AN INTERUNIVERSITARY EDUCATION CONCEPT FOR COLLABORATIVE PRODUCT DEVELOPMENT

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ABSTRACT

This paper introduces an educational concept for Collaborative Product Development. It aims at providing skills for leading and contributing to interdisciplinary projects involving different locations, typical for globalized enterprises. Attention is especially paid to heterogeneous teams involving members of different disciplines and varying levels of experience as well as differing cultural backgrounds.

As collaborative product development projects are characterized by manifold possible configurations and require a high degree of action flexibility from everyone involved, the proposed concept ceases from the common focus on curriculum-driven education. Instead, principles of active learning, an approach developed in the early 90s, are incorporated: Whilst base knowledge is imparted by means of conventional lectures, the students are encouraged to apply that knowledge on practical problems with no or little faculty guidance or interference.

The approach chosen for the discussed course is to create a realistic setting that simulates respective collaborations. For that purpose, a liaison has been established between the Institute for Engineering Design (RWTH Aachen University) in Germany and the Departments of Industrial Design and Mechanical Engineering of Hongik University in South Korea. Students from each involved department on the two sites participate in project teams to develop a product. During the project, the lecturers predominantly assist as consultants, acting mainly if explicitly asked for help. It is intended to let critical situations emerge as under realistic conditions, so the students learn by first hand when and how certain techniques can be applied.

Keywords: Engineering design education, collaborative product development, Product Data Management (PDM)

1 INTRODUCTION

Industry faces global changes in engineering as well as manufacturing. In order to decrease time to market, sustainable processes and facilitating tools have to be established to enhance collaboration across borders and time zones. To cope with these challenges, industry seeks to employ Design Engineers and Industrial Designers that are able to accomplish interdisciplinary, inter-enterprise international product development projects.

As it is to the universities to satisfy this demand, educational concepts have to be worked out that are able to reflect the changes in industrial practice. However, the style of imparting knowledge in university education typically remains conventional, even if the presented contents that should reflect current trends and developments are rapidly changing.

The term Collaborative Product Development represents entailed kinds of projects and processes characterised by teamwork, agile processes, Simultaneous Engineering, cooperation between different disciplines as well as cooperation and collaboration between enterprises. Although the basic contents of conventional educational methods are still valid for Collaborative Product development, specific amendments of the curricula are required in order to prepare the prospective engineers for collaborative work. The challenge lies in the lack of clearly definable structures within collaborative processes.

2 PEDAGOGIC CONCEPTS

2.1 Active Learning

The educational concept proposed by this contribution is based on Active Learning. This approach evolved in the early 90s and has been popularised by Bonwell and Eison [1]. According to Mayer [2], it can be seen as a pedagogic concept which advances the base principles of Discovery Learning developed two decades ago by Piaget et al. [3][4]. Active Learning incorporates the concepts of self-direction and constructivism [5]. Instead of being passively confronted with the preconceived explanations of a lecturer, students are encouraged to actively engage with the subject matter of the curriculum.

Active Learning has been primarily intended to improve the effectiveness of teaching, which means students become more likely to recall the imparted knowledge when needed in a practical context. Besides method knowledge, specific engineering skills are essential to cope with the challenges of current collaborative engineering scenarios emerging in line with globalised product development as outlined in chapter 1. The authors know of no other appropriate concept than Active Learning to effectively teach such skills.

2.2 Design Sprint

A common problem observed to occur in line with Active Learning is the lacking student’s drive for results and focus towards the objectives of the course in case adequate guidance by the lecturer is missing [6]. Without guidance students will develop their own ad-hoc techniques and reinforce bad habits [7]. Students need to see good designs as well as the consequences of poor designs [7].

A solution to enhance the collaboration behaviour of students in line with the curriculum can be derived from the “Student Design Sprint”-pattern of the pedagogical Pattern Language by Bergin [7] as follows: During a design sprint two so called core groups are each combined to a development team collaborating or competing with other teams. After a certain period of time, the lecturer poses a set of questions or suggestions to point out the particular objectives and encourage the students to differentiate between good and poor design, but without giving an explicit answer. To start the subsequent design sprint new development teams are created by recombining the core groups. This enforces a serious review as each team comprises two core groups with competing solutions.

