DESIGN EDUCATION VIA COLLABORATION IN AN ADVANCED KNOWLEDGE ENVIRONMENT

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ABSTRACT
Industry is demanding for years to see engineering educators "teach the fundamentals" of global enterprise engagement and skilled use of information and communication technology. The collaboration of universities and industrial partners is a major prerequisite for the realization of an advanced knowledge environment. Therefore a knowledge network has been established, which is an essential part of the overall collaboration framework. Knowledge is built via collaboration among users (lecturers, researchers, industrial partners), via various forms of interaction.
A knowledge pool, organized in a database, is the basis of the system, enabling users to compile personalized forms of utilization (online courses, electronic books, portfolios, etc.). This can be achieved by a high level of modularization and structuring of the content.
Based on a socio-constructivist approach, the environment promotes the acquisition of knowledge on the basis of users' experience and via shared activities in a collaborative environment, which serves for the working on common projects. A highly interactive environment with advanced communication tools fosters the realization of virtual innovation projects by project teams. Beside other issues this paper presents the framework of a project for developing a new sports gear within an advanced knowledge environment. The environment integrates universities and industry partners in a common effort, to build a knowledge pool and a space for interaction and learning.
Based on a pedagogical model, which encourages individual and social cognition via reflective practice, it is an environment, which offers different learning possibilities and several collaborative instances. The main concept and features will be discussed.

Keywords: collaboration, design education, e-learning

1 INTRODUCTION

University students are nowadays increasingly challenged within their specific core disciplines; in addition however, they are also supposed to develop skills in order to apply this particular knowledge in practice. This ideally goes hand in hand with a sense of maturity of the individuals' characters vis-à-vis the social, cultural, and economical environment. The practical application of theoretical knowledge can thus only be implemented successfully, if these three basic elements are taken into account.
In addition to university students' disciplinary knowledge, the ability to work efficiently within multicultural environments has become increasingly important. Universities are therefore looking to expand and deepen this particular aspect in order to provide the necessary expertise in this field. This realization has led to universities becoming more proactive with regards to networking and offering joint courses, which is where POLE

Europe (Project Oriented Learning Environment) is actively involved in. POLE Europe provides an essential part, the backbone of the advanced knowledge environment presented [6].

POLE Europe sees itself as a learning system cooperating with other European or foreign universities. It does so within a reflexive context, taking into account the various cultures involved in order to create new methods of resolution regarding teaching and learning methods. The students are at the core of this concept, and are given the option to develop process-oriented expert knowledge through interdisciplinary teamwork. Simultaneously, they learn to work independently and to deal with current problem cases through the use of modern information and communication tools. In the course of this collaboration activity, it has become apparent that the complementary aspect has gained in importance.

2 BACKGROUND

The rapid technological development and the need to cope with an increasing amount of information generate a difficult situation for both: professional courses at universities and the industry. University teachers and researchers have to be constantly updating their knowledge on newly available technologies and products. The same happens to professionals from industry. The research developed at universities needs the support of industry, not just financial, but also to test ideas in practice. Industry can also benefit from having the opportunity to present their products to students, who will be future professionals and probably work with their products or in development teams in industry. Therefore, it is obvious the potential which a collaborative networked learning environment could have for both, universities and industry.

Product innovation, which essentially means the definition, development and production of new products and their successful launching to the market, is the driving factor for a powerful, competitive economy and the prosperity of society. Therefore, the education of professionals at universities and the continuous professional development of engineers in the wide field of product innovation are of central importance [7]. Knowledge about product development and product innovation has both, an enormous width in topic variety and a considerable depth regarding know-how.

An analysis of the present education programs and offers of different universities in the area of product innovation shows the following situation:

- the specific knowledge is extremely distributed among the different universities,
- the different curricula have distinct focuses with respect to specific subjects and themes.

