Collaborative design education supported by CAD/PDM and Wikis

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Résumé : The objective of academic education for mechanical design engineers is to convey qualifications which are necessary for product development in an industrial environment. The goal of the work described here is to improve engineering design education by providing an active learning experience and introducing students with collaboration and knowledge management issues in design. Design cannot be taught sufficiently in lectures alone (Churches & Magin, 2007; Schuster, Dick et al., 2007) and requirements on graduates are continuously increasing. Not only professional skills but also social skills as well as proficiency with new technologies and methodologies become increasingly important (Hayes & Pande, 2007). For meeting these requirements the Karlsruhe Education Model for Product Development (KaLeP) (Albers, Burkardt et al., 2006) was developed at the Institute of Product Development (IPEK) in Karlsruhe, Germany. In this contribution we present KaLeP and the integration of CAD/PDM and Wikis in collaborative design education projects.

Mots-clés : design education, collaboration, wiki, cad, pdm

1 Introduction

The Institute of Product Development (IPEK) is an institute in the faculty of mechanical engineering at the University of Karlsruhe (TH) in Germany. The unifying goal of the research at IPEK is to improve product development processes and engineering design education simultaneously in the Humboldtian sense. To this end the special Karlsruhe Education model for Product Development (KaLeP) (Albers, Burkardt et al., 2006) was developed at IPEK.. Besides having classical core engineering skills, design students should also be familiar with modern methods and technologies which they will most likely encounter in their future. One problem is that requirements on graduates in design are continuously increasing, not only for professional skills but also for social skills as well as proficiency with new technologies and methods. The overall goal of this work is to improve design education and to provide a more active learning experience by giving students hands-on experience with modern technology which they will encounter during their careers. To better achieve this goal, wikis, a CAD/PDM environment and other tools for collaboration knowledge and project management were provided to 600 second year university students for use in a design project, and to 42 selected students in a final year design course.

2 Presentation of the KALEP design education approach

According to modern theories of education knowledge cannot be transferred directly into the brain of learners. They have to construct this knowledge individually and embed it into their previous knowledge to understand it. So any kind of teaching should permit phases of individual construction of the learning content.

This has been recognized and addressed by several universities around the globe. Grimheden and Hanson for example (Grimheden & Hanson, 2007) state that project-organized courses and problem-based education are examples of preferable methods for design engineering. Churches (Churches & Magin, 2007) emphasizes that design learning does not come from a textbook, but needs to be transferred in a supportive "design ambience". According to studies conducted by Lindemann (Schuster, Dick et al., 2007), students are able to use methods taught in lectures when they are practiced in accompanying workshops but still need some guidance to tap their full potential.

Course work in KaLeP consists of three components: Lectures are supplemented by tutorials and project work in which students apply the lecture contents to real problems in a realistic work environment. To solve the design tasks, students are trained in using modern software tools like CAD/PDM systems, wikis etc. in two major design courses. These courses are Machine Design, a pre-diploma course with approx 600 students and Integrated Product Development, a final year design course with 42 selected students. Together with a third course on design processes, the KaLeP approach is integrated throughout most of the mechanical engineering curriculum from prediploma studies to the final year, continuously increasing the depth of theory and application from simple design tasks to complex tasks from a real industry partner.

The constructivist approach of KaLeP is suitable to address current issues in engineering design education as described in a current study of the German Chamber of Industry and Commerce (DIHK, 2004). It points out, that the main reasons for dismissal are the disability of job entrants to transfer theoretical knowledge into practice and furthermore the job entrants' overestimation of their own capabilities. Today many companies share the opinion that key qualifications are the very weak point of job entrants as well as a systematic proceeding.

