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TEACHING CAD WITH A PEDAGOGICAL SYSTEM RANGING FROM VIDEOS TO INDIVIDUAL TUTORING

Abstract: *This CAD course aims at lifting as many students as possible to a preferably high and well-defined level of competence. At the same time, the teacher's workload should be kept within limits that allow him or her to spend the major part of his or her capacity on supporting the individual student. In order to reach this aim in spite of common unfavourable teaching conditions a complex pedagogical concept of individual learning in large groups is developed.*

Key elements of this concept are the following:

- *Building up and maintaining the student´s motivation;*
- *Ensuring favorable conditions for a successful teaching performance;*
- *Orientating knowledge transfer at the storage system of the human brain;*
- *Clearly defining content and level of competence;*
- *Presenting contents and methods via hands-on projects;*
- *Systematically addressing geometrical topics at optimal stages [1];*
- *Using 150 short videos to convey principles, contents and methods;*
- *Utilizing a graded system of exercises for building up individual competence in all participants;*
- *Employing a comprehensive system of individual support for the students;*
- *Using teamwork for all individual learning phases.*

This course has already been carried out several times with great success and has been further optimized.

Keywords: *advanced instructions, blended learning, CAD education, didactic conception, individual learning, learning processes, soft skills.*

1. INTRODUCTION

Many teachers suffer from time constraints and often inattentive students who are either bored or overcharged. If students acquire basic knowledge on their own, it is often fragmentary and left to chance in spite of the high expenditure of time. Consequently, lecturers repeatedly have to deal with basics instead of more advanced subjects. Moreover, achievement of the teaching goals appears at stake.

This course offers a solution for the transfer of basic CAD knowledge [2]. It enables students to obtain well-defined fundamentals within a minimal amount of time. At the end of the course, the lecturer can be sure students will master the basics smoothly and reliably. Many of the methods used may seem unorthodox at first and require some adaption time. Nevertheless, due to the positive outcome, four other colleagues have adopted this course into their curriculum.

We shall describe a pedagogical concept that enables students and teachers to focus successfully on the essentials for a high standard of teaching and learning.

2. BUILDING UP AND MAINTAINING THE STUDENTS´ MOTIVATION

Participants will only take full advantage of the teacher's input when able to pay undivided attention. This depends on various aspects. The more convinced the student is of the importance of the subject matter for him- or herself personally the more focused he or she will be (Fig. 1).

Statements made by other lecturers, experienced practitioners and graduates often appear more convincing than those of the lecturer in charge. Arguments, however, can only ever ensure motivation on a cognitive level. Not until students experience their individual competence, will positive feelings and evaluations be produced that are subsequently increasing intrinsic motivation. During the course, the quality of learning increases in proportion to the students' sense of achievement and lack of unnecessary frustrations. It is therefore essential for the teacher to remove all obstacles, which are of no value concerning the teaching aim.

Fig. 1 Project pallet truck.

3. FAVOURABE CONDITIONS FOR A SUCCESSFUL TEACHING PERFORMANCE

Teaching is successful only if it enhances the participants' competence [3]. This requires new powerful neural networks to be built up in the human brain. Research in brain science shows that the effective construction of neural networks is proportionally influenced by the degree to which the following criteria are met:

The student

- feels safe
- feels part of a social environment
- considers subject significant for his or her own life
- has to apply the new input promptly
- has a realistic self-assessment
- can adapt the degree of difficulty of the task to his or her abilities
- realizes that he or she him- or herself can influence his or her learning results
- is not distracted by disturbances.

4. KNOWLEDGE TRANSFER ORIENTED AT THE STORAGE SYSTEM OF THE HUMAN BRAIN

The human brain is very effective in connecting apparently useful new information to already stored data using multitudinous references [4]. However, it is less suited to processing new data without prior experiences. Thus, one should not aim to establish a broad basis from the very beginning. Instead, we will start only with what is needed for a quick practical implementation (Fig. 2a). Experiences gained through application facilitate the subsequent reception of further information during the next lesson (Fig. 2b-e). Contents will be introduced at the time when needed for the project so that their relevance is obvious to students at any time, making time-consuming explanations superfluous (Fig. 8). Only very few topics will require a lecturer's summary on top of the students' overview gained by their own experiences and reflections.

5. HANDS-ON PROJECT FOR THE PRESENTATION OF CONTENTS AND METHODS

The use of a single demanding project from professional practice (Fig. 1) throughout the course ensures that at no time the relevance of the teaching material is questioned. High complexity is reached due to the fact that four partners each prepare and compile the single elements of the project. Thus, these really intricate topics can be practiced and reflected. Hence, this is an attractive task for both participants and teacher.