For instance, there are several good courses in innovation management, development methods, engineering tools, engineering and structural analysis, and rapid prototyping design. However, the subjects are often presented in kind of isolated view, driven by the specific know-how and interests of the teacher. These differences can have an undesired influence on the exchange of students and on the development of collaborative work, for example. However, the difference has also its richness. Making these differences clearly accessible and open to collaborative use and debate can improve creativity and generate further developments in educational practices as well as in research. We believe that the use of networked technologies can be of immense help in this positive process, facilitating the collection of and access to content, allowing for collaborative exploration and development of it. Teamwork in joint projects and courses allows students to further expand their specific professional skills; on the other hand, it also gives them the op-

portunity to develop more generic competences, which nowadays is one of the key qualifications in order to be able to adapt to a continuously changing environment.
The course also enables students to evaluate their ability to function in a team and to analyze their styles of communication. Through practical examples, students are given the opportunity to explore how well they are able to work in a team, and to what degree they are flexible to accept members' concerns from other disciplines, i.e. how they can integrate these into their own work and patterns of thinking.

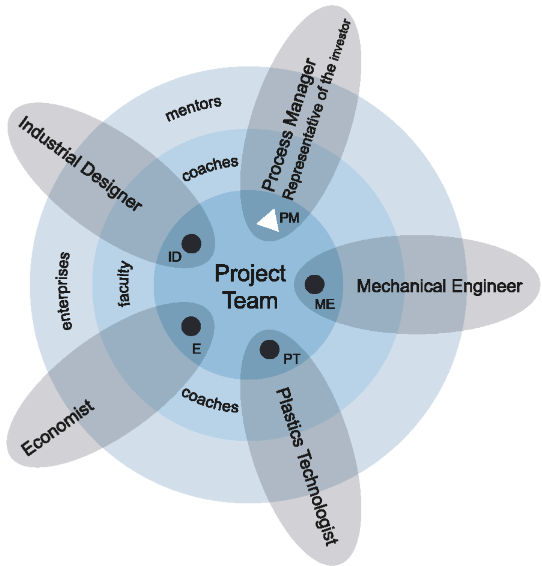

Figure 1 Interaction of project teams, coaches and mentors [7]

Experts and mentors from industry are an essential part of the courses (Figure 1). Their participation contributes a high degree of practical knowledge to the projects, pointing out the actual 'state of the art'. In this manner, the environment manages to link academic education and professional practice. The intensive interaction between these two elements guarantees a rapid transfer of technology, while at the same time ensuring that the students involved are motivated to a high degree.

3 LEARNING PROCESS AND PEDAGOGICAL MODEL

The learning process is mainly structured in three major phases, preparation, application and consolidation. A variety of different learning modes are integrated, from individual to class and team. At the same time an adaptation of teaching technology and teaching modes are necessary. This includes e-learning technology to fill the gaps, where traditional teaching and learning can be supported by complementary measures.
Aiming to generate a networked collaborative environment for the consolidation phase within the learning process, a socio-constructivist approach is favourable, where the acquisition of knowledge is based on the users' experience and collaboration. Within this approach, it is important to provide a choice of activities within a reliable and secure environment, where users can develop individual and social cognition.
Dealing with the education of practitioners also a higher demand for the development of critical and reflective abilities is desirable. The constant exposition to an increasing amount of information and to technological developments generates new demands on

individuals. They need to develop the ability of critically select the most appropriate information and of taking immediate decisions to efficiently respond to the changing scenarios of practice. Therefore, principles of 'reflective practice' and 'critical pedagogy' are also to be considered [1]-[3]. Combining these issues, the critical socio-constructivist pedagogical model was adopted [9].

3.1 User interaction model

The way the user interacts with the content and with the environment as a whole has significant importance, if more than providing reliable information, we want to promote learning. The learning content needs to be accessed via a coherent navigational approach, within a coherent user-interaction model.
Based on the pedagogical model above, the environment promotes the following types of user interaction:

- interaction with content,
- interaction with other users (incl. mentors and experts),
- interaction with tools.