3 PREVIOUS PDM-PLM TEACHING ACTIVITIES

The course "Collaborative Product development" (CoPro) has been introduced as an elective for RWTH students specializing in product development in 2004. Since then, the concept has been continuously upgraded until the current configuration could be realized.

In the course's first run, selected students of the 2nd semester undergraduate "Introduction to CAD" course took on the role of project engineers. Their CAD output as well as corresponding workflows were managed by CoPro students on a Windchill™ PDMS, which was also administered as part of the exercises' scope.

Although this concept proved to be well suited for the subject matter, there was a feeling that the course's potential had not been used to its full extent as "it all went too smooth". The course should not only deal with producing and managing product data but about overcoming all obstructions that occur during its development. As such obstacles only appear in a real-life development scenarios, the concept had to be modified.

For the second take on the course, a partner from industry was identified who was willing to supply a design task and act as client to the project, contributing design restrictions and conducting reviews. Here, the project teams did not only manage the project using the PDMS functionality but also produced engineering data while concurrently working on the same design task according to the concept of the Design Sprint. The wanted outcome was that the students were confronted with more "solicited challenges", such as missed deadlines and restrictions, communication issues, actual design problems and problems due to different software used on both sides of the collaboration.

This concept proved to be successful; all emerging problems could be resolved by employing the methods taught in the lectures or by utilizing the PDMS' functionality. To name just one example: It was as late as the time of the first design review when the students found out that their CAD data files could not be opened by the software used by the client, because a newer software version had been used. This problem could be resolved by using the PDMS' viewing functionality for reviews, which required some familiarization with the involved tools. It must be stressed that these tasks were tackled by the students alone with only a minimum of guidance and driven by the motivation to meet the deadline.

4 COURSE DESCRIPTION

The seemingly absurd conclusion gained from the first two takes of the course is that it can only run effectively if problems that can occur in actual collaborative engineering or product development projects arise naturally during the example project. This is achieved best if the students are given a real development assignment that is new even to the consulting lecturers. Although this project is only a means to end, the students' motivation to successfully terminate the product development project is a prerequisite for the intended teaching aim. The described runs of the courses have proven that the active learning approach can successfully be used in this course, as this concept seems to motivate the students to meet the challenges and even put more time into the project than required by the curriculum if necessary to reach the design goal. The reason to change the existing concept was to include more typical challenges that haven't been included so far: cultural and language barriers, different time zones and direct collaboration with stylists or industrial designers.

This has become possible because of a new partnership between ikt and the Departments of Mechanical Engineering and Industrial Design of Hongik University, Seoul. The course “Collaborative Product Development” is being held mutually and simultaneously on both sites at the time of the preparation of this paper with students from all three departments taking part in and receiving credit for the course.

4.1 Schedule

A major problem with mutual courses in different countries is that the semesters usually are not synchronized. Here, the summer semester in South Korea starts and ends 5 weeks earlier than in Aachen, Figure 1. This allows for a slightly different emphasis in the lectures, and it also structures the overall project into three stages. Only during the second stage all team members collaborate, while during the stages 1 and 3, fragmented teams have to work on adequate sub tasks. A very important part of the concept is a mutual visit of the partners’ campuses, during which the working on the project was significantly intensified. Needless to say, the actual meeting of the project partners included social events that immensely boosted motivation.

