INTERNATIONAL DESIGN CONFERENCE - DESIGN 2014
Dubrovnik - Croatia, May 19 - 22, 2014.

A DECADE OF PROJECT BASED DESIGN EDUCATION – IS THERE A FUTURE?

N. Vukašinović and N. Fain

Keywords: design practice, project-based learning, European Global Product Realization, challenges

1. Introduction

In the past decade, engineering university programmes have undergone an intensive curriculum redesign in order to adapt their educational initiatives to the emerging needs of the 21st century. Globalisation and technological developments have influenced and changed industrial demands, and consequently brought about new social and business rules and norms, (i.e. migration and long distance cooperation using advanced IT communication channels), which have extensively changed the job roles people undertake in design.

All these trends represent an additional push, that demands from the students that they gain the full knowledge of traditional, core university subjects, along with acquiring valuable competences of teamwork, creative thinking, cooperation, language and presentation skills, at the same time.

Together with rapid development of different available technologies the products become more and more complex and come to the market in shorter and shorter time [Mistree 2013], which also requires great organisational skills and knowledge of concurrent engineering. The way the product lifecycles have shortened, the student's transition from an educational environment to real life practice has also shortened. When they leave the University they are expected to have acquired an integrated set of skills that will enable them to lead and manage design projects smoothly, with as short as induction as possible.

Most of design engineering faculties and universities around the world, where professors and teachers are either design practitioners or are following the evolution of product design engineering, have started different project-based design engineering modules already at the start of the new millennium. The main objective of such modules has been to engage the students with the industrial environment and teach them the procedures and practices needed to solve different real-life design and engineering problems in smaller teams.

This paper reflects on one of the first modules that engaged in project-based learning and further more expanded the practice of design education beyond a single university. European Global Product Realisation (EGPR) is an elective design engineering class offered at 4 different European Universities. It is also one of those rare courses, where an industrial partner is involved and provides a real industrial case/task for the students. The key behind it is that although the case is provided, the problem itself must be identified and elaborated by the students. They then go throughout the full design process to develop a working full-size prototype within one semester. The students cooperate across Universities and countries with the use of ICT technologies and meet at the end of the semester to build their prototypes and present their solutions to the company.

The main purpose of this paper is to reflect on over a decade of EGPR practice in order to outline challenges students face when transitioning from education to practice. This will be done through exploration of student and professorial experiences with project-based learning within EGPR. The

expected outcomes are: (1) defined set of skills students perceive as relevant for their transition from theory to practice, (2) identified gap between educational approach to design and design practice, and (3) propositions on how to evolve project-based learning within design education to better fit the emerging trends in design.
To achieve this, qualitative and quantitative means of data collection have been implemented. They will be discussed in the following section of this paper. Furthermore, literature within the field has been reviewed and will be outlined to inform what is perceived as best-practice within design education and practice. Finally findings from EGPR course will be discussed and conclusions based on results given. Although the findings presented in this paper are limited to one design module, they provide valuable insight to how students perceive their education and thus, should guide further research in the field.

