INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
2 & 3 SEPTEMBER 2010, NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, TRONDHEIM, NORWAY

ON THE IMPORTANCE OF HANDLING OBJECTIVES IN DESIGN EDUCATION PROJECT WORK

Albert ALBERS, Quentin LOHMEYER and Thomas ALINK
Karlsruhe Institute of Technology, IPEK – Institute of Product Engineering

ABSTRACT
This paper gives a review of the course of Integrated Product Development (IP) which was presented in a former E&PDE conference and is evolved in its concept since 1997. The IP is a course conducted for 42 Students and for an industrial partner where research, education and strict praxis orientation come together to provide a solution for the contradictory objectives. After introducing the course of Integrated Product Development the paper provides background of objectives in product development. Reasons for the difficulty of taking up, interpreting and communicating objectives especially in early phases of product development are reviewed briefly. In the further sections the measures for handling the definition, communication and controlling of objectives in IP are shown up. The evaluation of the measures in the past project of IP gives an overview of their usefulness. In the end it is shown that "misunderstood" objectives can lead to failures in the project work and thus lead to frustration. However, the measures taken work very well within IP, but also cause a huge teaching effort.

Keywords: Project-based learning, objectives, communication, coordination

1 INTRODUCTION

Product development projects are determined through uncertainties and are based up on assumptions. This causes the course of product development projects to be very hard to plan and it is impossible to predict all oncoming events. One reason for this is that the objectives in a product development project depend from the solutions that are generated throughout the project [1]. Therefore the teaching of product development becomes another challenge. Unlike teaching of various other subjects, the lessons are hard to plan in advance as engineering design includes a focus on finding new product ideas and defining product requirements [2].

New concepts for education in engineering design consist of praxis oriented project work, where students can "live through" and reflect the lecture based theoretical explanations of design issues. Project-based learning is an adequate pedagogical method for design and engineering education since it allows a group of learners to collect, analyze and synthesize information, develop alternative problem solving strategies, and improve their skills and capabilities [3]. Students should learn and activate methodical and social skills in combination with applying their subject-specific knowledge in a realistic environment. One method of creating the realistic environment is to integrate an industrial partner into the project work [4]. This integration is challenging to the education system because contradictory objectives need to be pursued. Beneath didactic objectives which focus on the impartment of technical and methodical knowledge, lecturers for design have to evolve the social and personal competencies of the students as well as they have to satisfy the demands that are determined through the industrial project partner. Thus, the design lecturers and researchers also have to manage industrial projects with concrete demands for results, time and budget conditions.

Their task is to integrate the different objectives, communicate and control those to the students. In this way lecturers exemplify the handling of objectives to the students and impart even challenging contents of teaching, like decision making and management skills [5].

Objectives in product development are abstract, thus ambiguous and are subject to interpretation of designing engineers. This issue causes design problem solving processes to lack of a straight and efficient course. This paper focuses on the handling of objectives within a course of product development, as the management of the students is conducted through defining, communicating and

controlling objectives [6]. The consciousness of fuzziness is one teaching goal in the Integrated Product Development project.

2 INTEGRATED PRODUCT DEVELOPMENT (IP)

The Integrated Product Development Course (see Figure 1) is part of the Karlsruhe Education Model for Product Development KaLeP [7]. On E&PDE 2008 the lecture and tutorial concept of the Integrated Product Development Course was presented and it had been shown, how the educational project work, exemplified by teamwork and cooperation, enables key competencies of students [8]. This paper focuses on the realistic project environment, which strongly interacts with the development and communication of objectives.