To improve this situation, the main requirement for engineering education is the development of key qualifications. KaLeP is based on three elements, imparting the taught knowledge in a possibly practicable form: the teaching units of the courses are divided into three parts: lecture, practice/workshop, and project work. This measure enables the effective teaching of theoretical matter (lecture), the demonstration of its application in example and practice (practice/workshop) and the intensive experience of realistic work (project work). KaLeP supplements these three elements of knowledge transfer with two additional columns: their embedding into a realistic, industry-near development environment and – in addition to the technical competence – the teaching of methods and process knowledge of different competence fields. The utilization of CAD/PDM and Wikis in the context of KaLeP is the logic step to make the work environment for the students as efficient and realistic as possible. To support the realistic impression the result of the students project work is to be presented at regular review meetings. In these meetings not only the mere result of the project work is evaluated, but also the how students achieved this result as a team.

3 Evolution of KALEP

KaLeP has been continuously evolved and extended since its first implementation and publication. In the next paragraphs, a few examples for aspects which have been added or adjusted since will be given.

One key aspect in the development of KaLeP is a continuously increasing focus on systems theory and systems engineering aspects in all design courses to enhance thinking in systems. Part of the increased emphasis on system thinking is the continuous and consistent integration of the generic product emergence process model iPeM (Albers, Deigendesch et al., 2008) in all design courses throughout the curriculum. The model provides students with a generic approach to describe and plan product emergence processes. An important part of this model is the generally applicable problem solving method SPALTEN (Albers & Meboldt, 2006). It provides provides students with a guideline for solving problems that is not limited to engineering and a common language for describing and planning the problem solving process.

The aspect of team work in design projects has also been strengthened. In the very early phases of KaLeP, all students in machine design had to solve identical design tasks. Now this is only the case in the beginning of the curriculum. In the final semester of the machine design course, students now need to solve a complex design task in teams of five. Each student has to solve different problems and designs different parts and subsystems which need to fit to the partial solutions of the other students in the team. This gives students the opportunity to experience design work in teams and trains their social skills.

Since the first publication of KaLeP, IPEK has become an active member of the Global Engineering Alliance for research and education GEARE (GEARE, ; GEARE/IPEK). In the context of the GEARE student exchange program, students who participate in this program get to work on their team design projects in the machine design course in Karlsruhe in international teams together with students from Purdue University in the U.S. and Shanghai Jiao Tong University in China before their study abroad phase at these universities.

The usage of CAD-software during the project work has been introduced in the year 2000, but has been limited to a selected group of students. To prepare the students better for their later work as design engineers, this has been extended to all 600 students per semester.

A significant change is also the increased use of modern information and communication technology like Wikis and PDM, which is explaine more in detail in the following sections, from the beginning of the curriculum on. Wikis and PDM systems support distance collaboration, an aspect of design which is becoming increasingly important also for academic design education in times of globalization with increasing complexity of products and organizational structures (Hayes & Pande, 2007). Therefore students receive special tool oriented training so that they can use the functions of these tools but also methodological training for applying these tools efficiently in product development processes.

Regular feedback and coaching for up to 600 students per course throughout the semester can only be realized with the help of student tutors. To ensure the quality of the education, these student tutors need to be adequately prepared for their tasks. KaLeP has been extended with a training concept for student tutors. This concept includes special workshops on pedagogic topics from professional trainers as well as on specific engineering design topics which a being researched at IPEK like the Contact and Channel Model, a model for the description of relationships between function and embodiment (Albers, Alink et al., 2008).

To continuously improve KaLeP, input form various sources is considered. Feedback from alumni and industry leaders is one source for input for the further development of KaLeP. Feedback is requested regularly from alumni to ensure that the academic design education fits to what graduates will have to face later on in their professional careers. Contact with alumni is held actively through social networking websites, newsletters and invitations to public activities at IPEK. There is also a student feedback team which reports directly to the head of the institute. They offer a first hand view of the learning experience and continuously deliver valuable input to improve the institute's courses.