6. USING 150 SHORT VIDEOS TO CONVEY CONTENTS AND METHODS

Contents and methods are being imparted via a series of 150 short videos divided into 5 units. Each unit is followed by exercise periods for the application and

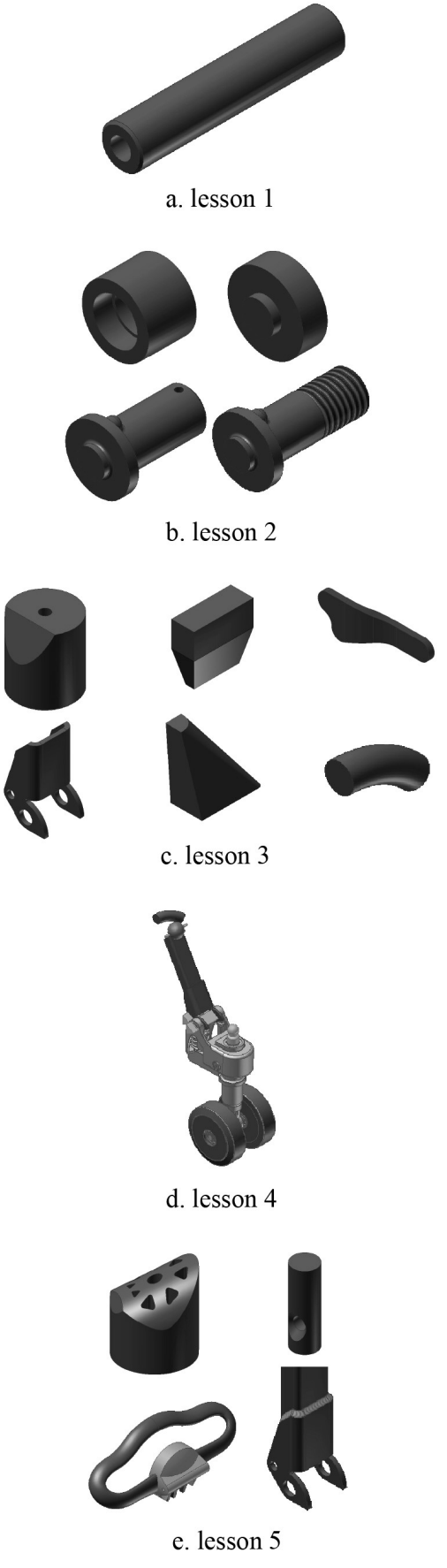


Fig. 2 Content structured in five lessons.

consolidation of the skills learnt. Our students use the videos and do the exercises in class (Fig. 3). Each video has its own topic. It starts with performing construction steps within the software accompanied by superordinate explanations. Emphasis is put on enabling students to manage follow-up exercises independently and without further support.

Fig. 3 Tutoring via videos in classroom.

To minimize the dependency on supervision each video concludes with pointing out frequently observed mistakes. The shortness of the videos is tailored to the students´ attention span (2-8 minutes) while at the same time enabling optimal usage of the storage system of the brain via speedy application. As the videos are smoothly integrated into the work flow of the project, the high quantity is hardly noticed. The students get access to the videos of the next unit after finishing the previous one.

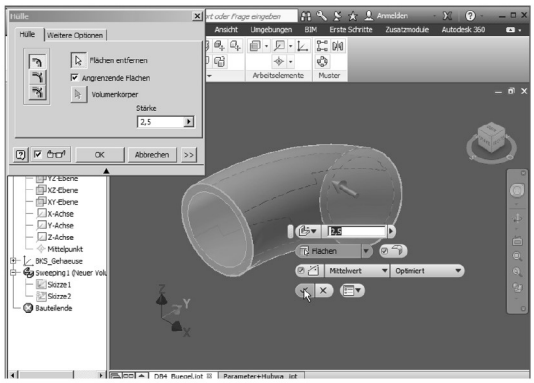
7. GRADED TASKS FOR DIFFERENT DEMANDS

The solution process of engineering tasks can be divided into different steps. For this CAD course, we have derived the following types of tasks with corresponding requirements and a supplementary video module.

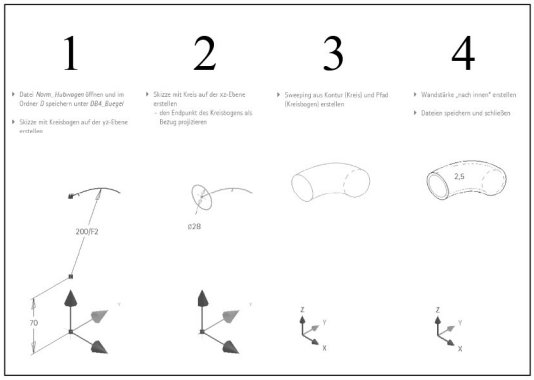
For a structural component the following items are given:

- a photograph or sketch: The student defines suitable measures for the structural component in a sketch or a technical drawing (Fig. 4d).
- a technical drawing: The student develops the structuring of the necessary construction steps for the component (Fig. 4c).
- a structuring of constructions: The student shows that he or she can implement the constructions independently with CAD software step by step (Fig. 4b).
- a video presentation with software inputs: The student acquires knowledge through independent repetition of the software inputs (Fig. 4a).

