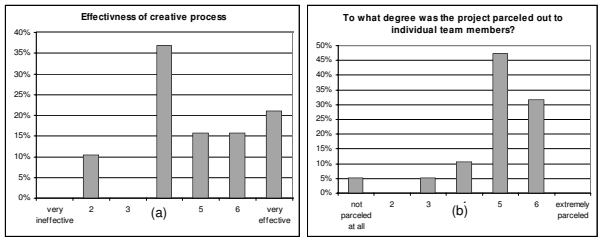

Figure 2. Results, showing the rates of (a) Effectiveness of creative process in E-GPR course; (b) individuality of work among the team ($n = 19$).

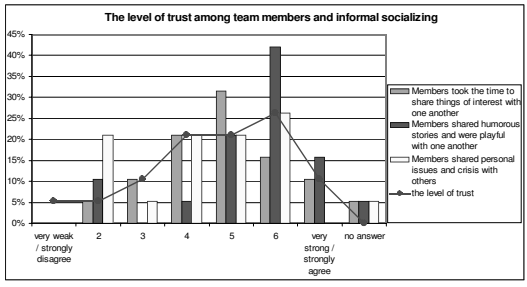

Figure 3. Diagram showing the level of trust among team members and activities necessary to build personal bonds between team members ($n = 19$).

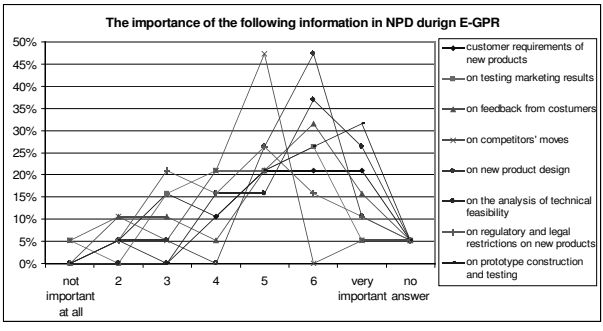

Figure 4. Importance of different information in NPD during E-GPR course, according to students ($n = 19$).

The results are gathered in Figure 4. Looking on the graph, we can see that students put the most of their attention on information regarding technical issues. So the information on new product design, on the analysis of technical feasibility and on prototype construction and testing were described as the most important. According to participants the least important information was on regulatory and legal restrictions on new products. It was surprisingly followed by the information on customer requirements of new products. However students much more appreciated the feedback from costumers than their requirements. Also two other marketing information profiles gained only moderate importance value, where competitors' moves seem somehow more important than information on testing marketing results.

The results surprisingly showed that students evaluated information regarding technical issues as much more important than information about marketing subjects. It is known that good marketing information is essential for product's success on the market as well as for its development (e.g. information on competitor's moves and costumers demands can be very useful for faster development of

a product with better technical solutions.), so there are several possible reasons for such evaluation: since there was the largest number of (mechanical, electrical) engineering students and the work was mostly parceled among team members according to their profession it is obvious that there was biggest demand for information concerning technical problems. The other fact worth considering is, that when working for real industrial case, especially in design-development phase, there was a constant demand for technical information support which should be provided to students from the host company.

How crucial is the information bridge between the project owner (company) on one and working teams (student participants and universities staff) on the other side, it became obvious in the E-GPR 2008 course. There were frequent information interruptions and ambiguities in this information chain which was causing project delays and changes in project assignment. The result was a loss of motivation among team members, killing also the creativity in teams and individuals. To cope with such situations, which can happen in any creativity team it is necessary to have a team member who can act as a crisis manager. Since this should be a person with a lot of experience, team coaches and other university staff took that role.

In such situations the multi-x environment and virtual nature of the teams can work as a catalyst. Depending on team management, trust among all team members and their interests, it can boost the creativity and motivation of the whole team and drag the process on, or it can act as the anchor which slows down the process.

The statement of previous paragraph becames obvious when we look at the Figure 5. We can see the rising complexity of E-GPR prototypes from the beginning until now and despite of the problems mentioned above, the students successfully finished a very complex project of mobile ecological house.

4. CONCLUSION

It is more and more obvious that the traditional design methodology is not sufficient anymore, as it can not face and satisfy all the new design requirements within a reasonable design timeframe. Therefore there is an emerging trend of new design methods, basing on iterative collaboration of different disciplines, professions, cultures, etc. To introduce students of five different universities and professions with these trends and methods there is an E-GPR course. During several years of this course, organizers also gained a lot of knowledge and experience about the modern design process.