4 PDM/CAD in Design Education

The utilization of 3D parametric CAD-Software has become a standard in almost all sectors of mechanical engineering. This development has been accompanied by growing possibilities in the field of Computer Aided Engineering (CAE) which goes along with huge amount of data that needs to be handled. This and the increasing complexity in product, process and organizational structures in modern companies makes it difficult to work efficiently. A way to handle this complexity is to control the data and information flow combined with a predefined product structure. Product Lifecycle Management (PLM) is a strategy to address these topics. While PLM is a strategy, PLM-Systems are software solutions to actually implement such a strategy in a company (Krause, Franke et al., 2006). Therefore the companies working on these sectors expect experience with working within such environments and with such software-solutions from job entrants. This demand has been addressed by universities in various ways. In most cases the necessary skills are taught in separated courses and the necessary practice is expected to be gained in following projects.

At some universities very large systems have already been established to supply a lot of users with modern CAD and PDM Solutions. The RWTH Aachen with its initiative ProVerStand is capable of handling about 45000 users throughout the federal state of NRW (Germany), based on the PDM-system PDM-Link supplied by Parametric Technologies (PTC) (Feldhusen, Löwer et al., 2007).

In various publications ideas and requirements for the integration of CAD and PDM into the education of product development engineers have been expressed.

Bitzer et al. has proposed an education concept in which the necessary theoretical engineering background, soft skills and the usage of CAX-Systems is taught accompanied by work on projects derived from industrial design tasks (Bitzer, Burr et al., 2008). Ye et al. (Yea, Penga et al., 2004) emphasize that not only the mere use of CAD and PDM Software should be thought, but more how to actually use it in the product development process.

This has been addressed by Feldhusen in the undergraduate course “Introduction to CAD”. Next to a project task supplied by an industrial partner the students from Aachen were teamed up with students from the Korean Hongik University in Seoul (Feldhusen, Brezing et al., 2008). Watty and Binz comment on the experiences with the introduction of project based work in second semester design courses and give an interesting insight on how to overcome heterogeneous team compositions and to ensure equal learning opportunities(Watty & Binz, 2008).

In Dankworts understanding not only CAD and PDM education needs to be part of the curricula but also a basic understanding of all CAX-Technologies (Dankwort, Weidlich et al., 2004).

5 Wikis in Design Education

Due to the depth and breadth of knowledge required to develop a complex product today, it is no longer feasible for an individual to work alone on a compound design project. This causes a growing need for both effective collaboration and knowledge management tools and practices (Citera, McNeese et al., 1995). Consequently these aspects should be included in a modern engineering design approach.

Wikis are software systems, which allow users to easily generate, publish and edit web pages, i.e. open content management systems. Wikis have become increasingly popular in recent years mainly due to the following advantages: Easy collaboration and formation of opinion, easy documentation and editing, easy cross-linking between pages, full text search and most wikis are free and open source.

Advantages of wiki use in design include the potential for increased reflection and development of shared understanding (Hill, Dong et al., 2002), improved concept generation (Wodehouse, Grierson et al., 2004), and easier design reuse in later projects. They are one way of enabling computer-supported cooperative work (CSCW) (Cunningham & Leuf, 2001; Gross & Koch, 2007). The collaboration and communication capabilities, the potential to serve as an interactive education tool, and the valuable documentation features make wikis an ideal platform for exploration in design team settings. Hill et al state that “communication in a social setting is often characterized as the creation of shared understanding through interaction among people” and that development of shared understanding is a key factor in high performing teams (Hill, Dong et al., 2002). Studies of wiki use in industry show that wikis can support collaborative design activities; however, drawbacks in the current state of wiki technology and wiki use inhibit more efficient use of this technology in design (Werasinghe & Salustri, 2007).

