

# Machine Design Teaching Enhancement at the University of West Bohemia in Pilsen

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**Abstract**— Technical faculties are permanently confronted with increasing demands for the quality of graduates and efficiency of education. In addition, the growing demand of the labor market regarding graduates and at the same time the decreasing interest from applicants who wish to study engineering are issues which technical faculties have to deal with. One of the ways to deal with these issues is to improve different aspects of teaching technical subjects in order to improve quality, efficiency, comprehensibility and attractiveness of Machine Design. The Faculty of Mechanical Engineering at the University of West Bohemia (FST) is concerned in this matter and it has launched the Machine Design Teaching Enhancement Project. Project-based learning materials and learning materials concerned with teaching of computer aided engineering (CAE) systems were developed as a part of the project. The learning materials have been developed by academics in cooperation with local engineering companies and software developers to provide quality learning materials. This paper presents the learning materials and their contribution to students and academics at FST.

**Keywords**—learning material, teaching, Machine Design, CAE, 3D models, design project

## I. Introduction

In 1989 the Velvet Revolution in Prague started dramatic changes in the engineering industry of the Czech Republic as well as in other countries of the former Soviet Union. As a consequence of tough international competition many of the established companies in the region went bankrupt as they could not rival the technologies and productivity of their competitors. The majority of the surviving companies stayed on the market thanks to their unique knowhow. For students of Machine Design this means that the engineering companies in the region are therefore reluctant to share their knowhow in order to educate a new generation of design engineers. Thus the competitiveness of Machine Design graduates has been reduced [1]. The need for gaining practical experience in the field during their studies is very important for engineering students and “this perception is shared by students themselves” [2]. However, the situation will get better over time as international companies enter the market.

In the meantime it is important for universities to provide real applications to students of Machine Design and to improve the teaching of Machine Design overall in order to avoid any further negative effects of this issue. FST is concerned in this matter and it has launched the Machine Design Teaching Enhancement Project in cooperation with local engineering companies.

### A. Introduction of the Machine Design Teaching Enhancement Project

Wulff says that many graduates enter the workforce ill-equipped for the complex interactions, across many disciplines, of real-world engineered systems [3]. Other current issues are also the growing demand for graduates and at the same time the decreasing interest of applicants in engineering education. One of the ways to deal with these issues is to improve different aspects of teaching technical subjects in order to improve the quality, efficiency, comprehensibility and attractiveness of teaching Machine Design. The goal of the Machine Design Teaching Enhancement Project is a complete innovation of teaching technical subjects. The project is focused on providing:

- Knowhow transfer from engineering companies to the university
- Involvement of specialists from engineering companies in teaching
- Interdisciplinary knowledge
- Linguistic support (subjects taught in English)
- Support for teaching CAE software
- Learning materials concerned with teaching CAE systems
- Interactive project-based learning materials using 3D models
- learning materials for technical subjects in foreign languages
- Teaching tools (e.g. CAE models or physical models)

In this paper the project-based learning materials and the learning materials concerned with teaching CAE systems are described as a part of the Machine Design Teaching Enhancement Project.

The learning materials are designed to exploit the advantages of modern information technologies. The integration of effective technology into the learning process could enhance the learning process and “enable learners to process complex material more easily” [4]. Engineering content is necessarily visually intensive. Strong visuals separate engineering from other disciplines that may be more suited to strictly audio content [5].

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## II. Learning materials for teaching CAE systems

Knowledge of CAE systems is crucial for graduates of Machine Design as these systems replaced drawing boards in every engineering company several years ago. CAE systems are able to increase the productivity of designers as well as improve the quality of design when properly used. These days, there is a wide selection of CAE systems available on the market and there is currently no single predominant CAE system used generally in engineering companies, as every CAE system has its own specific advantages. Although the user interface of major CAE systems has become more intuitive over time, the complexity of these systems combined with the lack of quality learning material can cause problems for students during their self-study. Therefore, it is quite important to provide learning materials to students in a proper form and structure.

### A. Learning material description

The most important CAE systems (ProEngineer, Catia and Siemens NX) were considered when creating the learning materials. Step-by-step learning materials were selected as a proper form for learning materials. They can be used either separately to learn each module of the CAE system in sequence, or when combined with completed CAE models one can skip some steps and learn the functions of the CAE system randomly according to the student's own needs. In this way, students could e.g. learn the drafting module without having to create CAE models first. A sample page of the learning material is depicted in figure 1.