The user-interaction model allows the description of the visual appearance of the system, including user interface elements, information shapes and organisation. The user-interaction model will guide the design of the environment, determining:

- the organization of the content presentation;
- the character of the different parts within the learning environment;
- the hierarchy of information;
- the forms of navigation through the environment.

4 REALIZATION – THE TEAM PROJECT

The POLE Europe course offered during the winter term 2003/04 brought together the disciplines of mechanical engineering, plastics engineering, product design, industrial design as well as economics with students and faculty from University of Applied Sciences Aargau (with its faculties of economics, industrial design, plastics engineering and process management), Aalborg University (Department of Production and Institute for Architecture & Design), ETH Zürich (Institute of Mechanical Systems, Center for Product Design) and NTNU Trondheim (Institute for Innovation & Product Development). For external evaluation and assessment Stanford University (Center of Design Research) was involved in the course. The composition of the participating universities was mainly defined by the project subject and may change from one project to the other.
As diverse expertise was required in the area of research and development for the successful development of this project, the close collaboration among partners in industry and several universities was paramount. As they were also users of the learning and collaboration environment, their active involvement on all the stages of the project was essential to guarantee a broad and fast acceptance and use of the learning environment as well as the richness of the knowledge pool.

4.1 Design task

Snow sports have gained a strong stimulus, when the traditional skis were supplemented by snow boards. The combination of snow boards with kind of a scooter device was an idea, which came up app. 8 years ago, called the Snowscoot™. It allows even beginners to rapidly develop their skills and move down relatively steep slopes - even in deep snow fields.

Based on this existing sports gear, a new performance profile of base version was defined with functional and aesthetic improvements according to the agreement with the industrial partner:

- weight reduction of 30 per cent compared to the base version (Figure 2),
- reduced transport volume: the improved version had to be foldable, in order to be easily carried or transported,
- considerable improvement with respect to cost effectiveness,
- improved safety during operation and use,
- definition of a suitable production method for medium sized series (10'000 pieces/year) with adaptable tooling, flexible enough to integrate future adaptations.
- development of a business/ marketing plan,
- evaluation of legal aspects in the context of protection by international patents,
- product documentation: the design and edition of an instruction manual for potential users.

Figure 2 Base version (initial design) of the sporting gear (Snowscoot) [11]

In summary: this project of POLE Europe had a complex scope which could only be solved in teams of graduate students, who integrated knowledge from their faculties of mechanical engineering, plastics technology, light weight design, economics, marketing, industrial design and process management. For the whole development process, from testing of the existing base version until test drive of the new prototype, the teams only had a time budget of 14 weeks.

Forty students in five interdisciplinary teams worked on the design and development of a novel sporting gear for snow, sand and eventually water under the guidance and supervision of 14 faculty members.

The project started at beginning of the winter term 2003 with a kick-off week, held at the University of Applied Sciences Aargau, where all students and faculty came together mainly for the following purposes:

A. team forming: the team forming process was an essential part of this event. It turned out to be extremely important to build a profound social link among the students as the basis for a solid collaboration during the course of the project,
B. instructions on ICT: the teams could only communicate through ICT during the whole development process. Therefore all students attended a workshop on using the communication tools (video conferencing for review meetings, exchange of documents, process management)
C. lectures on specific topics: several lectures were given to facilitate the start-up for the project with respect to a common nomenclature. Critical aspects of the

project were addressed by the lectures, given by faculty and also experts from industry.

D. definition of the project outline/ plan: at the end of the kick-off week the teams were in charge to present a project plan including work packages, time line, definition of milestones, resource planning, schedule of further activities, etc.. The presentation of the project plan to faculty, mentors and experts from industry concluded the kick-off week, dismissing the students to their home universities with comments and recommendations for the further course of the project.