Wikis are not only becoming increasingly popular in industry but also in design education. At Stanford University, Chen et al explored how the use of wikis and weblogs in combination with the pedagogic approach of Folio Thinking in design courses can have a positive effect on students' knowledge and skills in engineering design (Chen, Cannon et al., 2005). After two ten-week quarters the students were interviewed; the survey results showed that wiki and weblogs can be suitable tools for design education, as they helped students to become more aware of their learning progress and design skills. While this particular study focused on the use of wikis and weblogs as a pedagogic tool, it provides strong support for improved design learning and enriched experience through wiki use. Wodehouse et al. presented a study of groups of third year design engineering students who were using a particular Wiki engine, TikiWiki, for solving a design task in teams in six weeks (Wodehouse, Grierson et al., 2004). Results showed that using the wiki helped students to generate product concepts. The teams who interacted more with the stored information in the wiki generally achieved better results in the design project. Specht (Specht, Vajna et al., 2007) describes a design education approach that is based on a generic integrated product development process model implemented and supported by means of a wiki.

The notion that wikis are useful tools for higher education is not only supported by research in design education, but also through wiki use in education in other academic fields. Raitman et al. for example explored the use of wikis in Computer and Information technology course work at Deakin University in Australia (Raitman, Augar et al., 2005). Survey results showed that most users thought that wikis generally support collaboration but many wished wikis to be easier to use and to provide more features. In general, wikis seem to be a useful tool for design and design education.

6 Training in CAD/PDM

In order to meet the requirement of computer skills in the engineering domain, students of Mechanical Engineering learn using Computer Aided Design (CAD) Systems, such as Pro/Engineer, Catia, Unigraphics etc. If one considers only the capability of operating a piece of software, CAD systems do not appear more complicated than ordinary office Software. The big challenge is however, the integration of CAD into a product development process. Therefore the education at universities not only needs to offer CAD courses, leaving the students alone afterwards. It is important to educate students with the methodology of CAD and its integration in real product development problems (Field, 2004). Only then the students understand and learn the advantages of CAD Systems. This is not only true for Computer Aided Design, but also for Computer Aided Engineering, such as Finite Element Methods, Computer Aided Machining (CAM) and much more (Dankwort, Weidlich et al., 2004). An integrated education of CAD is illustrated with the example of Pro/Engineer training at IPEK. The CAD training is integrated in the Machine Design course in the first semesters of the Mechanical Engineering curriculum and also in the final year design course Integrated Product Development.

The goal for the recently conducted extension of CAD education was to offer it to all students and to supply advanced Product Data Management (PDM) functionalities within an extended network, integrating students private Laptops and Workstations into the IPEK CAD/PDM environment. Besides for infrastructural reasons, the introduction of a PDM system also allows to fit the CAD training better to very modern working techniques and working environments, like in the automotive or aircraft industry.

The goal of CAD training together with Machine Design education consists of building competencies of the students in the following fields:

- User interfaces of Pro/E and PDMLink
- Design principles
- Model topologies
- Engineering design features
- Assembly design
- 2D engineering drawing design
- Workflows within CAD and PDM
- CAD model management (CAD centric)
- CAD data management (PDM centric)
- Rendering still images and animations

The first and most important topic to explain in CAD classes is the login to the PDM system. Each student has an individual login, but is also member of a Machine Design class team with four other members. Thus this login is associated with a certain product, belonging to the team. Inside the PDM system students can find their product represented by a Commonspace folder structure. Additionally a part library but most important all education materials like manuals, tutorial books and learning parts are accessible within the PDM system. By exploring the learning materials the student automatically gathers experience with the PDM system.

After getting familiar with the GUIs of Pro/E and PDMLink the students start with rather classical tasks. At first they learn how to create new parts, initial references and basic design features. In the Diploma curriculum all tasks were arranged around a training assembly, namely a coffee grinder. In future, during Bachelor curriculum the training tasks are more connected to the Machine Design tasks, since the CAD training is spread over the semester. But in both curricula the tasks are all part of a bigger project.