Figure 1 shows the step-by-step instructions supplemented by illustrations in order to be comprehensible. The page is divided into three sections by horizontal separators. The picture in each section illustrates the steps in the section. Therefore, figure numbering is not necessary.

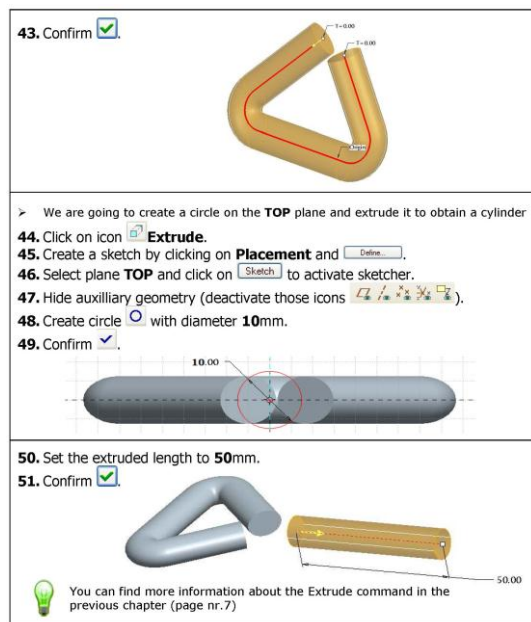


Figure 1. Learning material sample page

### B. Contribution to students

The new learning materials allow students to self-study in computer labs, which are available to them at the Department of Machine Design, and thus be prepared to ask questions in tutorials. The set of learning materials is available to students via the Courseware of the University of West Bohemia. The set includes step-by-step learning materials accompanied by completed CAE models and all necessary settings and templates for the CAE system. The introduction section describes the basic principles of the selected CAE system as well as its user interface, and therefore no previous knowledge of CAE systems is required. The learning materials cover the basic modules of the CAE system (part design, assembly design and drafting), some special modules (sheet metal, piping, mechanisms,...) and also stress and stiffness analysis based on the finite element method (FEM).

## III. The new concept of project-based learning materials

FST was unable to provide real design projects to students as it had no archive of real design projects. Therefore a new concept of electronic learning materials for Machine Design was developed to provide a knowledge base for both academics and students at FST. The intention was to deliver real and complex tasks to students of Machine Design as “the prevalence of low-level tasks contributes to students’ lack of understanding of content and process and poor attitudes toward learning and schooling” [6]. Attention was paid to “emphasizing design (system) thinking, where students learn creative thinking and open-ended problem-solving, but always within the context of design’s close connection with manufacturing (i.e. ‘if you can’t build it, you can’t use or sell it’)” [7], as understanding the connection between mechanical design and manufacturing processes is essential for all Machine Design graduates.

### A. Knowledge transfer

The conventional way of learning Machine Design is depicted in Figure 2. Students work through several subjects to acquire the required engineering knowledge. Sometimes the knowledge they have acquired is then required in other subjects (subjects 3 and 5 in Figure 2), while at other times they will need the knowledge in project-based subjects. The theoretical knowledge transfer assumes transferring gained knowledge from one subject to another (from F->G->H->I). But the reality is different. The sequence of subjects is often not ideal (e.g. for operational reasons) and therefore knowledge transfer does not work (D->C). Additionally, the project-based subjects are often placed in the fourth and fifth year of study. This means the students do not need the knowledge they have learned in their first year for another three or four years of their studies. The problem is not only the fact that they forget most of the knowledge during these years, but this way it is also almost impossible for students to see the connections between subjects. Therefore, this learning approach could be called “learning without context”.

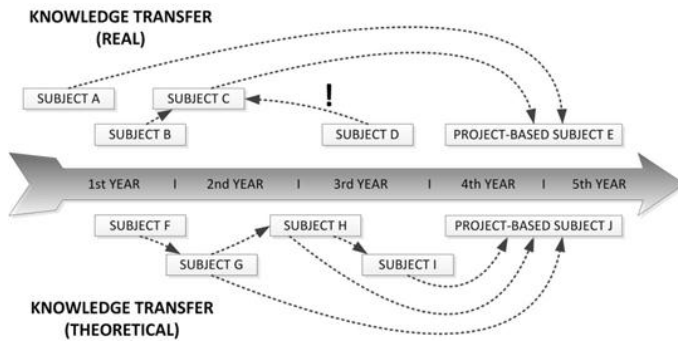


Figure 2. Knowledge transfer

The electronic learning materials focusing on real design projects allow students to study “in context”. This means the students would study the design project to see its different aspects and connections. They would also be able to practise the knowledge acquired in different subjects. This learning approach could be called “learning in context”.

