Intercultural and Interdisciplinary Collaborative Product Design Education Concept

Hyunjune Yim[1], Jörg Feldhusen[2], Frederik Bungert[3], Alexander Brezing[4], Keun Lee[5], Manuel Löwer[6], Haeseong Jee[7], Byongjoo Kim[8]

[1,7,8]Department of Mechanical & System Design Engineering, Hongik University, Seoul, Korea,
[2,3,4,6]Chair and Institute for Engineering Design (ikt), RWTH Aachen University, Aachen, Germany
[5]Department of Industrial Design, Hongik University, Seoul, Korea

hjyim@hongik.ac.kr[1], brezing@ikt.rwth-aachen.de[2], kleeoh@hongik.ac.kr[3]

Abstract

The delineated approach provides an educational concept for Collaborative Product Development. It aims at teaching and training skills to accomplish collaborative product development projects as the head of the team as well as a team member. Attention is especially paid to heterogeneous teams of different skills, knowledge, specialization, ambition, location as well as cultural background.

As Collaborative Engineering aggravates the definition of structures the proposed approach ceases from the common focus on curriculum-driven education. Instead, the approach incorporates principles of active learning, an approach developed in the early 90s, for exercises. Whilst base knowledge is imparted by means of conventional frontal instruction lectures, the according skills are trained in line with exercises lessons encouraging active participation.

A novel exercise concept has been developed to cope with the challenges raised by Collaborative Engineering. This concept stipulates a realistic simulation of a collaborative product development environment. For that purpose, cooperation among the Institute for Engineering Design, RWTH Aachen University, Germany and the Mechanical & System Design Engineering (MSDE) Department as well as the Industrial Design Department, both of Hongik University, Korea has been established. Students from the three departments participate in cooperating project teams to develop a certain product. During the project, the lecturers just assist as consultants, acting if explicitly asked for help by the students. 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.

Introduction

Industry faces global changes in engineering as well as manufacturing. With the need of further decrease of time to market, sustainable processes and facilitating tools, enhancing collaboration across borders and time-zones have to be established. To cope with these challenges the companies demand for engineers being able to accomplish interdisciplinary, inter-enterprise international product development projects.

The universities, as they conduct the teaching for future employees, have to keep up with these industrial needs in order to facilitate the competitiveness of product developing companies. However, conventional approaches for product development education generally reflect the market situation from a couple of decades ago. Those approaches are based on sequential development processes with exactly defined tasks and responsibilities entailed by the formerly common flow-oriented organizational structure.

Current enterprises are commonly structured according to a matrix organization. The term Collaborative Product Development represents entailed kinds of projects and processes characterized 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. However, this is aggravated by the lack of clearly definable structures within collaborative processes.

Pedagogic Concepts

The educational concept proposed by this contribution is based on Active Learning. This approach evolved in the early 90s and has been popularized 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. 34. 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, i.e. the students are more likely to recall the imparted knowledge. Besides knowledge, specific engineering skills are essential to cope with the challenges of current collaborative engineering scenarios emerging in line with globalized product development as delineated above. Active Learning is considered by the authors as an appropriate approach without serious alternatives to teach those skills.

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 behavior 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.

Previous related teaching activities

The introduction of the new course "Collaborative Product development" (CoPro) by the Institute for Engineering Design (ikt) at RWTH Aachen University as an elective for students specializing in product development paid tribute to the growing importance and complexity of Product Data Management Systems (PDMS) and the strategic management of product lifecycles (Product Lifecycle Management, PLM). While the theory to this subject can be presented in conventional lectures, an actual understanding of the tools and methods and the necessity to employ them in a collaborative product development situation required a set-up project that enabled the students to act in a close to real-life situation during the exercise part of the course.

The spectrum of courses conducted by ikt was used for the course's first concept: Some selected students of the 2nd semester undergraduate "Introduction to CAD"-course took on the role of project engineers and supplied CAD data. This data as well as corresponding workflows were managed by CoPro students on a WindchillTM PDMS, which was also administered as part of the exercises' scope.

This concept proved to be well suited for the subject matter as it was able to impart practical knowledge on the use and administration of a PDMS and approaches such as role concepts as well as creating a feel for some of the challenges of collaborative working, as the "project engineers" had a different academic background and worked on a different campus than the "project managers".

On the other hand, the Mechanical & System Design Engineering (MSDE) Department of Hongik University has been offering similar courses on CAD, PDMS, and PLM while the Industrial Design Department of Hongik University has a well-established digital design process curriculum. Most software used by both departments of Hongik

University has been provided through the international industry-university cooperation program, called the Partners for the Advancement of Collaborative Engineering Education (PACE) [8], which Hongik joined in 2005.

Also, collaboration between the MSDE and Industrial Design departments has been established in teaching mutual courses. One typical example is the course, Automotive Design and Engineering, offered to the senior undergraduate students of MSDE. Within this course, about a quarter or a third of the classes has been assigned to the understanding of the processes and tasks of the industrial designers of car companies. Through this portion of the course, the engineering students learn what designers do and how designers think, and most importantly, how to collaborate with industrial designers in automotive development.

With RWTH Aachen joining the PACE later, the two universities had an opportunity to consider developing and offering a mutual collaborative course. While all three departments had been doing some type of collaborative design education, a mutual understanding was reached that such an intercultural and interdisciplinary course would provide much greater value to what each had been doing separately. This would more closely simulate the real-world situation of international collaborative product development as explained above.

All students are now challenged by cultural and language barriers, different time zones and direct collaboration with stylists or industrial designers. .Although the design project in this course 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 active learning approach 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.