Knowing already a lot about design features like shaft fits, threaded holes and shaft design, the students can implement their knowledge seamlessly in CAD models. It is a strong component of Machine Design education at IPEK to develop a working technique not focusing on the powerful features of a CAD program, but more on a structured way of implementing functions into a geometric design. There is a heavy emphasis on making some thoughts first on model topology, references and parametrics. Typically students are required to start with a sketch on paper and then implement the basic references in their CAD model. Then they follow design and manufacturing principles to detail their models.

As soon as the students have completed a few parts, the next task is setting up a Bottom-Up assembly. Bottom-Up assemblies are rather simple to handle as long as all parts fit together and if the parts are not subject to frequent changes. The latter requirements are complied due to given design tasks.

All topics mentioned so far are rather single-worker centric. No special team data and team model management techniques are mentioned to the students until this point. But right after the Bottom-Up design topic, a new topic is introduced: Top-Down assembly design. In opposite to Bottom-Up design, the designer doesn't start with parts but with a skeleton. A skeleton is a component on itself and consists of abstract planes, axes, curves, surfaces and points. New components can derive their location, geometry and parameters from a skeleton. Skeletons allow designing a product on a very abstract level, without focusing too much on the volume design. Therefore using skeletons is a good method for teams to fix certain common references which are important for more than one part. During CAD training classes the student teams are required to discuss and create a skeleton in a design meeting. After the meeting they are required to use PDM functionalities to bring the skeleton in their workspace in order to derive the parts which they are responsible for. The goal is to show to the students how their skeleton based Top-Down assembly keeps growing by their common contribution.

The next step is the introduction of 2D drawing creation. Again the Machine Design curriculum is related to the CAD curriculum allowing the students to apply their newly gained knowledge about drawing standards. Today the drawing capabilities of Pro/E and similar systems are quite sophisticated, allowing to implement most 2D drawing standards into a CAD drawing basing on a 3D model.

During the above mentioned CAD tasks the students are permanently using PDM functionalities such as "check-in" and "check-out", model previewing, model updating in assemblies, moving, renaming and deleting CAD data. Such many common PDM tasks become routine behavior, particularly team related data management tasks.

As an outlook peripheral tools (from a CAD point of view) are introduced at the end of the course. For example Multibody Dynamics in Pro/E or sophisticated animation and rendering tools such as Blender (Blender). Only basic principles and model exchange functionalities are explained. The goal of the outlook is to allow a student to orient oneself better in the extensive world of computer aided engineering tools. Additionally more talented students get the chance to broaden their competencies by voluntarily applying one or the other peripheral tool to their own models.

7 IT Infrastructure and Working Environment

The educational concepts described above need to be applied over a pre-diploma course which spans over four semesters with around 600 students per semester, which results in over 1100 users per semester. The technical enabling of the goals described is somewhat difficult due to the large number of students in the pre-diploma-studies. The current amount of 150 work-stations at IPEK only allows a part of these students to do their project work. The external access as shown in Figure 1 to the web-based

PDM-System PDM-Link enables the students to also work from within the campus wireless-lan or their homes and is therefore virtually extending the amount of available Workstations. The Institute is supplying the students with student licenses accompanied by customized installing procedure to ensure, that the local ProEngineer installation meet the institutes standards. This has proven to be an efficient way of reducing the amount of support the students need in operating the software.

To enable such a broad Infrastructure, IPEK has been relying on virtual server environments for some time. This environment is based on VMware infrastructure. Utilizing VMware has not only facilitated the setup of the environment but also allows adapting to the fluctuating user load.