**B. Structure of the learning materials**

The design projects are presented to students in the form of PDF files. The PDF files contain interactive 3D models exported from major CAE systems. The 3D models are a great source of information regarding the design process, but they have to be supplemented by additional information regarding the manufacturing processes and technologies, function of the tool (or machine) and its components and so on. This additional information is inserted into the structured PDF file together with 3D models and technical drawings. The general structure of the PDF file is depicted in Figure 3.

Figure 3 shows the structured PDF file containing the 3D models, technical drawings and additional information regarding the mechanical design process, manufacturing processes and the tool description. Information related to component functions, manufacturing processes and materials is already included in the 3D models.

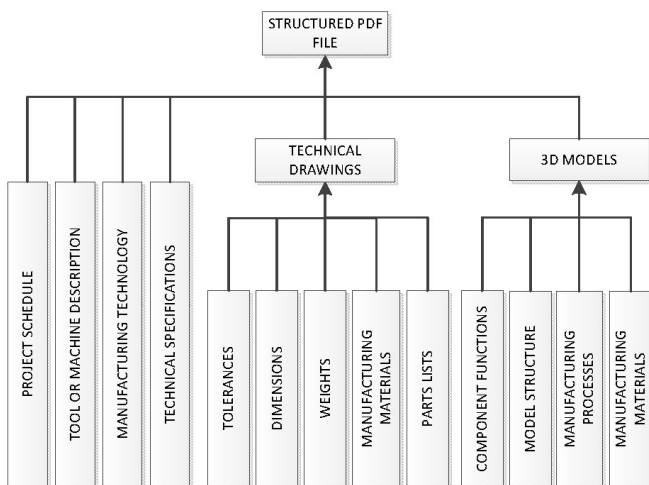


Figure 3. The structure of the learning material in PDF format

**C. 3D models**

3D models serve as a source of mechanical engineering knowledge for students of Machine Design. The 3D models are exported from CAE systems to the PDF format. By importing the 3D models to the PDF format it is possible to view them on most computers and therefore every student is able to use the study materials on his own computer. This way it is possible to use the study materials for many purposes. One can work with the 3D model, rotate it, zoom it, explore it or create cross-sections using the standard Adobe Reader application. There are many parameters regarding each component which one might need to know such as the part number, assembly number, materials or weights. This information can be found in technical drawings, but it is quite inconvenient to search for it, therefore these parameters are implemented directly into the 3D model and can be displayed by selecting the component, as shown in Figure 4. Figure 5 is divided into three main sections. The Model Tree showing the structure of the tool can be seen on the upper left side of the figure, the parameters regarding the selected component are displayed on the lower left side of the figure and the 3D model imported to the PDF file is located on the right side of the figure.

**D. Tool description**

The tool description part of the project-based learning material is crucial to the students’ insight into the tool design process and therefore it has to be well illustrated to be comprehensible. It describes the functions of important components, principles and conditions regarding the described tool. Tool description is a part of the structured PDF file as shown in Figure 3.

**E. Technical specifications**

Definition of technical specifications is the first step of the mechanical design process. The form of the technical specifications is crucial as it has to be clearly arranged, unambiguous and all important requirements and conditions relating to the design project have to be included in it. Technical specifications are written as a multilingual document. Czech, German and English languages were selected due to the importance of these languages in the region.

