

EXPERIENCES WITH NAVIGATED ACTIVE LEARNING IN MULTINATIONAL ACADEMIC VIRTUAL ENTERPRISES

I. Horváth, M. Wiersma, J. Duhovnik, P. Xirouchakis and D. Marjanovic

ABSTRACT

A series of engineering design courses, called global product realization, has been offered to university students of various countries in the last four years. Each course was organized with different partner companies and universities and with different pedagogical objectives. This paper summarizes the experiences considering organizational, professional, technological, pedagogical, and practical aspects. The organization of this type of courses needs much more efforts than of a regular course, but working in an academic virtual enterprise on real life problems with company experts and international partners opens up a new dimension of active learning for the students. Collaboration using a videoconferencing infrastructure develops the skills of the students for an effective operation in virtual enterprises.

Keywords: Academic virtual enterprise, navigated active learning, global product realization

1 INTRODUCTION

In the past, most of the engineering educational institutions were isolated from the industrial life, offered content fixed courses for classes of students by instructors of engineering background. Nowadays, design and engineering education faces new challenges [1]. In the developing global knowledge society, educational institutions should be open, holistic, market oriented, and integrated into the society. The educational programs are supposed to be more customized to the interest and capabilities of individual students. The students should be prepared for coping with the problems originating in the knowledge explosion, globalization of the world, and the increasing competition. It has also been recognized that the transition from students to the creative workforce should be aided by international, collaborative, and multidisciplinary experiences. To meet these requirements, various active learning approaches have been applied. The new opportunities offered by the emerging information and communication technologies are being studied and employed in the educational practice in a short time [2]. The number of engineering courses organized for groups of international students based on video-conferencing facilities has significantly grown in the last decade.

Based on video-conferencing infrastructures, new educational philosophies, organizational set-ups, and pedagogical methods can be developed and tested [3]. For instance, putting the students into the position of actively learning professionals, and creating collaborative virtual learning environments played a distinguished role in the approaches reported in the literature. Having recognized the necessity of experiencing

with teaching design in ICT based educational environments as well as the opportunities for the students and for the educators, the Section of Computer Aided Design and Engineering, Faculty of Industrial Engineering, Delft University of Technology (DUT), has initiated a series of courses called Global Product Realization (GPR). The very first GPR course was organized in 2001, based on the collaboration of the University of Michigan (UoM), USA, Seoul National University (SNU), South Korea, and the DUT, the Netherlands. The core company was a fictitious enterprise called Morning Coffee, Inc. This pioneering course focused on the development of a given class of global products. The students from the three continents took part in academic lectures and industrial case studies in the virtual classroom, and worked in international teams of 6-8 students on the semester project. The project focused on the design and prototyping of a global coffee maker fulfilling the needs in the above-mentioned three countries. The major challenges for this course were (i) working over cultural boundaries, (b) coping with extreme large time zone differences, (iii) mastering the use of new video-conferencing facilities, and (iv) providing digital-only course material for the students.

Afterwards, the GPR course was redesigned to involve 'real' companies and to serve the goals of a Europe-oriented international course (E-GPR) [4]. The second course was organized in 2002 with the participation of more than 30 students of the Ecole Polytechnique Federale Lausanne (EPFL), Switzerland, the University of Ljubljana (UoL), Slovenia, and the TUD. The organizational goal was to form a consortium with two industrial companies, namely LIV Postojna from Slovenia, and De Vlamboog BV from the Netherlands. The semester project focused on designing and prototyping a vacuum cleaner and a head mounted light and respiration protecting unit for welders, respectively, in the form of global products. Academic lectures providing dedicated knowledge for the project, case studies, progress and design review sessions, a student symposium and a product exhibition were the main elements in this course.