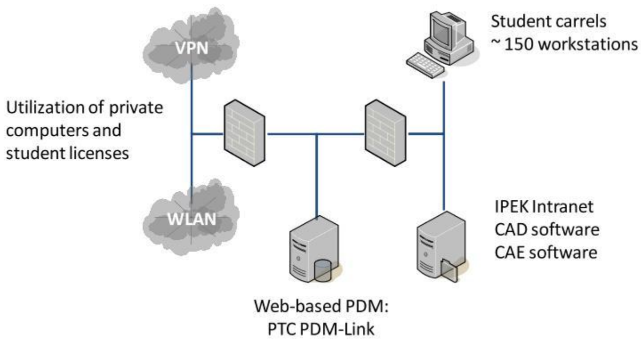

Fig. 1 - CAD/PDM Infrastructure for engineering design education

8 Machine Design Course

During their pre-diploma studies, students of Mechanical Engineering at the University of Karlsruhe have to participate in a mechanical design course for four consecutive semesters. The course consists of lectures, tutorials and workshops with project work. During the fourth mechanical design course students have to solve a complex design task in teams of 5 students. In the summer semester 2008 more than 600 students took part in this project and the design project assigned to students in the Machine Design course at the University of Karlsruhe was to design legs for the next generation of humanoid robots of the collaborative research centre 588 (SFB588) (SFB588, 2008). This student design task was set into the context of a real research project to motivate the students by giving them the possibility to contribute to this project which gives them the feeling that there is a real purpose for all the effort that they put into such a project which goes beyond just passing the course. The effect of increased motivation observed in this course was also described by Muecke and Hong for an educational design project in which a miniature humanoid robot was developped (Muecke & Hong, 2008).

The challenging but realistic task was divided into three phases. After each phase, the student teams presented their design solutions and discussed their progress with student tutors and academic assistants.

During the first phase, students gathered, synthesized and presented information about the state of the art in bipedal locomotion for humanoid robots, actuators, sensors and transmission elements. To collect this information, the students were supplied with a wiki. As each team was only required to investigate one of those four topics, approximately 125 students researched each topic. At the end of the first phase the students were given access to all information the other 600 students had gathered, to provide them with a large knowledge base.

During the second phase, students generated ideas and concepts for the design of robotic joints, using the findings from the first project phase. During the third and final phase, students completed the embodiment design for a pair of humanoid robot legs.

After each of the review meetings, the students were given detailed feedback. At the end of each review meeting they are rated in five categories, the fields of competence addressed in the Karlsruhe Education Model for Product Development (Albers & Deigendesch, 2008). This is done to supply them with an impression of their progress in the course and to give them a chance to reflect how well they could apply the theoretical lecture content in the course work. The ratings are visualized in a pentagonal shapes as shown in figure 2. As all ratings for one students are documented on one page, students can easily see how their ratings develop throughout the semester.

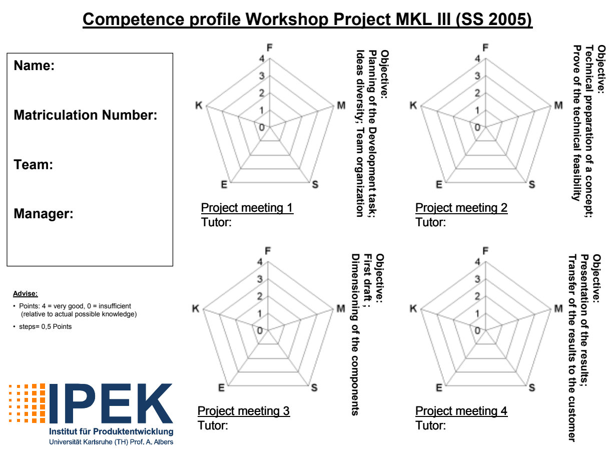

Fig. 2 - Evaluation sheet for Machine Design Course

The need for differentiated feedback in design-education has been recognized and addressed by several other institutions. Lauche (Lauche, 2007) points out that the success of a design project depends on a combination of skills that need to be taught and measured. She suggests a group of six behavior markers that should be further investigated and then used in design education. Rodgers (Rodgers & Milton, 2007) shows the need for more differentiated feedback for students to let them identify their personal strength and weaknesses and describes methods for assessing students that have been developed based on surveys with a small group of students.