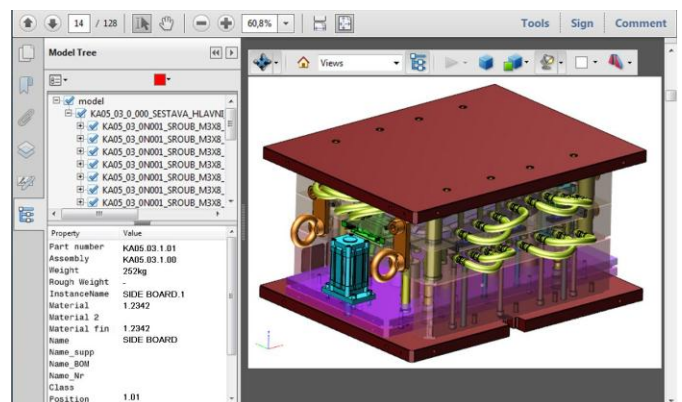


Figure 4. 3D model viewed within the PDF file

### F. **Project Schedule**

Project schedule shows the timeframe of the design project and the sequence of operations. The operations include project planning, design process, manufacturing processes and the distribution to the customer. This way, students get an idea of the time span of the project and the sequence of the performed operations.

### G. **Contribution to students**

The main purpose of project-based learning materials is to support teaching of Machine Design by providing the engineering know-how from industry to students and academics. Project-based learning materials contain interactive 3D models combined with supplemental information and are delivered to students in structured PDF files. By exporting CAE models to PDF format students are able to open the CAE models on any computer regardless of the installed specialized software, its policies and licenses. Thus, project-based learning materials can be used for many purposes such as students' assignments, theses, for their individual work or project-based teamwork. Students study the original design project, learn from it and apply the knowledge to their own project. In this way, students create their own tools or machines similar to those made by local engineering companies. Project-based learning materials have not been created to replace the conventional way of learning Machine Design. They provide a way for bright students to see the connections between different subjects even in the early stages of their studies. The design projects can also be used for supporting different aspects of teaching technical subjects at FST as they provide an archive of technical knowledge to both students and academics at FST. Project-based learning materials cover the following fields of Machine Design: acoustic parts, casting and forging, injection moulding, sheet metals, milling machines, lathes and hydraulic presses.

## iv. **Conclusion and future work**

Technical faculties are obliged to prepare students for their future engineering jobs. They are required to cooperate with local engineering companies to provide quality education that actually reflects the needs of industry. The lack of opportunities for students to acquire practical experience, growing demand for graduates and decreasing interest of applicants in engineering education are the issues technical faculties have to deal with. FST has been concerned with these issues for many years and has launched the Machine Design Teaching Enhancement Project in order to improve quality, efficiency, comprehensibility and attractiveness of teaching Machine Design. As a part of this project, FST has developed learning materials for teaching CAE systems and project-based learning materials. The purpose of this paper is to present those learning materials and their contribution to the education process. First, the Machine Design Teaching Enhancement Project was introduced, and then learning materials for teaching CAE systems were described. The project-based learning materials were introduced and their structure was described. Furthermore, different parts of the

project-based learning materials were presented along with their benefits to students of Machine Design.

In the future, it is important to identify any major drawbacks of the study materials. It would also be appropriate to carry out a questionnaire to verify the acceptance of the learning materials and to check the technical difficulties related to displaying the 3D models. Further research will be required to verify the influence of the Machine Design Teaching Enhancement Project on the competitiveness of graduates.

## **References**

- [1] J. Vavreckova, "University-educated specialists, the demand for them and their standing on the Czech labour market", *Acta Oeconomica Pragensia*, vol. 5, pp. 20-35, 2009.
- [2] The Royal Academy of Engineering, *Educating engineers for the 21st century*. London, The Royal Academy of Engineering, 2007.
- [3] W. A. Wulf, G.M.C. Fisher, "A makeover for engineering education", *Issues in Science and Technology*, vol. 18, no. 3, pp. 35-39, 2002.
- [4] D. Radosevich, P. Kahn, "Using tablet technology and recording software to enhance pedagogy", *Innovate Journal of Online Education*, vol. 2, no.6, p.7, 2006.
- [5] E. Berger, "Podcasting in engineering education: A preliminary study of content, student attitudes, and impact", *Innovate: Journal of Online Education*, vol. 4, no. 1, 2007.
- [6] P. C. Blumenfeld, E. Soloway, R. W. Marx, J. S. Krajcik, M. Guzdial, A. Palincsar, "Motivating project-based learning: Sustaining the doing, supporting the learning", *Educational psychologist*, vol. 26, no. 3-4, pp. 369-398, 1991.
- [7] J. H. McMasters, "Influencing Engineering Education: One (Aerospace) Industry Perspective", *International Journal of Engineering Education*, vol. 20, no. 3, pp. 353–371, 2004.