2. Context and research approach

2.1 EGPR through the years

EGPR was established at the beginning of the millennium as a response to the developing trends in design practice, that called for project-based learning to be incorporated into design education curriculum. It was initiated in 2001 by University of Ljubljana (UL), TU Delft and EPFL from Lausanne. During the years additional universities joined this consortium: City University of London (CUL), University of Zagreb (UZ) and Budapest University of Economics and Engineering (BME). Today EGPR consortium consists of 4 active academic partners: UL, CUL, UZ and BME. Each university provides approximately 10 students from 6th to 9th semester, who are already professionals in a specific field, e.g. design, mechanical engineering, engineering design, etc. Approximately 40 student professionals are then equally distributed in 5-6 international and multi-disciplinary project teams, which are given the same initial industrial problem to solve in one semester. The teams are independent in their NPD process, however constantly supervised throughout the process by one of the coaches (academic representative); and by company representatives and other academic staff on three, equally distributed project reviews as well as at the final workshop.
Although there exist many project based courses, EGPR is still unique in aspect of disperse and virtual collaboration of several European universities and at the same time in aspect of complexity of tasks which have to be brought to feasible solutions in one semester all to the demonstration of developed physical working prototypes. This approach demands additional effort from all involved stakeholders but simulates the creative working environment of real multinational enterprises.
Since the course is voluntary at all involved universities, the course is build only by highly motivated students, however they can gain internationally recognised ECTS at all participating universities.
The basic philosophy of the EGPR educational project is based on developing competences of students to solve problems by design for a real-life company. This requires an integrated approach that builds on the five key competences: (1) design capability including intelligence, imagination, creativeness, inventiveness, artfulness, technicality, pragmatism and productiveness, (2) design attitude including the way of thinking about practical creativeness, motivation and inspiration of creating useful things, enjoyment of inventing artefacts and mind set related to materialization and realization, (3) design knowledge, gained through lectures, industrial case studies, projects and self-management, (4) design skills, such as multi-disciplinary cooperation, application of research and design methods, communication and exchange of technical information, analysis of complex design problems and task allocation, combining creative capacities with system development capacities, project management, and prototyping and testing, and (5) design experience, or the familiarity gained from seeing and doing things in the course of acting as a designer, and the obtained feelings and reflections related to designing and designs [van Doorn et al. 2008]. The students come together with their own backgrounds and fields of experience, they share and combine it, and create new experiences as a result of the synthesis of experiences. Involvement of a company gives them further insight into how real-life design projects are developed and managed, thus expanding their competences further.

2.2 Exploring a decade of EGPR experiences

As indicated above, design practice is constantly adapting to the changing business environment, which ultimately means design education should follow their lead and adapt as well. The outlined EGPR module serves as a case for the authors to explore the degree to which such adaptations have been achieved in the past decade and enables discussion on challenges ahead.

Both secondary and primary research were conducted to satisfy the objectives of this paper and to answer the research questions at hand: (1) what are the challenges students face when engaged in project-based learning in design, and (2) how can design education address these challenges to enable the development of practice-relevant skills of design students?

A literature review of development in design engineering has been conducted to outline the main themes emerging as relevant for design practices in the 21st century. The themes that emerged as highly relevant were: work design approach, communication, teamwork and creativity. They will be further explored in the next section of this paper and will also serve as input into the primary research of this study.

At the end of EGPR 2013 module, the students were given a questionnaire where they were asked to evaluate project, product and team success of the course. The scales to study these constructs were taken from established methodologies i.e. [Nemiro 2004]. To measure project success the students were asked to evaluate on a 5-point Likert scale to what level they were able to (1) meet project objectives with their prototype, (2) reduce product complexity, (3) stay within budget, and (4) meet the company's needs. To evaluate product success, they evaluated to what level their product met (1) the functional performance specified, (2) technical specifications and standards, and (3) the determined customer needs. Finally, they evaluated their team performance by evaluating the validity of the following statements (1) we had difficulties with sharing knowledge with each other, (2) it was hard to share knowledge virtually, (3) there were differences between how different team members shared information, (4) it was difficult to ensure everyone had the same information at the same time, (5) there were differences in what procedures different team members wanted to take to get to the final result, (6) there were delays due to misunderstandings and access to information within the team, (7) the differences between team members with regard to culture had a negative effect on the development process, and (8) the differences between team members with regard to written material, communication and leadership affected the team's performance. In total 15 students who participated at the EGPR 2013 course from all universities responded to our questionnaire.

To gain further insight into the topic of project-based learning and its effects on student experience, a sample of students from the same module was interviewed. The interview guide for the discussion included question relating to how the process of their learning evolved during the module and how the experience gained influenced their transition to design practice in their first job roles. To benchmark their expectations of project based learning and design practice, several professors, with vast experience in design education curriculum development were interviewed. The existing gap between the two perspectives is the final outcome of these interviews and together with the survey results gives initial guidelines into where design engineering and design education are/should be heading in the future.

3. Design engineering in the changing environment

The key themes that emerge with regard to design in the changing business environment of 21st century are dispersed teamwork, creativity, communication and design processes. They will be discussed in the following sections.