Taking into consideration the experiences of the students and the course organizers and aiming at a new pedagogical design, we introduced a novel framework for the E-GPR course in 2003. The concept of academic virtual enterprise (AVE) has been developed and implemented with the support of the partners. De Vlamboog BV formed the industrial core of the AVE, and the above-mentioned three universities played the role of knowledge centers. Altogether 44 students took part in this course. The course project was oriented towards the conceptualization of future global products according to the specification and requirements of the core company. In order to build the necessary knowledge platform for product conceptualization, the students had to go into extensive trend, competitor, market, technology, and user analyses [5]. As a new didactical element, the concept of navigated active learning has been introduced, which included both professional guidance and technical assistance for the student teams. In 2004, the students and instructors of the University of Zagreb (UoZ), Croatia, joined the course and extended the academic virtual enterprise. The AVE again enjoyed the financial and professional support of De Vlamboog BV as a core company. The semester project was arranged around a life cycle oriented re-conceptualization of two existing concept products. The students had to do experimental research with the concept products to (i) explore their strong and weak points, (ii) find out the opinion of the potential customers, and (iii) investigate new product materials and technologies [6].

2 ACADEMIC VIRTUAL ENTERPRISE: A LEARNING ENVIRONMENT

Due to globalization of the business operations, there is a tendency to distribute product realization and marketing between different physical locations [7]. Virtual enterprises

are new types of knowledge-related organizations in industry, which makes it possible to (i) work over geographic, economic, ethnographic, historic and cultural boundaries, (ii) achieve the best utilization of knowledge, financial and physical assets in business functions, and (iii) produce and distribute products and services globally. Their number keeps increasing as multinational companies spread production around the world and as small and medium sized companies (SMEs) with specialist skills sub-contract to supply parts of larger products. Recently, types and characteristics of virtual enterprises were interpreted according to environmental constraints, production processes and strategic objectives [8]. In this rapidly changing world, the industry will need many designers, engineers, and managers in the near future, who are equipped with the knowledge, capabilities, experiences and skills requested by operations in shared virtual environments. Since future designers and engineers will most probably work in these telecommunication-based environments, it seems to be important to prepare the students for operation in virtual enterprises. The students should learn the concept, the infrastructure and activities of virtual enterprises that enable product and service realization.

Our multi-faceted industrial relations, experiences in design and engineering education, and the availability of the necessary information and communication technologies (ICT) made it possible for us to bring the concept of academic virtual enterprise to existence. We wanted to create an advanced learning environment that could mimic the functions and the daily operation of industrial virtual enterprises. From an organizational point of view, an academic virtual enterprise is a project work oriented alliance of industrial and academic partners for mutual advantages. For the university it gives the opportunity to (i) open the doors for a real-life industrial cooperation in education, (ii) create an environment for design and engineering students in which they act as evolving young professionals, (iii) learn the best practices from leading edge industrial companies as well as explore new pedagogical and didactic approaches, methods and tools, (iv) challenge the students with product development tasks originating in the industrial practice but geared towards developing new product concepts for the mid-term future, and (v) exercise collaborative teamwork in a video-conferencing based multi-cultural environment. Successful implementation assumes the collaboration and systematic activities of university students, company experts, academic staff and individual consultants. On the basis of these, the student can learn much more and can produce outcomes superior to that any one of them can achieve on its own without collaboration.

Stimulated active learning represents a broad diffusion of approaches to a learner-centered education. From a didactic point of view, the students:

- can follow individual learning paths, can be in different functions, and can compete and collaborate,
- can integrate new knowledge in their own mental schema in various ways and get immediate confirmation on the appropriateness,
- can constantly check the validity of their mental models having been constructed in the process of problem solving, and
- can exercise more social interaction and prepare themselves for the challenges of rather complex tasks by acting together,
- substitute absorption of information with more intensive forms of thinking such as inquiry, analysis, synthesis, evaluation and application,
- put the focus on problem-solving which requires them to selectively activate and properly use knowledge, and
- have the role of self-management, self-motivation and self-critique.

The primary goal of all courses was to increase the awareness of the students that global product require a deeper consideration of ethnographical, cultural, historical, community expectations together with the basic technological, economic, legal, safety, and organizational issues [9]. It has been emphasized that global product realization not only requires more knowledge, skills and experiences from the designers and engineers, but also their ethics, responsibility and liability to fulfill *de jure* and *de facto* regulations and their openness to consider sustainability issues. We were always aware of the fact that use of ICT and industrial cooperation does not automatically lead to better education. For this reason, we placed special emphasis on the pedagogical design of the course, not only on the application of sophisticated information technologies. Our primary goal was to methodologically support the learning process. The academic virtual enterprise favored this idea by offering a non-hierarchic structure, organizational control, and multiple facilitators for active learning. Developed over the years, the methodology of navigated project-based learning enabled us to shift from teacher-driven to learner-organized design education. Figure 1 shows the symbiosis of the navigation part and the project part, which have been achieved after multiple iterations.