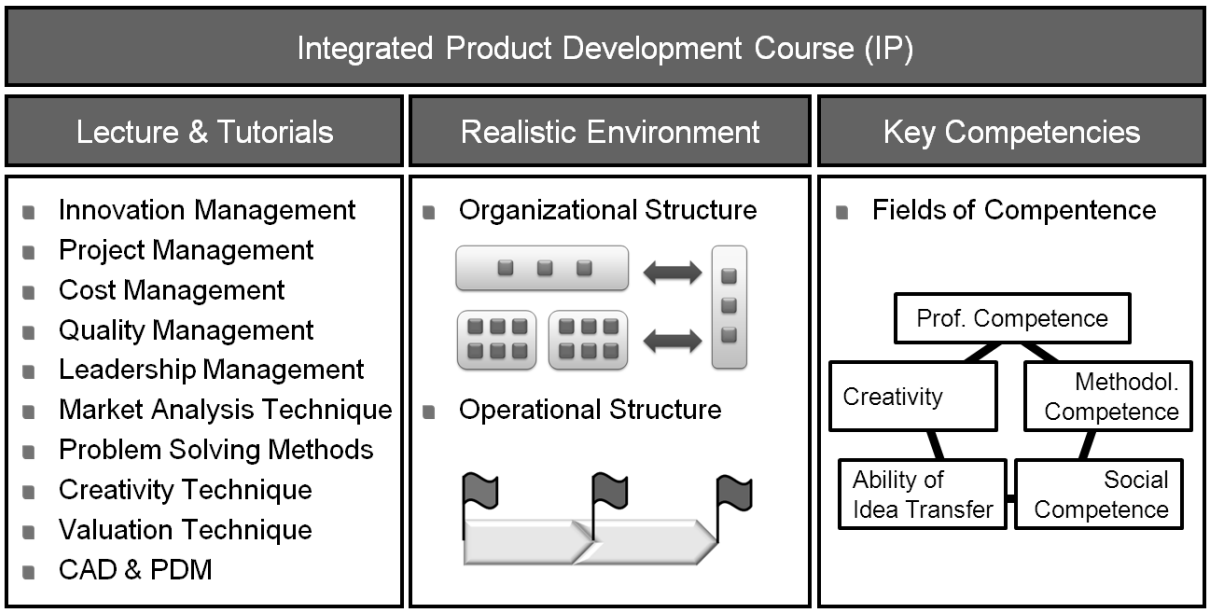

Figure 1. Development Teams and Cross-Section-Teams

2.1 Organizational Structure of the IP Project

The IP project work is initiated and supervised by the employees of the IPEK. A core team of one professor and three research assistants is responsible for project coordination and student mentoring. Due to the intense coaching in the project and the limited work space, the number of participants is restricted to only 42 students. The students usually are in their last of five years before graduation. For project work the students are organized in seven teams, each consisting of six members.

To ensure realistic design problems, the project task is brought in by an industrial project partner, who outsources a current strategic topic in IP and thus is seriously interested in a successful development process and innovative project results at its end.

2.2 Operational Structure of the IP Project

All student teams are starting the project with the same task. However, any product development process course of the 7 teams on a lower level is individual and leads to a widespread variety of solutions. As this variety is wanted by the project partner, an open definition of the development topic is very important. A typical task definition would be, that “the industrial project partner would like to enter a new market segment and thus needs innovative products with a high market potential”.

The project is subdivided in stages, in which the students run through certain activities of product development in order to generate product profiles, product ideas, concepts and prototypes. At any stage the findings are evaluated according to weighted criteria derived from market and technical feasibility. The results are presented at milestone meetings at the end of each stage to the project management board, which consists of the project partner and the IPEK employees. Student teams are asked to suggest their further proceeding in the project, so that at these milestone meetings the objectives of the teams can be compared to those of the project partner. In the case the objectives match, a team can continue its work in the way they suggested. If the objectives are contradictorily,

they have to be aligned by discussion and argumentation. In some milestones meetings the difference between objectives are not noticed. This causes critical situations for the further course of the project. Avoiding misunderstanding and different notions within the understanding the decisions of future objectives is one main challenge for the project leaders in IP.

3 HANDLING OBJECTIVES IN THE IP PROJECT

In twelve years of coordinating IP projects, different measures to handle objectives have been established. In this section four points of action are presented.

3.1 Early clarification of expectations

At the milestone meetings the teams have to present their solutions to the project partner. The students only have a time slot of ten minutes to explain their development results and prepare the necessary decisions the board has to make. Thus, a high presentation quality is demanded. So the mentoring team invites each student team two days earlier to a "preview presentation" and helps to clarify the expectations of the milestone meeting.

In the last two IP projects the approach of "objectives briefing" has been established. Based on the experiences of previous projects a briefing concept has been developed, that advises the students at the start of each project stage, which objectives they have to archive within the stage. At a single milestone meeting a clear communication of the objectives cannot be archived.