3.1 Challenges of designing in virtual environments

In today's business environment managers strive towards greater design effectiveness to ensure customer satisfaction and consequently success for their organization. With implementing virtual teams into the development processes they get a greater spectrum of expertise, since they can involve experts beyond the boundaries of their organizations and even geographical area and consequently the design and development effectiveness level can be influenced. With organizing and distributing human resources in a virtual form all team members are able to contribute their abilities as much as

possible, and the organization can acquire, develop and deploy knowledge as a resource in a dynamic way and can consequently influence its overall capabilities to achieve superior performance.
The advantages of forming virtual teams include independence from time and space constraints, reduced opportunity costs, greater flexibility in meeting market demands, and better integration of knowledge from members in remote locations. Such teams are consequently presumed to be more creative, because they are not bound by the local resources, organizational boundaries and climate. They are becoming crucial components of a firm's overall marketing strategy [Sarin and McDermott 2003]. As such, they are also presumed to modify the design process within product development, all for the purpose of raising development effectiveness. Furthermore, organizations involved in design have to adopt flexible, dispersed methods of working to meet the numerous and varied demands of the global marketplace [Tseng and Abdalla 2006]. Thus, virtual teams come together to perform a specific design task. As they are located in separate geographic areas, they heavily depend on IT technology to gather information and get feedback [Staples and Webster 2007]. Their project meetings are therefore carefully structured and planned in order to ensure highest effectiveness possible in this time. This also means that the design process is carefully planned and executed more formally then in face-to-face teams.

3.2 Creativity and design

Creativity is exhibited when a product is generated that is novel and useful with respect to the firm [Amabile 1997]. A creative output must be relevant, effective, appropriate, and offer a genuine solution to a particular problem or presented task [Nemiro 2004]. Based on coaching experience we claim that creativity is a virtue of individual or team, which transforms diferent stimuli into a new form. Thus, it is crucial to keep an optimal flow of stimuli, to sustain "chain reaction" of creativity, which is usually done in smaller teams using different creative thinking methods. However, too weak or sometimes even too large inflow of stimulation can extinguish creative process.
Our statement goes along with findings of [Leenders et al. 2003] who claim that in design, team creativity requires teams to combine and integrate input from multiple team members. They also need to perceive creativity as vital for design in order to enable its positive effects. Creativity plays a decisive role in the process of idea generation, which represents input into the design process [Duhovnik 2003], [Duhovnik and Balic 2004], [Duhovnik and Horvath 2005]. The design process is defined as an innovative process, whereby the inputs into the process are creative ideas and the final result is a definition of the final product.
Each phase of the design process requires specific knowledge and skills to assure a successful transition to the next phase, whereby creativity is essential to start it. It provides a critical point for a firm's performance in a complex and changing environment [Basadur and Hausdorf 1996]. In design creative performance is of preeminent importance [Leenders et al. 2007].

3.3 The phases of the design process

The design process is usually viewed as a logical, patterned sequence of steps or stages through which an individual or a team moves, to define, clarify, and work out a problem and then produce a solution to that problem [Nemiro 2004]. The essence of the design process is to represent the idea of a new function in the environment down to the smallest detail and build a product that satisfies this function in the end [Duhovnik and Tavcar 2000]. This process is similar in face-to-face and virtual design teams; however [Nemiro 2004] has found some intriguing differences (i.e. in virtual teams there is more of a push to get to development quickly). As this study is done on an example of virtual teams, we follow her definition of the design process. She [Nemiro 2002, 2004] argues that virtual teams follow a path of four stages in the quest toward the production of creative results: idea generation, development, finalization and closure, and evaluation. The idea generation phase starts when an unmet need or an unsolved question is recognized and pursued by a team [Nemiro 2004]. After the starting efforts are drafted, presented and disseminated, an integrative stage of development follows. The team works to develop a product, project or service that meets the proposed needs. Once ideas are developed into workable outcomes, the creative products are finalized and implemented [Nemiro 2004]. After implementation the evaluation phase concludes the design process. The team assesses the

strengths and weaknesses of the completed project. It is crucial to realize that these stages may not be mutually exclusive and the activities can overlap and reoccur in another stage. However, the establishment of procedures and forums for team members to clarify their goals, get feedback from one another and ensure accountability has an important role in final design success [Nemiro 2004].

3.4 Changes in design practice

Previous practice in the companies was to assign designers near the end of the product development sequence of activities, which significantly reduced their potential for contribution to corporate goals and strategies [Yang et al. 2005]. Five phases in the product development process were identified as the industrial design process: task clarification, concept generation, evaluation and refinement, detailed design of the preferred concept and communication of results [Lewis and Bonollo 2002]. But as the global market is becoming increasingly competitive, corporations are adapting the holistic design program, where designing includes the concept-to-market process and the designers participate also in decision-making for product planning and positioning.