3 EXPERIENCES WITH GLOBAL PRODUCT REALIZATION COURSES

In the end of each GPR course, the students and the junior instructors were asked to

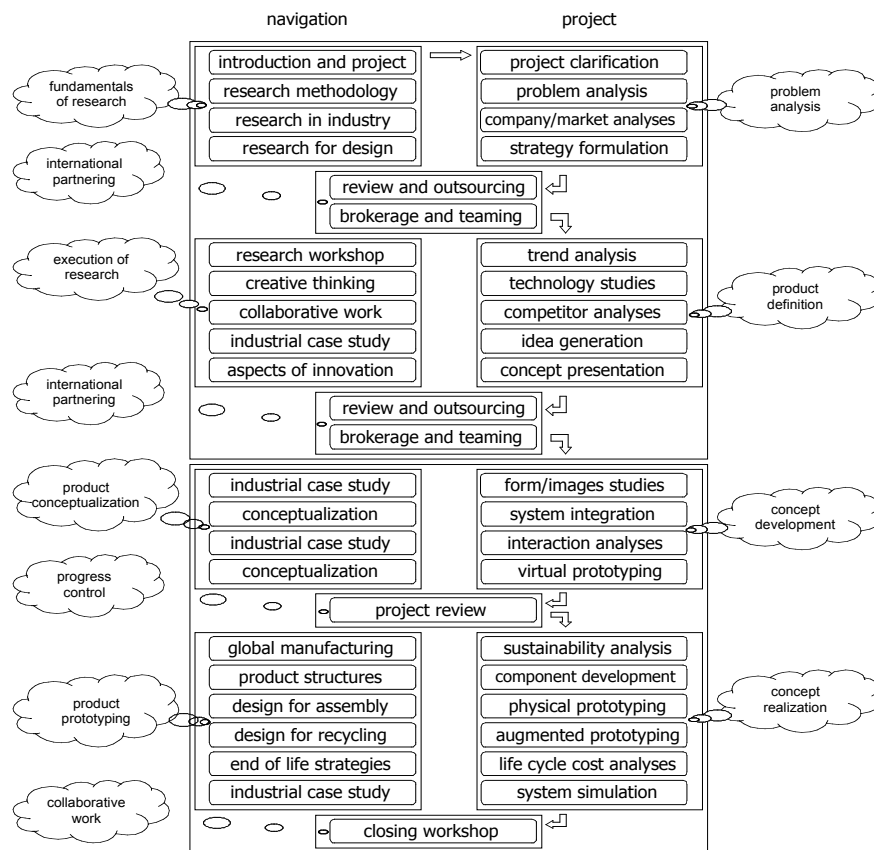


Figure 1 Layout of the E-GPR course in 2004 Spring semester

express their opinion and to make comments about the course. Questionnaires containing yes/no questions and open-ended questions were used. The students' answers have been sorted as organizational, professional, technological, pedagogical and practical experiences. The students' experiences were very close to that of the course organizers and the instructors.

3.1 Organizational experiences

In order to be successful with the organization, first we should understand the differences in the goals and interests of the co-organizers and then harmonize. The organization of the GPR course needed much more investments and efforts than a regular course. At the same time, the organizational and managerial overheads as well as the infrastructure facilities limited the number of students (50-60 students as the maximum). It was not easy to find a company supported project every year that fulfills all requirements of learning global product realization. On the one hand, the core company of the academic virtual enterprise was supposed to have a well fitting practical problem for the semester project and the whole course. On the other hand, they needed to have a good reason to participate, which means the chance of profiting from the course.

It was very difficult and time consuming to find universities with compatible semester schedules since most of them start and end the semesters at different dates and have holidays on different days. Although these questions were eventually resolved, they built up a lot of tension and made the road of collaboration quite difficult. Although the academic virtual enterprise integrated all participants into an operational framework and a community driven by shared goals, the geographical distribution brought about various difficulties, which had to be surmounted. These can be classified as difficulties in (i) communication, (ii) logistic and management, (iii) knowledge platforms, (iv) working cultures, (v) different mentalities, (vi) different time zones and systems, and (vii) different design and engineering system platforms. There is one thing what the organizers have learnt, namely that you can never be well prepared for cultural and language differences.