	Week	Day	Date	Events	Lecture	Exercise/project work
Stage 1	10	Wdsdy	05.03.08		Course Introduction	
		Frdy	07.03.08			Team formation / Project outline
	11	Wdsdy	12.03.08		Product Development Process	
		Frdy	14.03.08			Conception
	12	Wdsdy	19.04.08		Product Pevelopment Process	
		Frdy	21.03.08			Ideation
	13	Wdsdy	26.03.08		Introduction to PLM	
		Frdy	28.03.08			Ideation
	14	Wdsdy	02.04.08		Introduction to PLM	
		Frdy	04.04.08			Ideation
Stage 2	15	Wdsdy	09.04.08		Project Management Methods	
		Frdy	11.04.08			Global team formation / Communication tool / Sharing prev data
	16	Wdsdy	16.04.08		Industrial Design	
		Frdy	18.04.08			Intro to NX (ergonomics, layout) & Alias / NX-Alias interfacing
	17	Wdsdy	23.04.08		Industrial Design	
		Frdy	25.04.08			Teamcenter Engineering
	18	Wdsdy	30.04.08		Design review 1	
		Frdy	02.05.08			RP / CNC / CMM
	19	Wdsdy	07.05.08		Introduction to PDM/PLM	
		Frdy	09.05.08			Working on project
	20	Week of field-trips (no lectures Aachen)		14.-23. May: Aachen visits Hongik	Client-Subcontractor Collaborations	Working on projects, design reviews
					Design review 1	
	21	Wdsdy	21.05.08		Critical Path Analysis	
		Frdy	23.05.08		Interdisciplinary Design Processes	
	22	Wdsdy	28.05.08		PDMS Implementation in SMEs	
		Frdy	30.05.08			Working on project
	23	Wdsdy	04.06.08		PLM in Action (HIU)	
		Frdy	06.06.08			Working on project
	24	DIES Academicus		Exam. Hongik	Processes and Workflows	
		Frdy	13.06.08			Presentation (body + package + some mech parts)
Stage 3	25	Wdsdy	18.06.08		Variant Management	
		Frdy	20.06.08			Working on project
	26	Wdsdy	25.06.08	Hongik visits Aachen	Distributed Product Development	
		Frdy	27.06.08			Working on project
	27	Wdsdy	02.07.08			
		Frdy	04.07.08			Working on project
	28	Wdsdy	09.07.08			
		Frdy	11.07.08			Working on project
	29	Wdsdy	16.07.08	Exam. Aachen	Presentation (completed model)	
		Frdy	18.07.08			

Figure 1 Course schedule. The shared part of the course is greyed.

4.2 Design task

The task was to propose an innovative concept for an electric vehicle. The ideas were allowed to address rather special user groups, so they needn’t necessarily be suited for a mass market. As the Korean semester started earlier, the specification of the vehicle concept ideas has been mostly worked out by the Korean Industrial Design and Engineering students during the first stage of the project before the German students joined the teams. In this second stage, the most concept-defining technical challenges had to be identified and solutions to realize them have been worked out by the collaborating Korean and German engineers in the teams, while the designers refined their concepts and incorporated the emerging engineering restrictions. During stage three after the end of the Korean semester (which will be after this paper has been finished), the drive concepts will be laid out mostly by the German team members.

4.3 Team formation and Design Sprint

The number of participating students has been strictly limited to 10 students per department. Five concurrent teams were formed, made up by two students each of each participating department. This layout challenged all participants to tackle time and language aspects while working on the project at all stages. The formation of a team spirit within the international teams is supported by the Design Sprint concept: Each team is required to present their own concept (including a mockup), at the end of the course, which will be ranked.

4.4 Collaboration Infrastructure and Tools

To realise the concept described above a realistic learning environment is required which emulates scenarios commonly occurring in line with industrial collaboration. Besides an organisational framework, this comprises an appropriate software infrastructure. Figure 2 depicts the infrastructure implemented to support the course described above. The applied software has been partly provided by the PACE-Initiative (Partners fort the Advancement of Collaborative Engineering Education) [9].
A data layer established according to common industrial implementations comprises CAx-systems of various kinds. To ensure consistency and share the created product data amongst students in Aachen as well as in Hongik those CAx-Systems are connected to an underlying PDM-System (Product Data Management).
A virtual product development environment is established by a collaboration layer to support the collaboration between teams located at both sides and furthermore to enable distributed development teams incorporating students from Aachen and Hongik.