At the design level, it is evident, that the traditional engineering design practice is not sufficient anymore, as it can not face and satisfy all the new design requirements within a reasonable design time frame. Collaborative design is emerging as a promising alternative to classical design approaches. It can be defined as a process where a product is defined through the collective and joint effort of more designers [Bufardi et al. 2005]. 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 are being formed to enable an in-depth view on design problems. Different institutions are participating in the concept-to-market design process, making it even more complex.

[Yang et al. 2005] acknowledge five trends of the industrial design practice that emerge from the changing global trends, institutional relations and market needs: (1) emerging new technology increases the use of digital media, and has changed the presentation methods of sketching, rendering, model making and technical drawings; (2) the boundary between design disciplines is fuzzy, which makes it necessary for designers to understand other fields and interact more with other disciplines; (3) there is a need for multidisciplinary teamwork involving not only traditional issues of physiology, materials and technology related to product development, but also user research and lifestyle trends before the product development, and social, psychological and ideological issues; (4) the expanded definition of products concerns not only the specific functions for individual products, but also the system composed of various products and the interfaces among the parts; (5) there is an increasing dependence on online resources, and the internet has become a tool to deliver teaching, learning, interaction and communication among the institutions involved in product development.

Because of such transitions, designers not only need the individual cognitive skills and overall skill displayed in execution of design processes, but also require other skills, such as negotiation with clients, problem solving, acceptance of responsibility for outcomes, interpersonal skills and project management [Lewis and Bonollo 2002].

Hereby, another important condition to achieve and maintain high team creativity must be addressed, which is 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. [Zigurs 2003], [Žavbi 2007], [Lin 2008].

3.5 Communication in virtual design teams

Due to the virtual nature of design teams in 21st century most of the work process demanded various means of electronic communication. The methods of communication and the contents of the information to be shared within the teams are in a strong correlation with the phase of the design process and each of the tasks requires appropriate ICT (information and communication technologies) infrastructure [Montoya 2009]. However, the results of some researches show that just the availability of the ICTs does not necessary lead to use of them. Therefore it is essential to establish standards for

availability and acknowledgement of communication, which define how dispersed team member will be available for collaboration and how quickly they will respond to the messages [Montoya 2009].
These standards should be specified carefully since other studies showed that the frequency of the communication has a delicate influence on the creativity within the teams. Namely, there exist some optimal frequency of communication within the team, while too low or too high frequency has negative influence on the creativity [Leenders 2003].
Many studies also confirmed that different IT tools have different influence on the market performance, innovativeness and quality of a product, but they mostly foster the results [Durmusoglu 2011]. For example, E-mail communication has been proved to be excellent tool for the engineering project management and information sharing, but it is not that useful as a problem solving tool [Farris 2003], [Wasiak 2011].
The last study [Farris 2003], not only showed that the IT tools were less suitable for problem solving than for communication purposes, but showed, that web tools in general are more suitable for information sharing, project management and data mining and research than for the creative work. Creative work namely demand more complex services or programs, more computer power as well as the optimal rate of the filtered information flow [Leenders 2003], to establish best condition for creative process and good decision making.
Our experience only confirms what we found in literature overview, that the selection of communication channels and communication in virtual design teams itself vary significantly through different design phases. In the first – fuzzy front end – phase it is necessary to collect information about the company, market, existing products, etc. to set up a design vision which leads into a definition of a design problem to be solved in the following phases. This process includes internet data mining, literature overview, interviews and customer surveys etc. These activities require a lot of work to be done outside the office but also good communication among team members, industrial partners and external sources of information, which is therefore done mostly through electronic communication channels. The main form of the information flow during the first phase is digital text and graphics, while the voice communication is used mostly during VC team meetings and some face-to-face interviews.
The final goal of second – creative phase is to generate several creative concepts of solutions for the design problem. This phase depends mostly on cooperation within the team members, who are usually allocated in different departments and locations around the world. Therefore, the main information stream must connect different team members and regarding to the nature of the creative tasks consists mostly of real time verbal communication (voice and text), text notes and graphical documentation in form of digital pictures and photos.
The third phase represents the detailed design of the selected concept, which consists of CAD modeling, analytical and numerical simulations and analysis and generation of technical documentation. This phase demands daily communication among team members and company representatives to coordinate the activities and exchange the information. Usually a comprehensive computer work for modeling and analyses has to be done concurrently. For that reason the amount of digital information exchanged within the team increases respectively and could be managed only by integrating a powerful PDM/PLM system into the development process.

