INTEGRATED CONCEPTS OF DESIGN EDUCATION

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ABSTRACT

The current situation of design education is described and discussed in this paper from an industrial perspective. Based on this industrial perspective a need for action is derived that leads to suggestions for the improvement of the curriculum in design education.

Today, the education of young engineers is most often divided into separate engineering disciplines, which are further divided into different faculties; each specialized in their own area of engineering science research.

The topic of cooperative teamwork, even in virtual teams, has not played an essential role in engineering education. Moreover, soft interpersonal skills like communication skills or cultural management are also not addressed. Students are not trained to get the "big picture" or to develop a holistic process understanding. Instead, it is more common to discuss and solve isolated problems when they arise.

From the industrial point of view, the key challenge for the future is the engineers' ability to perform in a seamless process chain with a high degree of digital support. The management and distribution of information and knowledge is a key issue in order to compete in today's markets. The size and global distribution of the companies does not require the isolated specialist, but the generalists with good overviews for workflows and process chains and with good communication skills.

Based on the analysis of the current situation and the already stated needs of action, education modules are introduced in order to overcome today's weaknesses and to adapt to the complexity of real industrial processes.

Keywords: Interdisciplinary education, Industrial focus, Distributed team work, integrated design education

1 CURRENT SITUATION IN DESIGN EDUCATION

Over the last years there has been a great deal of discussion about the university educational system in Germany. Traditional degrees like diplomas have been questioned and the current trend is to introduce a new degree program based on the Anglo-American standards - bachelor and master degrees. In the technical area some new disciplines like mechatronics or business engineering have been established, which are a mix between traditional disciplines and thereby combining contents of both.

Despite this new trend, in some cases there is still a gap between industries demands and the way lectures and courses are organised at most German universities.

This paper aims at the functionality of the field of design education and focuses on the current way in which university engineering students are taught from an industrial perspective and compares it to the daily experience of engineers already working in business for an international car manufacturer. Based on this discussion, new suggestions for courses in engineering design education are presented.

2 DESIGN EDUCATION VS. INDUSTRIAL REALITY

In general, university alumni in Germany are very well qualified in their special disciplines because the quality of academic education in engineering disciplines is still very good and has a very good reputation on the international market. In most cases, the general disciplines, such as mechanical engineering, electrical engineering or information technology are again subdivided into a variety of different faculties, with each of them providing a certain research field and specialized core competencies. Such an environment is the ideal surrounding to generate specialists for the development and production of high-tech applications. But, if one considers the size of a company, such as a car manufacturer, there is much higher demand for generalists in engineering design, who bring along with them a good overview over holistic process chains and a deeper understanding of the whole product lifecycle. From an industrial point of view, a top-notch product alone is worthless unless it is assured that the product could be manufactured in a cost-efficient way and with a proper quality. Presently, the automotive industry has established, with a lot of efforts, the so-called cross-domain engineering processes, including design- and manufacturing departments.

Another topic that is addressed at only a few engineering design faculties in Germany and closely related with this issue is the new term “cross-enterprise engineering”. Cross-enterprise engineering addresses the fact that almost every project team is distributed over different organisational units within the company as well as over the company’s borders towards all kinds of suppliers and development partners. Working in virtual project teams is an industrial standard and young engineers must be trained to be able to share and manage information with their team members, no matter if they are located in the same room or across the ocean.

It is obvious, that such project teams could only perform in a proper way if they are familiar with all kinds of state-of-the-art IT tools for information generation, management and collaboration. Moreover, skills in management and human factors, like intercultural skills, are becoming increasingly more important [1]. Although most engineering disciplines are steeped with highly specialized IT tools, such as all kinds of CAx-Applications, the use of data management tools is still limited and the education of their benefits are still neglected in engineering design school. This leads to the observation, that most of the students are very good in using the CA-application, but they are overwhelmed when it comes to topics such as storing the models, working with different versions and using the configuration functions in PDM.

On the other hand, the industry has often been asked to support universities by giving more realistic scenarios and engineering tasks. Unfortunately, university academic staff members are mostly recruited directly after finishing their studies. Never having been in industry themselves they have had no chance to acquire some industrial experience. Seldom do industrial representatives find their way back to university departments in order to train the engineering offspring.

In comparison with other European countries, especially with Scandinavia, most of the German companies are very diffident when it comes to cooperation with academic research; however, young engineers must get familiar with real industrial life. It would even be more satisfying for the students, if their project work would be implemented in reality, and not be hidden in the desk of a faculty.