3.2 Professional experiences

It was known for the course organizers that the students and the staff should get acquainted at the very first moment and build trust. Most of the staff members knew each other. For the students, special sessions such as hand shaking, outsourcing, and brokerage were included to support coming to know each other and teaming up. Obviously, these sessions were not able to provide deep knowledge about the partners. Successful coping with the product conceptualization, development, prototyping, and reengineering tasks, respectively, required true collaboration from the student teams. Due to the complexity of the problems, the required multi-disciplinary knowledge, and the available relatively short time there was no other option. Nevertheless, we often observed that the decomposition of the tasks was easier for the students than addressing the tasks in their entirety by using collaborative methods and technologies. Actually, the students were complaining about not having enough knowledge on creative group techniques such as brainstorming supported by the videoconferencing facilities.

It was a great fun to bridge time zones and continents, though it was not that easy. In the very first course, we had to face serious problems with different time zones. When the American students were on their (high)way to the university classroom in the morning, the Delft students were about to finish their lunch, and the hard working Korean

students were longing for some rest approaching the late end of the day. The difficulty was not only in finding the time for classroom lectures and student sessions, but also in harmonizing the capacities of the students. It took a while to realize that this can be turned to an advantage: the semester projects could be worked on round-the-clock with the involvement of the American students in the evening, the Dutch students in the next day morning, and the Korean students in the afternoon. But still finding time slots for the shared sessions and for working together in real-time remained a challenge. Communicational difficulties also appeared due to reasons that can be traced back to language issues, different professional backgrounds, and skills in using videoconferencing facilities, but also to the capability of communicating design intent. Shared understanding of the common problem needed long time to develop in each course [10].

3.3 Technological experiences

Even the most advanced ICT infrastructure was not an exception to Murphy's laws. The ISDN based infrastructure performed better than a typical computer network facility, at the same time it was much more expensive. Compatibility issues have to be strongly considered before the launch of the courses, since connections had to be established with various sites of the involved companies. Used in all courses, the Blackboard system proved to be helpful in project management. Learning and using a large number of systems was a great challenge even for the most dedicated students. They found that communication in a virtual environment is time-consuming, especially when the performance parameters of the technical facilities were not optimal or the direct access was not possible.

The students referred to a phenomenon, what they called uncertainty paradox. It was a result of distance operation and asynchronous communication, and concerned the uncertainties of the team members as to whether the other team members have read the messages, and if not, why not; are there technical problems or rather a lack of interest; were the messages interpreted correctly, and so on. They missed a meeting in person at the beginning of the course; at the same time, they recognized that this could be the situation many times in a virtual enterprise. The students made complaints about the limited accessibility of the communication equipment, which was due to the busyness of the media rooms, and about the long response time, which was a consequence of the overloaded computer networks. To circumvent these problems, a reservation system was introduced and ISDN lines were used in the off peak-time. Both the students and instructors indicated the issue of motivating passive team members.

3.4 Pedagogical experiences

The different knowledge platforms meant both advantages and disadvantages in the first period of the courses. The students followed different specializations in their study at the mother universities and they were in different semesters. This resulted in completely different understanding of and contribution to the course and the semester project, respectively, when it was organized with overseas partners. Notwithstanding, the effects of the different professional background could be observed even though the courses were organized with European partners, but in these cases the cultural influences were less significant. Just to illustrate: the Delft students followed industrial engineering program, with a strong interest in human centered design, the Swiss students took part in mechanical engineering and micro-technical programs with focus respectively on life cycle engineering and electronic automation. The Slovenian and the

Croatian students followed mechanical engineering programs with specialization in computer aided design and engineering. This is the explanation why they interpreted the problems differently, followed their own educational traditions, and used different vocabularies.