4. Findings

As outlined in the introduction, the purpose of this paper is to reflect on the past decade of design education and project-based learning within the EGPR case in order to propose guidelines of future development of this course and project based learning in general, based on student and professorial input.
The presented literature review guides the reasoning behind the exploratory study presented in this section and will also inform recommendations made in the discussion section. To integrate the aforementioned guidelines, the findings section is structured as follows: first the results from the questionnaire survey will be outlined, followed by an analysis of the student and professorial interviews. These results will then be integrated with the literature review to inform the discussions and conclusions sections of this paper.

4.1 Survey findings

37,5 % students of the 2013 EGPR class responded to the questionnaire survey about project, product and team success of their course. Before testing the levels of perceived success the students evaluated, we analysed the degree to which the three success levels (project success, product success and team success) are independent concepts. The results of the factor analysis and the correlation analysis show that project and product success are to some extension correlated (Table 1).

Table 1. Correlations between studied constructs

Correlations				
		project_success	product_success	team_success
project_success	Pearson Correlation	1	.634*	-.238
	Sig. (2-tailed)		.049	.509
product_success	Pearson Correlation	.634*	1	-.114
	Sig. (2-tailed)	.049		.724
team_success	Pearson Correlation	-.238	-.114	1
	Sig. (2-tailed)	.509	.724	
*. Correlation is significant at the 0.05 level (2-tailed).				

This indicates that students actually interrelate their perception of success through their perceptions of product and project. Despite the result we decided to calculate three separate measures in order to see how students evaluate the levels of EGPR success. We calculated their aggregated scores and gained sufficient Cronbach alphas (Table 2). We then calculated the mean scores for the constructs to identify the degree of success students evaluated for the project, product and their team (Table 2). The results show that they evaluate the project and product as rather successful, (above average on 5-point scale), but are rather critical of the performance of their team (mean = 2.77).

Table 2. Summary statistics for the studied constructs

	Cronbach Alpha	Mean	Std. Deviation
project_success	.690	4.17	.677
product_success	.681	3.72	.919
team_success	.673	2.77	.590

These results indicate that the students were rather satisfied with the project management aspects of EGPR and their final result-the product, but found team work a challenge, possibly due to the fact that for most of them this type of learning – project-based and in a virtual environment, was a novelty.
These results are further supported by student responses in the interviews conducted after they have finished their university education and got their first job roles.

4.2 Interviews with students

6 students from EGPR 2013 have agreed to provide further insight into how EGPR influenced their transition from education to their jobs. As the EGPR module is a final year course the transition to real-life business environments was rather quick for the students.
The key skills they have gained in EGPR and they outlined as relevant for their jobs were teamwork and communication. Surprisingly, none of them mentioned any design or engineering related skills. This indicates that "softer" skills need further consideration when implementing a project-based design project into design engineering curriculum. This is in line with the trend discussed by Findeli already in 2001, where he outlined "effect of product engineering and marketing on design and the visual arts as the main issue to be addressed currently" [p.5].
5 out of 6 students however agreed that project based learning helped them with settling in into their new jobs. Interestingly enough, the student that answered that EGPR did not really benefit him when he started the new job, further stressed that "*only management side of EGPR was beneficial*". This

further strengthens the project management based success the students perceive, when discussing EGPR, but on the other hand also highlights the issue of lack of "engineering and design" benefits students thought EGPR brought to them.
The results of the questionnaire survey indicated that teamwork has been the most challenging aspect of the project-based learning, thus students were asked to elaborate on this in the interviews. When teamwork challenges were discussed, only one of the students said, "*due to a great team, there were no real challenges. It didn't even matter that we were physically apart, as everyone kept to their tasks and communication was good."* Other respondents indicated that time management and leadership were the most challenging aspects of such projects. One of the students further stressed, that even though EGPR was a one-semester class and the deadlines were tight, the way his job role is structured in real-life asks for an "*even tighter time-frame*". This indicates that although project-based learning is outlining industrial practice, some aspects are still tailored to the educational context to enable a structured learning and development process.
The final challenge that 3 out of 6 students outlined were the use of ICT communication tools to guide their project. New ways of communicating are now becoming business as usual in design practices, thus they should also become more common for students. EGPR has taken this on board just over a decade ago, but as it seems teaching the students how to use ICT communication tools and how to communicate and manage communication still needs further elaboration.