3.2 Explicit definition of responsibility

For a purposive coordination of the students, the mentoring team uses "team responsibilities", i.e. each of the six members of a student team has a special role to fulfil. The six roles are: team spokesperson, systems engineer, methodical engineer, knowledge manager, visualizer and prototyping engineer (see figure 2). The knowledge manager for example is responsible for the maintenance of the wiki-system including the continuous storage of ideas, whereas the systems engineer has to formulate the objectives of the accordant project stage in a form called "project route card".

A further advantage of the team responsibilities is given by setting cross-section-teams consisting of then seven students, who are given the same role in their respective team. Cross-section-teams ensure a common level of information all over the student teams and they have the ability to coordinate specific subtask in a self-contained way, e.g. organizing the team independent research in the project topic.

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7
Team Spokesperson	ip11	ip21	ip31	ip41	ip51	ip61	ip71
Systems Engineer	ip12	ip22	ip32	ip42	ip52	ip62	ip72
Methodical Engineer	ip13	ip23	ip33	ip43	ip53	ip63	ip73
Knowledge Manager	ip14	ip24	ip34	ip44	ip54	ip64	ip74
Visualizer	ip15	ip25	ip35	ip45	ip55	ip65	ip75
Prototyping Engineer	ip16	ip26	ip36	ip46	ip56	ip66	ip76

Figure 2. Development Teams and Cross-Section-Teams

3.3 Realization of direct communication

Direct communication between the project managing board and the students is the apparently easiest and most flexible way to define and communicate objectives. Unfortunately the time frames of such meetings are limited. In figure 3 the level of satisfaction of a team along the project time is mapped. It is noticeable that frustration phases especially appear between the milestone meetings. The reason can be seen in the lack of feedback during these days and resulting uncertainty. Thus, it is very important to realize direct communication, on the one hand by an "open door" to the office of the mentoring research assistants, on the other hand by regular visits of the mentoring team at the workplace of the students. Furthermore there have been additional meetings between the milestones in the latest projects, where the students got to ask the project partner questions in less formal circumstances.

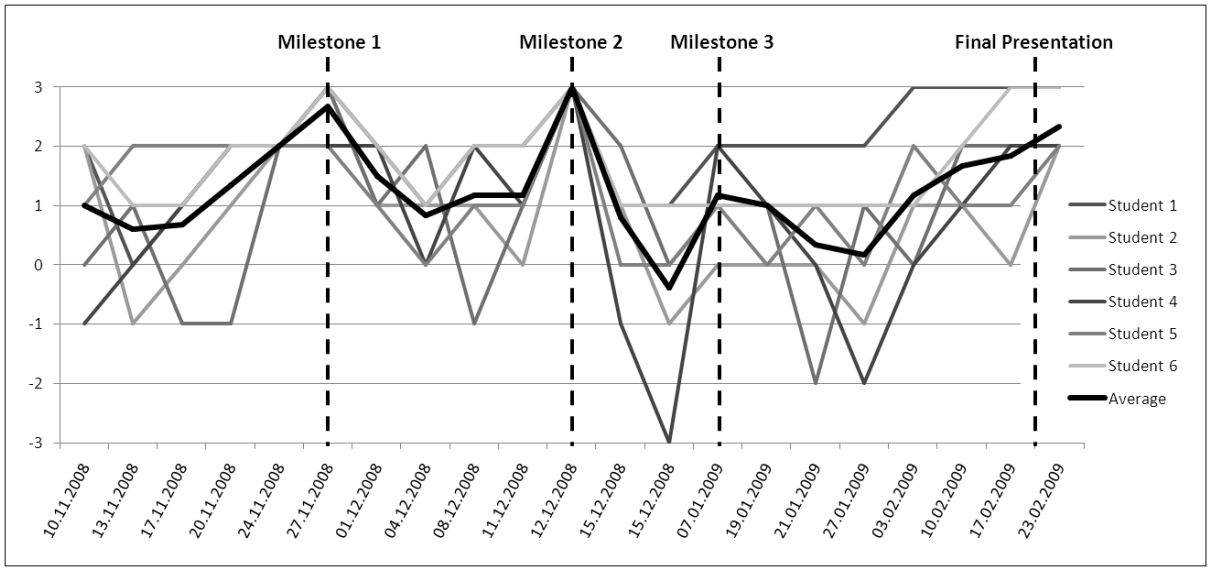

Figure 3. Level of Satisfaction (3 = high, -3 = low) from project start until project end

3.4 Ensuring quick coordination

In the coordination of seven simultaneous development processes it is necessary to distribute information (e.g. objectives) quickly to the right addressees. In the IP project every student has an own IP e-mail address. This allows an easy assembling of specific mailing-lists and therefore a purposive distribution of incoming information. The arrangement of dates is also realized by e-mail. There is one common online-calendar, which is regularly updated by the mentoring team and accessible for all IP students.