Figure 2 Product variants for a filter unit for respiratory protection for welders

The closing workshop made it possible for the students to meet in person and work together side by side. Here the responsibility for the success of the project and for the team level satisfaction was the main driving force. It was fun for the students to be together and to be member of a large spontaneously formed community. Visiting the involved companies and meeting the company experts were also interesting for them. The Student Symposium gave possibility for the students to summarize their work in the form of oral presentations, and to discuss it with the other teams and the visitors. In the Global Product Exhibition they could show and explain their achievements in the form of posters, video recording, virtual model animations, physical and augmented prototypes, and full scale working models (Figure 2). The opinion of the course organizers was that this added value and recognition to the very hard work of the students and the supporting assistants of all participating universities.

3.5 Practical experiences

After the years of experimenting, we had to realize that it is actually not easy to embed a videoconferencing-based course in the list of regular master courses. The wealth of sources of knowledge in the international set up created an opportunity to have the best lecturers on the stage, but it also brought about negative experiences: there were too many lectures just because it was difficult to leave out a topic which was thought to be interesting and useful for the students. However, in certain cases, the presented material was too general to be useful in the project, and was not always in harmony with other presentations or case studies. The cohesion between the course lectures and the student projects was in average good, but there were exceptions to the rule. Furthermore, some students already knew from other courses some parts of the lectures presented by the international speakers. Therefore, deeper analysis of the past studies and more careful selection and planning of the course material are necessary.

GPR proved to be a good example of one kind of realization of an academic virtual enterprise. However, students seemed to be overloaded by the amount of knowledge they could obtain in the AVE environment. The course projects also meant a large challenge for the students not only intellectually, but also from a resource management point of view. Only the extreme motivation of the students helped overcome the difficulties. The personality of the professors, the company experts and the instructors also played an important role. The students offered the GPR courses a surprisingly large amount of working hours, which could be observed in their results. The course

organizers meditated several times about what the results would be if a course was repeated in the next semester with the same students, for whom videoconferencing based collaboration and a company related design task did not mean novelty and challenge any more.

REFERENCES

- [1] Bucciarelli, L., Designing and Learning: A Disjunction in Contexts, in Lloyd, P. and Christiaans, H. (eds.), *Designing in Context*, Delft University Press, Delft, 2001, pp 411-424.
- [2] Chu, K. C., Urbanik, N., Yip, S. Y. and Cheung, T. W., The Benefit of Virtual Teaching to Engineering Education, *International Journal of Engineering Education*, 15(5), 1999, pp 334-338.
- [3] Rich, T., E-learning Futures: Report of an AUA Study Group, *Perspectives*, 5(3), 2001, pp 68.
- [4] Irandoust, S. and Sjöberg, J., International Dimensions: A Challenge for European Engineering Education, *European Journal of Engineering Education*, 26(1), 2001, pp 69-75.
- [5] Driver, R., Asoko, H., Leach, J., Mortimer, E. and Scott, P., Constructing Scientific Knowledge in the Classroom, *Educational Researcher*, 1994, 23(7), pp 5-12.
- [6] Friedman, K., Creating Design Knowledge: From Research into Practice, in Norman, E. W. L. and Roberts, P. H. (eds), *Design and technology educational research and curriculum development*, Department of Design and Technology, Loughborough University, 2001, pp 1-129.
- [7] Berggren, C., Söderlund, J. and Anderson, C., Clients, Contractors, and Consultants: The Consequences of Organizational Fragmentation in Contemporary Project Environments, *Project Management Journal*, 32(3), 2001, pp 39-48.
- [8] Martinez, M. T., Fouletier, P., Park, K. H. and Favrel, J., Virtual Enterprise – Organization, Evolution and Control, *International Journal of Production Economics*, 74, 2001, pp 225-238.
- [9] Archer, L. B. and Roberts, P. H., Design and Technological Awareness in Education, *Studies in Design Education Craft & Technology*, 12(1), 1979, pp 55-56.
- [10] Jonhson, G. R., Issues to Consider When Creating a Virtual University, *International Journal of Engineering Education*, 15(1), 1999, pp 8-13.

Contact Information:

Professor Dr. Imre Horváth
Section Computer Aided Design and Engineering
Faculty of Industrial Design Engineering
Delft University of Technology
Landbergstraat 15, 2628 CE Delft, The Netherlands
Phone: +31 15 278 3520
Fax: +31 15 278 1839
Email: i.horvath@io.tudelft.nl