4.3 Interviews with professors

The discussions with the teachers of EGPR were oriented towards establishing their views on how design practice has changed over the past decade and how this has influenced the development of the course and implementation of the project-based learning approach into the design curriculum at their Universities. 4 EGPR professors engaged with us on the topic. Initial findings suggest, that the teachers are aware and appreciate the challenges new environments bring to design education and have employed several tools to adjust design curriculum to the new design trends.
One of the professors for example stressed, "*project-based learning has an important role in modern education. Students seem much more satisfied and enthusiastic when they can produce something real."* This indicates the relevance of implementing such practices in education at an early stage, but at the same time brings the challenge of mixed competences. As one of the professors mentions, "*content would need to be harmonised with the students' competence levels*" and furthermore, "*it is important to teach trends that will develop over, maybe, the next ten years and teach students how to maintain and further their professional skills*".
This notion is in line with findings from the survey, where students indicate that teamwork and communication seem to be the most challenging aspects of project-based learning implemented in EGPR and thus teaching such skills should be more focussed in further education.
When prompted about the future of project-based learning in engineering, one of the professors outlined the skills and team interactions he expects to be crucial in the coming decade when discussing design practice: "*to systemize the design process, the importance of interdisciplinary team work, importance of all stakeholders within the product life-cycle, introduction of 'virtual work' to exploit geographically dispersed resources and higher time pressures*". This means "*education tries to hit a moving target*", as summarized by one of the interviewees and further adaptations might be needed to serve the purpose of developing young professional designers already at the University level.
The challenge that all interviewed professors see with project-based learning is that of funding and cost. One of the interviewees summarizes: "*what I would like to see is financial support for projects on a more stable basis. This support needs to be provided both for the project providers, universities, as well as for the problem suppliers, companies - especially SMEs. This is also tied to the need for the development of an improved infrastructure in Europe to raise awareness of projects as well as to channel real industrial problems to project providers.*" This is further acknowledged by another professor, who foresees "*The current practice will continue until resources on either side will give out. On the long run it is everyone's interest to keep the balance*".

5. Conclusions

With this paper we aimed at three key outcomes when discussing project-based learning and EGPR as a case study: (1) outline of skills that students see as relevant for their development as engineers, (2) identification of potential gaps when facing education with practice, and (3) propositions for future development.

From the interviews and survey with students the following conclusions emerge:

1. Students appreciate project-based learning, but acknowledge that the key skills that they still need to address for successful practice are related to communication and teamwork in dispersed design environments.
2. Engineering and design skills are not considered as most influential by the students, which might be due to the structure of their further curriculums, where these skills are addressed in more detail.

These findings are further supported by the professors, who see the biggest gap between project-based learning and practice as "the moving target", where the change in trends is so rapid, education is struggling in following; the key reason being lack of sufficient funding support from both governments and practitioners.

The third outcome could not be fully explored within this paper, as the responses were limited, but some of the trends that need to be considered, when taking project based learning to a new level include ICTs and communication skills across borders and teamwork. It seems that these skills are taken for granted and students are expected to "learn by doing", thus further exploration and structured inclusion in the curriculum might bring about potential high impact.

References

Amabile, T. M., "Motivating Creativity in Organisations: On Doing what you love and loving what you do", California Management Review, 40 (1), 1997, pp. 39-58.

Basadur, M., Hausdorf, P. A., "Measuring Divergent Thinking Attitudes Related to Creative Problem Solving and Innovation Management", Creativity Research Journal 9 (1), 1996, pp. 21-32.

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

Duhovnik, J., Balić, S., "Detail Functionality Analysis Using Design Golden Loop", in 4th International Seminar and Workshop, EDIProD', 2004.

Duhovnik, J., "Techniques and methods for product development", In: Automatyzacja produkcji. Referaty plenarne isesyjne. #Tom. #1 / IV Wroclawskie sympozjum, Wroclaw, Oficyna Wydawnicza Politechniki Wroclawskiej, 2003, pp. 93-101.