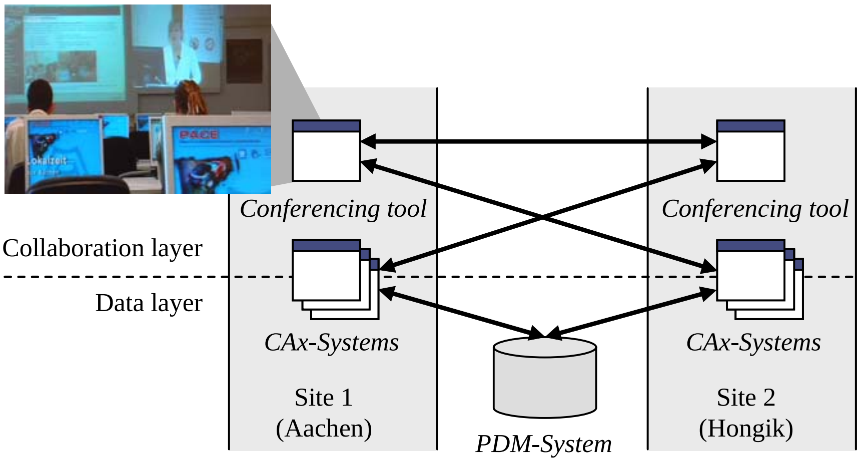

Figure 2 A conceptual representation of the collaboration infrastructure

The collaboration layer comprises multi-medial conferencing tools providing each student access to the virtual environment. Those tools support acoustic and visual bilateral communication as well as the arrangement of conferences with several participants. Additionally, software resources can be shared to access the CAx tools from within the virtual environment.

5 SUMMARY, DISCUSSION AND OUTLOOK

A concept for a course is presented that uses an Active Learning approach and the idea of the Design Race as well as a collaboration of two Universities in different parts of the world to achieve a setting that effectively prepares students of Industrial Design and Mechanical Engineering for Collaborative Product Development. At the time of finishing this paper, more than half of this course's first run has been completed and the authors and students agree that the concept is proving to be a success. The teams have come up with very promising concepts to be published soon that include for example vehicles that address the needs of wheelchair users and mothers with infants. Team formation and collaboration has been made possible through collaboration tools over the internet, so results could be produced without the team member having physically met at first and using only their second language to communicate. Also, the shared lectures and the mutual visits have proven to contribute immensely to the students' perception of the challenges of Collaborative Product Development. The success has led the involved institutions to decide that this course is going to be offered each year. Also, at least one second course is planned to be established that focuses on Product Design to complement the concept.

REFERENCES

[1] Bonwell, C. and Eison, J. Active Learning: Creating Excitement in the Classroom. *AEHE-ERIC Higher Education Report*, No. 1 (Jossey-Bass, Washington, D.C., 1991).

[2] Mayer, R. Should there be a Three-Strikes Rule Against Pure Discovery Learning? The Case for Guided Method of Instruction. *American Psychologist 59* (1), pp.14-19 (2004).

[3] Piaget, J. and Elkind, D. (Eds.) *Six Psychological Studies*. (John Wiley, New York, 1970).

[4] Bruner, J.S. The act of discovery. *Harward Educational Review 31* (1) (1961).

[5] Fosnot, C.T. (Ed.) Constructivism. Theory Perspectives and Practice. (Teachers College Press, New York, 1996).

[6] Kirschner, P. A., Sweller, J., and Clark, R. E. Why Minimal Guidance During Instruction does not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist 41* (2), pp. 75-86 (2006).

[7] Bergin, J. Fourteen Pedagogical Patterns. In: *The Pedagogical Patterns Project*. Available: http://www.pedagogicalpatterns.org [Accessed on 2008, 13. February], (2007).

[8] Feldhusen, J., Löwer, M., Nurcahya, E. and Macke, N. Advances in Collaborative Engineering Education. In: Proceedings of the International Conference on Engineering Design, ICED'07, Paris (2007).

[9] *Partners for the Advancement of Collaborative Engineering Education – PACE*. Available: http://www.pacepartners.org, [Accessed on 2008, 13. February], (2007).

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