Each year, 5 groups with the best results in the project work are awarded by the professor. They receive a small price and get the possibility to present their design results in front of all the other students. Figure 3 shows examples for robot legs which were designed in this course.

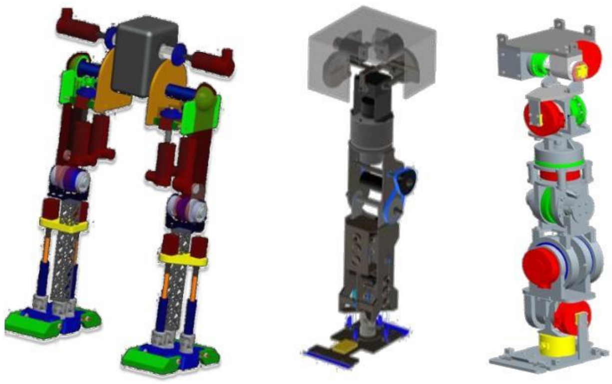

Fig 3 - Exemplary Final Design Results for humanoid robot leg

At the end of the summer semester 2008, a survey based on a questionnaire with all students of the machine design course and additional personal interviews was conducted to investigate the usability of wikis as design support tool. A more detailed description of the survey and its results can be found in (Walthall, Sauter et al., 2009).

9 Final Year Design Course Integrated Product Development

One of the core elements of KaLeP is the final year design course Integrated Product Development (Albers, Deigendesch. et al., 2007). This course consists of lectures, workshops and an intensive design project in cooperation with an industry partner. The overall concept of this major course enables the students to experience a product development process from market analysis and definition of the development task to product profiles, ideas, concepts and the design, manufacturing and testing of first prototypes. Due to the intensive effort for coaching the students, the course capacity is limited. Currently a maximum of 42 students can participate in 7 teams with 6 students each. To provide a realistic setting for the design project the students need to solve a open product development problem from the industrial partner and not a purely academic task.

The students are given a realistic working environment with access to almost all infrastructural resources of the institute including a cubicle which they can use solely throughout the whole project as shown in figure 5. These cubicles are equipped with modern workstations and each team can work there on its own.

The students are also given access to nearly the same infrastructure as it is used by the employees of the institute. This includes for example software for office tasks, CAD, PDM, CAE, project management, Wiki and document management.

The introduction of a PDM system to this course was not only with the intention of providing a realistic working environment. Experience from previous projects showed that often during the final weeks of the projects file-based CAD assemblies were regularly causing additional work expenses and frustration due to concurrent access to central files, resulting in unavoidable version conflicts.

Throughout the project the students also have the possibility to build prototypes of their products in a dedicated student workshop in close proximity to their working cubicles. The students make intensive use of this possibility to create prototypes of different levels of complexity to illustrate and validate their ideas and also to convince the representatives from the industry partner of their ideas in the milestone presentations. All teams receive a limited budget for building their prototypes and need to justify and document all expenses. The prototyping machine shop was implemented because students in previous projects were already enthusiastically building prototypes with very simple means and expressed a strong wish for better prototyping infrastructure.

Another means to create a realistic environment is the simulation of an organizational structure as shown in Figure 4 that integrates the student teams and puts them into a slightly competitive position with the other teams.

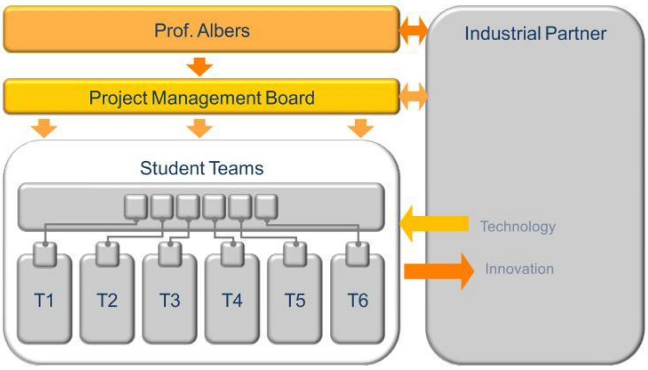

Fig 4 - Organizational Structure for design project

Like in a real design project, the teams need to plan their projects and have to present their intermediate and final results at predefined milestone presentations to the industry partner. Figure 5 gives an overview of the project schedule which normally spans 4 months. At the end of the project the students get to present the final results of their work in a public presentation in front of representatives from various companies, other research institutes, friends, family and others.