Duhovnik, J., Horvath, I., "Towards a better understanding of the methodological characteristics of engineering design research", In: ASME 2005 International Design Engineering Technical Conferences and computers and Information in Engineering conference, 24-28 September 2005, Long Beach, USA, 2005.

Duhovnik, J., Tavčar, J., "Elektronsko poslovanje in tehnični informacijski sistemi: PDMS – Product Data Management Systems", Ljubljana: Faculty of Mechanical Engineering, 2000.

Durmusoglu, S. S., Barczak, G., "The use of information technology tools in new product development phases: Analysis of effects on new product innovativeness, quality, and market performance", Industrial Marketing Management, Vol. 40, 2011, 321-330.

Farris, G. F. et al., "Web-enabled innovation in new product development", Research Technology Management, November-December 2003, pp. 24-35.

Leenders, R. Th. A. J., van Engelen, J. M. L., Kratzer, J., "Virtuality,Communication, and New Product Team Creativity: A Social Network Perspective", Journal of Engineering and Technology Management, 2003, 20, pp. 69-92.

Leenders, R. Th. A. J., van Engelen, J. M. L., Kratzer, J., "Systematic Design Methods and the Creative Performance of New Product Teams: Do They Contradict or Complement Each Other?", Journal of Product Innovation Management 24, 2007, pp. 166-179.

Leenders, R. Th. A. J., van Engelen, J. M. L., Kratzer, J., "Virtuality communication, and new product team creativity: a social network perspective", Vol. 20, 2003, pp. 69-92.

Lewis, W. P., Bonollo, E., "An analysisi of professional skills in design: implications for education and Research", Design studies, Vol. 23, No. 4, 2002, pp. 385-406.

Lin, C., Standing, C., Liu, Y.-C., "A model to develop effective virtual teams", Decision Support Systems; 45, 2008, pp. 1031–1045.

Mistree, F., "Strategic Design Engineering: A Contemporary Paradigm for Engineering Design Education for the 21st Century?", J. Mech. Des. 135(9), 090301 (Aug 07, 2013) doi:10.1115/1.4025125, 2013.

Montoya, M. M., et al., "Can you hear me now? Communication in Virtual Product development teams", The Journal of product innovation management, Vol. 26, 2009, pp. 139-155.

Nemiro, J. E., "Creativity in virtual teams: key components for success", San Francisco: Pfeiffer, 2004.

Nemiro, J. E., "The Creative Process in Virtual Teams", Creativity Research Journal, 2002, 14: pp. 69-83.

Sarin, S., Mcdermott, S., "The effect of team leader characteristics on learning, knowledge application, and performance of cross-functional new product development teams", Decision studies, 34, 4, 2003, pp. 707-739.

Staples, D. S., Webster, J., "Exploring Traditional and Virtual Team members "Best Practices": A Social Cognitive Theory Perspective", Small Group Research, 2007, 38(1): pp. 60-97.

Tseng, K. c., Abdalla, H., "A novel approach to collaborative product design and development environment", In: Proceedings of the Institution of Mechanical Engineers, 2006, 220 (12): pp. 1997-2020.

Wasiak, J. et al., "Managing by E-Mail: What E-Mail can do for engineering project management", IEEE Transactions on engineering management, Vol. 58, No. 3, August 2011, pp. 445-456.

Yang, M.-Y., You, M., Chen, F.-C., "Competecies and qualifications for industrial design jobs: implications for design practice, education, and student career guidance", Design Studies, 2005, 26, pp. 155-189.

Zigurs I., "Leadership in virtual teams: Oxymoron or opportunity", Organisational dynamics, 31(4), 2003, pp. 339-351.

Žavbi R., Duhovnik J., "Experiences based on six years of the E-GPR course", ICED 07, Paris, August 28-31, 2007.

dr. Nikola Vukašinović, assistant
University of Ljubljana, Faculty of Mechanical Engineering, LECAD Laboratory
Aškerčeva 6, Ljubljana, Slovenia
Telephone: +386 1 4771 719
+386 1 4771 156
Email: Nikola.vukasinovic@lecad.fs.uni-lj.si
URL: http://lecad.fs.uni-lj.si and
http://www.fs.uni-lj.si