During the following weeks the teams could only communicate via ICT. At the same time the formed local teams at their home universities to exchange basic information useful for all project teams (i.e. geometry data of the base version, loading assumptions, list of requirements, specifications, etc.). The manufacturing of the fully functional prototypes of the enhanced version were managed over the information platform of POLE. The parts were then manufactured at different sites, the final integration and assembly was done on the occasion of the final presentation event, which concluded the project in the second week February 2004. It was the obligation of all teams to provide a fully functional prototype, which was demonstrated and test also test driven by skilled personnel.

Moreover the team presentation had to include:

- a comprehensive documentation on the team's web page, as well as through physical documents (e.g. scaled plans according to production standards) of product,
- production method(s),
- a marketing concept,
- convincing sales brochure of product,
- a process handbook of the whole development process in English.

The evaluation of the project results were in the duty of a jury, which was formed by one member of each discipline and two members of the POLE Europe directorate. Each team received a jury report with an acknowledgement of the contributions according to the following criteria: (1) technical functionality of product, (2) economic efficiency and feasibility, (3) innovation potential of the solution(s), (4) suggested production methods, (5) presentation of the product on web site, (6) fulfillment of given requirements, (7) general impressions.

The team results of this project were of high quality in various aspects, although the teams only met for the introductory week, then only communicated over the web having a very limited time budget. Steeling the words of Tom Kelley [13], one can say that all the five teams had turned into kind of "hot groups" after the kick-off week. They all were absolutely determined to reach the final goal of delivering a new version of the sporting gear. After the test drive of the base version, nobody had any doubts, that the device could be improved and therefore everybody was highly motivated to start the project. The very little time budget also created an additional motivational factor, because it seemed to be almost unrealistic to fulfill the goals. The teams developed a tremendous determination for being successful. Key factors also have been the balance, the multidisciplinarity and cultural variety of the team members, which all foster the process of negotiation during the design process.

5 CONCLUSIONS

The experiences gained from the collaboration project are very promising so far. The learning experience of the students is very rich with respect to various aspects. Further development and research issues include the creation of knowledge databases, which will serve as a tool for more rapid evaluation of solutions and decision-making processes in the future. These efforts are based on the knowledge that a large part of creational, construction, and design processes are substantially shaped by re-design. The learning environment and its associated methodology allow students to apply their theoretical knowledge in practical cases. Through collaboration in interdisciplinary teams guided by process management students, students from fields such as architecture, urban planning, civil engineering, interior design, and economics are given the opportunity to understand the individual processes involved and acknowledge their relation to the social, economical, and political dimensions.

In the final stage the result of our work will end up in an integrated learning environment, which will effectively enhance learning in global, cooperative, interdisciplinary team work. Specifically, the approach combines the exciting idea of digital libraries with the development of virtual design studios for team collaboration in an international setting. The development of new products for the global market requires the ability of today's students to be able to cooperate by using cutting-edge technologies beyond disciplinary and cultural borders. Modern communication technologies - like virtual platforms, spatially distributed work places, video and audio conferences and email – and in particular digital libraries – will be the backbone in the upcoming courses.

In future team-based project test bed, the following criteria will be of strategic value:

- multi-disciplinary and international teams,
- real world tasks to be solved,
- negotiation and resolution of open-ended development and planning scenarios,
- geographically distributed team members as well as coaching networks,
- formative evaluation of the project-based learning processes.

On the one hand, it is the goal of this initiative to open to the students opportunities to work in interdisciplinary teams and to co-operate in different cultural contexts. But they shall not only apply the modern, but already established information and communication technologies, but learn to use, work with and co-create novel digital libraries and knowledge data bases. It is anticipated that as a mid-term goal it will fundamentally change the traditional way of learning and teaching by combining the use and the enhancement of digital libraries with virtual team based co-operation by using cutting edge information and collaboration technologies, and by recording and documenting the teams' creative process for later re-design.

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