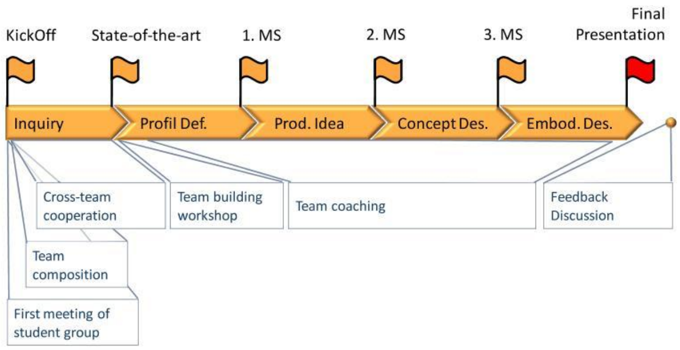

Figure 5: Project schedule with project phases and milestones

This public presentation and the positive feedback which students normally receive at this occasion is often a highlight in their curriculum for many students and it is also an important compensation for the additional voluntary effort which most students put into this project.

Through the regular presentations at the milestones and at the end of the project, the students do not only get a chance to train their design skills but are also given regular chances to train their presentation skills.

As mentioned above, collaborative design work in teams is an important aspect of the later design work. Even though the team structure in this project is relatively homogenous, problems in team work do arise regularly in this project. Later on in their professional career, the students will most likely work in teams which are more heterogeneous with more potential causes for team conflicts. To address these issues and to prepare the students for such conflicts and to provide them with possible solutions for such conflicts, the students receive coaching from a professional human resource consultant at the beginning of the project. If problems arise in a design team, this human resource consultant is available for individual sessions to address these problems. The students also receive a dedicated CAD/CAE-training similar to the training in the Machine Design course. At the end of the course they are also trained in processing the CAD-data for animations and rendered pictures. The students regularly do an impressive job in utilizing these possibilities to present their result in front of the project partner at the milestone meetings and at the final presentation in front of a large audience.

This course is output oriented in several ways. On the one hand there are well trained graduates in engineering design who were able to experience a realistic team-based design project and are attractive on the job market: Secondly the industrial project partner benefits from the fresh and new ideas which regularly spark new product development projects. Thirdly the course provides a possibility to evaluate new design methods and tools in a controlled environment with young and relatively inexperienced designers which, on the other hand are normally very open minded and interested in new approaches and solutions.

To achieve these tasks, the students are given the theoretical knowledge in lectures. In addition the students receive regular coaching in weekly workshops for the application of the lecture content in the project work. Throughout the semester the students apply the contents and techniques to solve their design task. The range of workshop topics spans for example creativity techniques, target costing or scenario management techniques for developing consistent descriptions of potential futures for deriving product profiles.

10 Summary and Future Work

The current state of engineering education at IPEK was described. It was shown how KaLeP could be supplemented by modern ICT-solutions. Surveys show, that students appreciate the active learning experience, which is also emphasized by the amount of extra time the students invest in their projects voluntarily. Comparison to other education models in design shows that KaLeP addresses a lot of the currently discussed issues and comprises some unique approaches. This paper also demonstrates the means necessary to establish modern educational approaches with a large amount of students, while maintain the necessary quality of education.

Future work will focus on a consolidated software variety and the provisioning of a single point of entry for PDM, document management and wikis. It is also planned to include students in sophisticated workflows, to facilitate user management and student assessment.

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