Course description

This course between RWTH Aachen ikt and the Departments of MSDE and Industrial Design of Hongik University, Seoul was launched in the spring semester of 2008, and is continued to be offered this year. Classes are held mutually and simultaneously on both sites, through the Internet, with students from all three departments taking part in and receiving credit for the course.

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 5 weeks earlier than in Aachen, Figure 1. This allows for a slightly different emphasis in the lectures.

Figure 1: Course schedule.

Week	Day	Date	Events	Lecture	Exercise/project work
10	Wdsdy	04-03-09		Course Introduction / Project theme	
	Frdy	06-03-09			Team formation / Project outline / Communication Tools
11	Wdsdy	11-03-09		Introduction to PLM	
	Frdy	13-03-09			Tools & Methods: Using Teamcenter Engineering
12	Wdsdy	18-03-09		Design Research	
	Frdy	20-03-09			Working on project
13	Wdsdy	25-03-09		Automotive Design Process	
	Frdy	27-03-09			Working on project
14	Wdsdy	01-04-09		Project Management	
	Frdy	03-04-09			Working on project
15	Wdsdy	08-04-09		Design review 1- Concept & Project plan	
	Frdy	10-04-09			Working on project
16	Wdsdy	15-04-09		Engineering Design Process	
	Frdy	17-04-09			Working on project
17	Wdsdy	22-04-09		Fundamentals of Automotive Engineering	
	Frdy	24-04-09			Working on project
18	Wdsdy	29-04-09		Product Data Mgt System	
	Frdy	01-05-09			NATIONAL HOLIDAY (Aachen)
19	Wdsdy	06-05-09		Industrial Design 1	
	Frdy	08-05-09			Working on project
20	Wdsdy	13-05-09		Industrial Design 2	
	Frdy	15-05-09			Working on project
21	Wdsdy	20-05-09	17. May - 28. May: Aachen visits Hongik	Design Review 2 - Embodiment	
	Frdy	22-05-09		(opt. Add. Lect.)	Working on project
22	Wdsdy	27-05-09		Design Review 3 - Embodiment	
	Frdy	29-05-09		(opt. Add. Lect.)	Working on project
23	Week of field-trips (no lectures Aachen)				
24	Wdsdy	10-06-09	(DIES) / Exam. Hongik	PLM in Action - Opel (opt.)	
	Frdy	12-06-09			Working on project
25	Wdsdy	17-06-09		PDMS-Implementation in SMEs	
	Frdy	19-06-09			Working on project
26	Wdsdy	24-06-09	21 Jun. - 2 Jul.: Hongik visits Aachen	Variant Management	
	Frdy	26-06-09			Working on project
27	Wdsdy	01-07-09		Final Presentation - Detail& Refinement	
	Frdy	03-07-09			
28	Wdsdy	08-07-09	Exam. Aachen		
	Frdy	10-07-09			

The design task, a vehicle for the "silver generation", was proposed by Hongik in 2008. As the Korean semester starts earlier, the specification was mostly worked out by the Korean Industrial Design and Engineering students before the German students entered the course, which matched the nature of the development task, which is mostly driven by usability and styling aspects.

This year, 2009, however the German students joined the Korean students from the beginning even though they were in the winter break because they eagerly wanted to participate in the stages of specification and basic concept development. The task selected for this year is redesign or improvement of municipal service vehicles such as fire engines, shuttle buses, ambulances, and so on. At the time of writing this paper, many interesting design tasks have been identified.

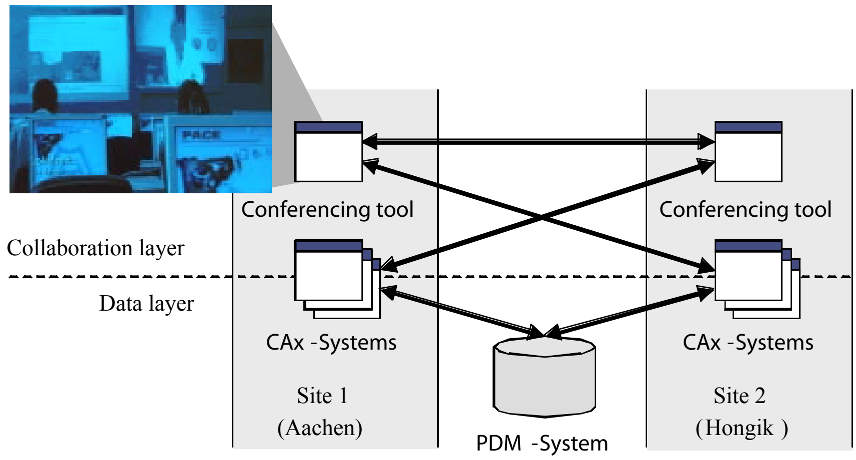
In both years, the number of participating students is strictly limited to 10 students per department. Five concurrent teams are formed, made up by two students each of each participating department. This layout challenges all participants to account for time and language aspects while working on the 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 is ranked.

To realize the concept described above a realistic learning environment is required which emulates scenarios commonly occurring in line with industrial collaboration. Besides an organizational 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 8.

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.

Summary

The concept delineated in this paper focuses on better preparing students for their professional career in an international engineering environment and to decrease the time needed for adjustment on the job after graduation. Today it is not sufficient for university to solely teach theoretical knowledge. The use of tools under realistic conditions within the described course enables members of a design team in widely spread locations and of different cultural background to effectively interact with each other in the process of collaborative engineering.

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