The largest step that each member of modern design team (more and more often set in virtual and multi-x environment) has to make, is the step from his field of profession into the multi-x environment, demanding from him, not only his professional knowledge, but also the understanding of the whole design process, starting from marketing and economic analysis, through design process, development and detailed design and prototype building in the last phase.

Figure 5. The increasing complexity of final prototypes of E-GPR course: The mock-up of a vacuum cleaner — year 2003; automatic vineyard spraying device — year 2005; male grooming POP display — year 2007; mobile ecological house — year 2008.

In this article we showed that E-GPR course could help a student to learn, how to make this step, which is essential for the creativity and success of the NPD process. The other, very important condition for a high creativity of teams is the trust among team members. We showed that the trust can be increased by (voluntary) exchange of informal, personal information between the members.

The third important issue of creativity and success in virtual and multi-x teams is the problem of information. The proper information which is accessible whenever necessary is crucial for any time-limited work, but also for the motivation and inertia of the process, which again influences on creativity and success.

Although the EGPR course turned out to be a success in providing the students with important competences in multi-x teamwork in virtual environments, we have to acknowledge that our research was in fact very limited and many further investigations need to be done. For better statistical evaluation a larger sample would be necessary, and also some questions remain unanswered. It would be interesting to see the difference in perception of a design process before and after the E-GPR course, especially the evaluation of importance of different information for NPD process. The deeper look into the creativity as group and as individual process should be made and the differences recognised.

Considering the E-GPR course itself, there are also thing still to be done. During the years this course became mature, but some steps still have to be made: especially in the field of communication between different partners and crisis management.

REFERENCES

[1] Bufardi, A., Xirouchakis, P., Duhovnik, J. and Horvath, I. (2005). Collaborative Design Aspects in the European Global Product Realization. International Journal of Engineering Education, **21**(5), pp. 950–963.

[2] Horvath, I., Design competence Development in an Academic Virtual Enterprise. Proceedings of IDETC/CIE 2006, September 10–13, Philadelphia, Pennsylvania, USA.

[3] Horvath, I., Wiersma, M., Duhovnik, J. and Stroud, I. (2004). Navigated active learning in an international academic virtual enterprise. European Journal of Engineering Education, **24**(9), pp. 505–519.

[4] Fain, N. van Doorn, E. C., Moes, C. C. M., Kline, M. and Duhovnik, J. (2008). Adding the Society Perspective to Triple Helix — the case of (European) Global Product Realization, Proceedings of TMCE 2008 Symposium.

[5] Yang, M. Y., You, M. and Chen, F. (2005). Competencies and qualifications for industrial design jobs: implications for design practice, education and student career guidance, Design studies, **26**(2), pp. 155–189.

[6] Žavbi, R. and Tavčr, J. (2003). Some observation on work within a virtual product development team, ICED 03, Stockholm, August pp. 19–21.

[7] Žavbi, R. and Tavčar, J. (2005). Preparing undergraduate students for work in virtual product development teams, Computer & Education, **44**(4), pp. 357–376.

[8] Duhovnik J. and Balić S. (2004). Detail functionality analysis using the design golden loop. In Proceeding of the conference, EDIProD'2004, Zielona Gora.

[9] Zigurs, I. (2003). Leadership in virtual teams: Oxymoron or opportunity. Organisational dynamics, **31**(4), pp. 339–351.

[10] Žavbi, R. and Duhovnik, J. (2007). Experiences based on six years of the E-GPR course, ICED 07, Paris, August pp. 28–31.

[11] Lin, C., Standing, C. and Liu, Y.-C. (2008). A model to develop effective virtual teams, Decision Support Systems; **45**, pp. 1031–1045.

[12] Pendergast, M. and Hayne, S. (1999). Groupware and social networks: will life ever be the same again?. Information and Software Technology; **41**, 311–8.

[13] Andreasen, M. M. and Hein, L. Integrated product development. reprint. Lyngby: Institute for Product Development, Technical University of Denmark.

[14] Grimson, J. (2002). Re-engineering the curriculum for the 21st century. European Journal of Engineering Education 2002; **27**, 31–7.

[15] Beitz, W. and Helbig, D. (1997). The future of education for product developers. In: Riitahuhta A, editor. Proceedings of the 11th International Conference on Engineering Design (ICED97), Zürich: Heurista; pp. 493–8.

[16] Lipnack, J, Stamps, J. Virtual teams (2000). People working across boundaries with technology. 2nd ed. New York: Wiley.

[17] Paul, S., Seetharaman, P., Samarah, I. and Mykytyna, P. P. (2004). Impact of heterogeneity and collaborative conflict management style on the performance of synchronous global virtual teams. Information and Management; **41**, pp. 303–321.