3 STATE OF THE ART

At German and European Universities there are several lectures and courses which have started to cross traditional ways of thinking and of education – they are specializing in one specific engineering subject and nothing more. In industry, beside these specialists in their field, more generalists are needed. In the following paragraph two existing approaches for "domain-crossing" education are presented.

3.1 Focus on concurrent engineering

Several lectures, seminars or projects do exist in engineering and design which focus on the aspect of concurrent engineering. Groups of students in those courses work on a specific engineering problem, mainly in the area of product design. These groups, each with around 10 students, would work together on *one* complex project. First, the students would have to take care of their group's tasks, while keeping the project task or overall task in mind. Typically, the students in those classes would solve design problems and/or have tasks like creating a vehicle that can drive on land and on sea but one that runs on muscular strength.

As discussed before, besides for dealing with complex design problems, several other points, like *project management* or *team work*, are covered in concurrent engineering courses; after all, concurrent engineering courses are supposed to be structured like real industrial projects. This means these courses have a defined starting point and also a defined end-date. In many cases it is common to give the students a concrete project aim to be achieved. To reach the goal a well-structured progress is needed. Therefore, it is necessary to make the students familiar with basic rules and theory of project management, even before starting the real project. Good project documentation is the best base for a final presentation at the end of a project. For students it is very important not only to be up to speed in their engineering-discipline but also to be able to present their results.

Likewise, beside these project characteristics, concurrent engineering courses often would cover several aspects of teamwork and closely related problems and challenges in working within the different disciplines; for instance like special vocabulary or dominance of other disciplines [2]. Groups, with about 10 students each, would learn how to work in and as a group and in many cases, the students would learn the importance of a heterogeneous group. Not only specialists of different engineering domains are required, but also generalists who are able to keep an eye on the big picture. Normally, in a semester there would be more than one group working in parallel. That leads to another aspect of teamwork – the relationship and situation between two or more groups. It might motivate the groups to call out a competition and create the feeling of stress of competition. (cp. [3])

All these aspects would help the students to get prepared for working in industry. Moreover, there would still be room for improvement. For example, in many lectures or seminars only one engineering domain is involved; that means that the focus is only on mechanical design methods for example, but aspects of electronic or software design need to be addressed, but presently they are not. At many universities the educational rules do not allow to combine crossover students of different engineering domains (electrical and mechanical) in one seminar, which needs to change.

3.2 Focus on problems of industrial case studies

Students who have just received their degree and are starting their industrial career often have a huge theoretical knowledge in their study subjects. During their studies they often didn't have the opportunity to come in contact with industry or experience industrial problems. Internships or industrial projects, for example for diploma thesis, are often the only opportunities for students to become acquainted with industry and vice versa. That is why at some universities, courses with a special focus on industrial case studies are offered.

Case studies courses often combine elements of a lecture and a seminar. In the first part of a case study course, the lecture sequence, students are taught the basics of case study solutions and project management. During the second part, students would work on several case studies which are dealing real-life problems of different industries. Each case study would outline a situation, problem or challenge of one specific company and would be presented and discussed in one separate lesson. A lesson would be structured into three phases. In the first phase the case would be presented by a company's expert. Second phase the students would work on the case and prepare a solution. In the last phase, each group would present its results in front of a board of experts from the company and university side.

In case study courses the elements of project management would be trained very intensively. Likewise, soft skills, like teamwork and presentation skills would also be part of the course. But currently, in most cases, case study courses are only provided by departments of management and international business, and not by engineering departments. The focus of case course often is about business topic and not engineering topics.

4 NEW APPROACH

A design education concept is being developed by the authors of this paper that will overcome the weaknesses of the university systems and that is designed to cope with the challenges mentioned above. According to this concept, engineering design will be taught in the framework of an interdisciplinary project whose layout is composed of the main building blocks theory input, industrial focus, distributed team work, human factors and IT-based realization. In this approach traditional boundaries between different engineering and educational disciplines are broken up, and students would be taught to work cross-discipline on common design projects (Figure 1). In the following the main building blocks of the concept will be discussed:

4.1 Theory Input

In this building block, students will be given input from all the necessary disciplines involved.

Firstly, the technical input. This part will be taught by an education team composed of specialists from the different technical domains (i.e., mechanics, electronics, and software). Focus will be on domain-specific design methodology, which in Germany is generally taught according to German Engineers Association standards (e.g., VDI 2221 for mechanics, VDI2422 for electronics), and integrated concepts, such as the standard for mechatronics design VDI 2206.

Secondly, organizational input is given. This includes topics such as project management, quality management, basic cost calculation methods, and presentation skills. Furthermore - if required - state-of-the-art engineering IT tools are introduced.