4 EVALUATION OF HANDLING OBJECTIVES

In this section the results of the present course evaluation is presented. All 42 students of the IP project 2010 have filled out a questionnaire concerning the definition and communication of objectives in their project work. The following questions are answered by marking a five-level-scale with a cross.
Figure 4 illustrates the results of two superior questions. The left diagram shows that the students learned by their project work how important objectives are. Out of the right diagram can be deduced that there are still problems in handling objectives and that the approaches have to be improved.

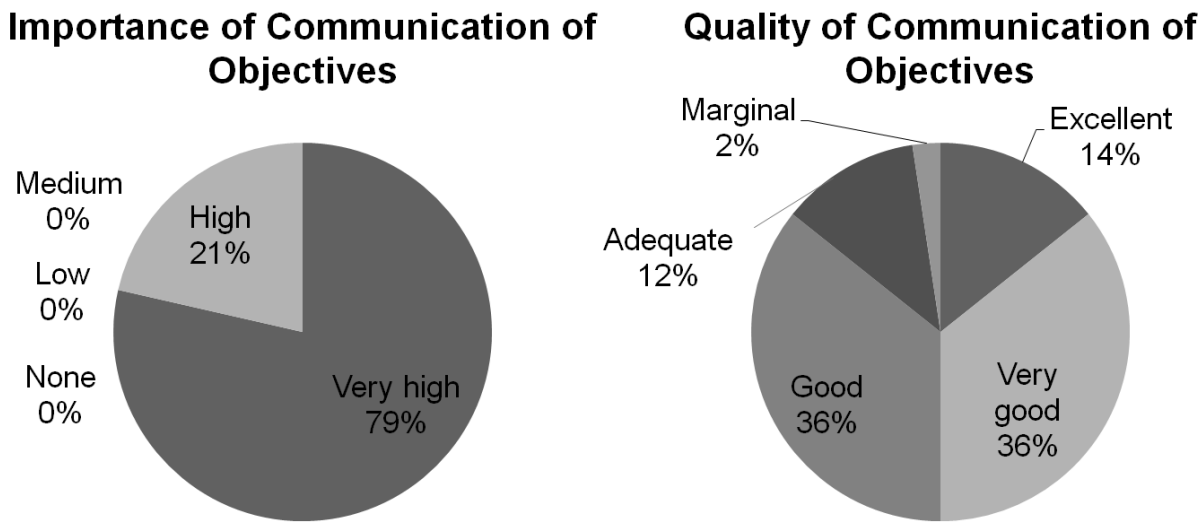

Figure 4. Result of superior questions (n=42)

Furthermore the measures described in section 3 have been evaluated for their usefulness in defining and communicating objectives (1 = not useful, 5 = very useful). Figure 5 gives an overview of the nine introduced measures and shows the calculated average values.

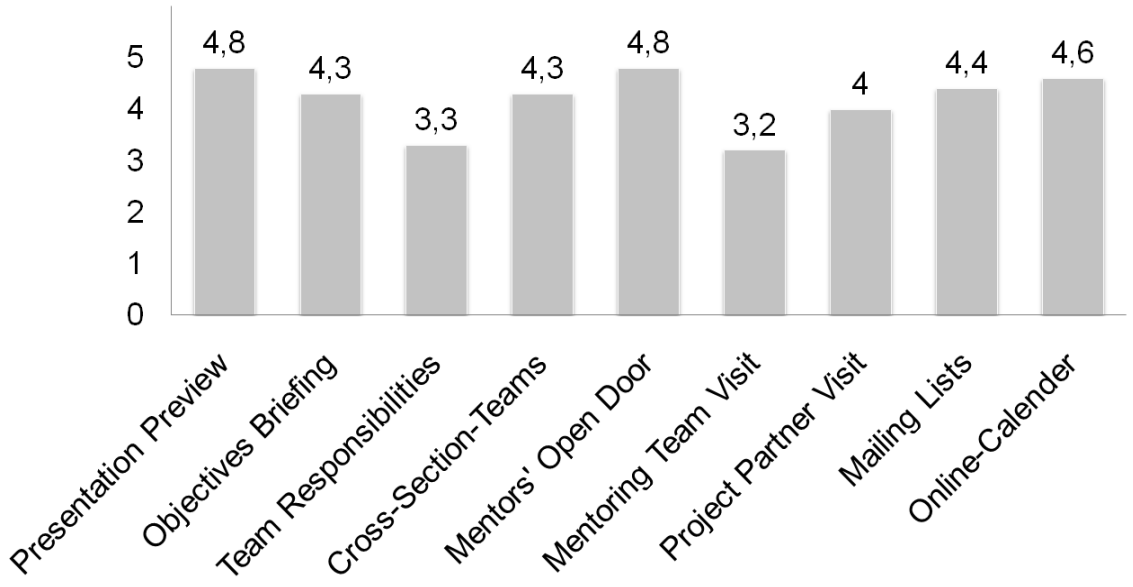

Figure 5. Result of detail questions (n=42)

The interpretation of the questionnaire data leads to four resulting statements, which have to be approved in further projects: (1) An early clarification of expectations can be successfully achieved by the combination of an objectives briefing at the start and a presentation preview near the end of each project stage. (2) The team responsibilities are more helpful for handling objectives, if they are used to enable cross-section-teams. (3) The availability of the mentoring team is important for project work, but the point of time for a meeting is related to a student's need. Thus, the open door is more useful, than a visit in the workplace. The possibility of a direct communication with the project partner is a purposeful way to refine objectives between the milestones and avoid misunderstandings. (4) The usage of mailing lists allows a quick distribution of information and the online calendar supports coordination of appointments.

5 CONCLUSION

The experience of twelve years of project based teaching of Integrated Product Development has led to a multilayer organizational system for procuring competence in product development. Feedback

from the industrial partners shows that the focus on methods and processes while not neglecting the expert know how for technical systems is the right way for design education. However, the teaching is extensive and could not work without the support from industry.
For reaching the teaching goals it is essential that students really live through the course while reflecting the relevance for their future engagement. Mistakes in the management of the projects made by the mentoring team can lead to frustration of the students and thus limit their motivation. A source for the frustration is the intransparency of the objectives in the projects while the intransparent and changing objectives are a normal event in design process. Thus, a special focus in design education should be on the clarity of objectives, as otherwise students might not feel participating in the project, where they put in a lot of effort and which they entered with a lot of raised expectations. Consequence is that students' learning benefit is limited because the missing "flow experience" in their first design project and thus falls back onto the unstructured approaches that were applied before.
A future question is how more than 42 students can participate in a project based teaching model in order reach a broader spread, while not raising the effort brought in.

REFERENCES

[1] Simon H. Sciences of the Artificial. MIT Press, Cambridge, MA, 1969.

[2] Shea K. Engelhard M. Helms B. and Merz M. Teaching an integrated new product development seminar on cognitive products. *International Design Conference, DESIGN'08,* Dubrovnik, May 2008, 1401-1408.

[3] Lehmann M. Christensen P. Du X. and Thrane M. Problem-orientated and project-based learing (POPBL) as an innovative learning strategy for sustainable development in engineering eductation. *European Journal of Engineering Education.* 2008, 33(3), 283-295.

[4] Meerkamm H. Stockinger A. Tremmel S. and Wartzack S. Realization of modern educational concepts in engineering design. *International Conference on Engineering Design, ICED'09,* Stanford, CA, August 2009, 10, 35-46.

[5] Kovačević A. Competence development in an international product design course. *International Design Conference, DESIGN'08,* Dubrovnik, May 2008, 1383-1392.

[6] Albers A. Alink T. and Oerding J. Abstract objectives can become maote tangible with the contact and channel model (C&CM). *In: Proceedings of the 20th CIRP Design Conference 2009 - Global Product Development*, Nantes, France, 2010, accepted .

[7] Albers A. Maier T. Sauter C. and Geier M. KALEP – An egineering education model supported by modern IT-solutions. *International Conference on Engineering Education ICEE ICEER'09,* Seoul, August 2009, 207.

[8] Albers A. Burkardt N. Deigendesch T. and Meboldt M. Enabling key competencies by educational project work exemplified by teamwork and cooperation. *International Conference on Engineering and Product Design Education E&PDE 2008,* Barcelona, September 2008, 43.