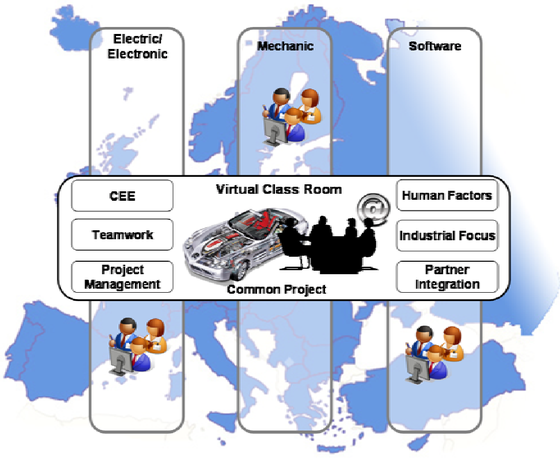

Figure 1 Aspects of the Integrated Concept of Design Education

Besides the input aspects, all project work is closely followed and supervised by the education team.

4.2 Industrial focus

For the organization of the project, the university would form an alliance with an industrial partner, who would provide a real design scope fulfilling several criteria, such as interdisciplinary, adequate size and complexity, and an appropriate timeline. The thorough definition of the criteria of this scope is critical for the success of the project.
The goal for the students would be to deliver in a first step a digital prototype, and then in a second step a real prototype to the industrial customer, who is on his side in charge of funding the realization costs. On a regular basis, concept and prototype presentations would be given to the customer.

4.3 Distributed team work

The targeted project scope would be a product consisting of (approximately) three main assemblies, each of which covers multiple engineering domains. Each of these assemblies would be assigned to a design team of approximately four students. One of these teams is also given the task to manage the project.
In a first step, a distributed design environment would be simulated within one university. In a second step, this will be done through cooperation with two other universities running the same program in parallel. In this case, the project would be designed three times in parallel with rotated roles, thereby simulating a competitive situation between the three project teams.

4.4 Human Factors

Besides technical and business aspects, it is important to teach human factors and soft skills in an educational environment. To work successfully in a team, people have to know several rules and internalize skills in order not to be sidetracked all the time. Therefore, students should learn how to discuss and work as a team and learn basic competences, like flexibility, management of complexity, trust, communication skills, knowledge sharing or self management [4]. Moreover, students need presentation and moderation skills, negotiation techniques and other soft skills not only to achieve their project goal but also to be prepared for industrial business world.

4.5 IT-based realization

The distributed project teams (each consisting of 3 teams of 4 designers) would be in charge of realizing the complete project – from the requirements definition to prototype manufacturing, and also of the accompanying project, quality, and cost management.
The whole process would be supported by an industry-like IT setup, whose main component would be a central product data management (PDM) system connecting all parties involved. Besides CAD, other state-of-the-art CA-tools would be used as required, e.g., simulation (CAE), planning (CAP), and manufacturing (CAM) tools.

5 CONCLUSION

In this paper, an integrated concept to design education has been presented. Major building blocks to the approach have already been introduced by the authors to design education modules with promising results. The integrated approach leads to a deeper understanding of design methodology, the organizational tools applied and challenges due to interdisciplinary and distribution as well as both benefits and restrictions of IT tools were experienced "on-the-job" and not just through lecture notes.
Some limitations however still apply. Although held by industrial teachers, in order to fine-tune the methodology, first projects were run on non-industrial design tasks, only. In order to allow for bigger project scopes including the physical production of the results, the university curriculum has to be adjusted, first.
Based on the experiences made, the authors are convinced, that - after introducing the last building blocks of the concept - the quality of design education will be significantly improved and the outcome would be closer to the demands of industry's needs.

REFERENCES

[1] Eigner, M. Process follows IT? *Keynote: ProSTEP Symposium 2007, Wolfsburg, Germany*, 2007.
[2] Karakaya, A.-F. and Senyapih, B. Rehearsal of professional practice: impacts of web-based collaborative learning on the future encounter of different disciplines. *International Journal of Technology and Design Education*, 2008, 18(1), 101-117.
[3] Mettas, A.-C. and Constantinou, C.-C. The Technology Fair: a project-based learning approach for enhancing problem solving skills and interest in design and technology education. *International Journal of Technology and Design Education*, 2008, 18(1), 79-100.
[4] Eigner, M. and Schleidt, B. Unternehmensuebergreifende Zusammenarbeit im Cross Enterprise Engineering. *wt Werkstattstechnik online* , 2006, 98(6), 411-416.

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