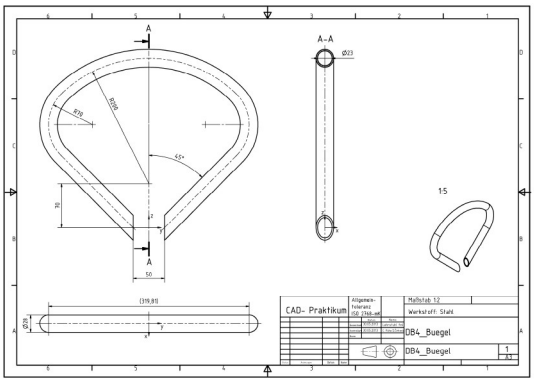
During the course students have to be led to this practice-oriented process step by step. The respective superior aspects are given in the video as supplements to the software inputs. They are then applied in reverse order.



a. Video Presentation



b. Structuring



c. Technical Drawing

d. Photograph

Fig. 4 System of applications.

8. A GRADED SYSTEM OF EXERCISES FOR BUILDING UP INDIVIDUAL COMPETENCE

Our system of exercises allows every student to individually adapt his or her learning curve. Students start acquiring knowledge via entering given steps into the program. Watching the complete video of a unit (Fig. 4a) before carrying out the entire step on one's own yields an optimal learning effect. Working and watching simultaneously might seem quicker to many students but has a much smaller learning effect. Entering all steps of a lesson once again - now based on the structuring (Fig. 4b) without using the video - consolidates the acquired knowledge. Further repetitions will build up routine. A successful training implies a safe transfer by the student: Each partner in the group will be given different tasks accompanied by instructions but without videos. Further exercises with construction drawings (Fig. 4c) or photographs (Fig. 4d) only will reveal whether the participants are now completely independent from support. For participants frequently encountering problems it is advisable to invest into building up a certain routine by using our system of useful repetitions [5]. This system easily allows additional work to increase the motivation of students with high potential.

9. A SYSTEM OF INDIVIDUAL SUPPORT FOR THE STUDENTS

In order to maintain the students' motivation their progress should be delayed by problems only briefly. Since all students work on similar tasks, fast solutions will easily be achieved via the following graded system:

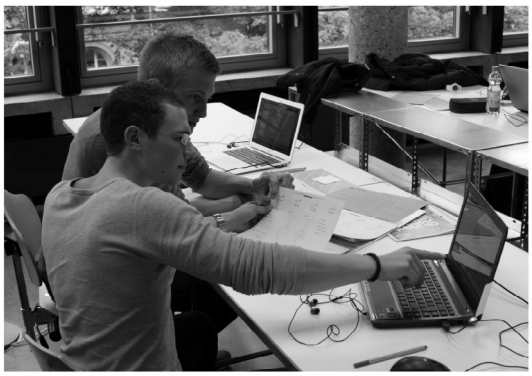
- The lecturer emphasizes that watching the complete video including the discussion of common mistakes will solve most problems (Fig. 5a).
- In addition, the team partners are often able to assist due to their unbiased view (Fig. 5b).
- Finally, a discussion among the members of the learning group will solve 95% of the problems arising (Fig. 5c).
- Therefore, the teaching assistant (Fig. 5d) has to deal with only few problems and the lecturer can concentrate on the genuinely individual assistance instead of being kept by predictable questions.

The participant, thus, will be swiftly supported in problems of any degree of difficulty.

10. USING TEAMWORK FOR ALL INDIVIDUAL LEARNING PHASES

Collaborating within a team can have positive effects in all learning phases [6]. To help freshmen build up a positive learning atmosphere they are encouraged to choose their own partners for groups of four. While watching the videos and working at the computer they are sitting close enough to be able to help one another with questions and problems promptly. Every participant contributes the parts he or she has created during the transfer exercises to the common project (Fig. 6a-d). At a practical level, the team members jointly assemble single

a. Self-help



b. Partner

c. Learning Group

d. Teaching assistant

Fig. 5 Different types of individual support.

files to a common unit. Transfer tasks are at hand to develop and optimize construction ideas within the team. Collaboration within the team will help the students to reasonably assess, reflect and specifically enhance their own performance at any time via the modules offered. It also pays off for the lecturer to support cooperation through his or her own assistance.

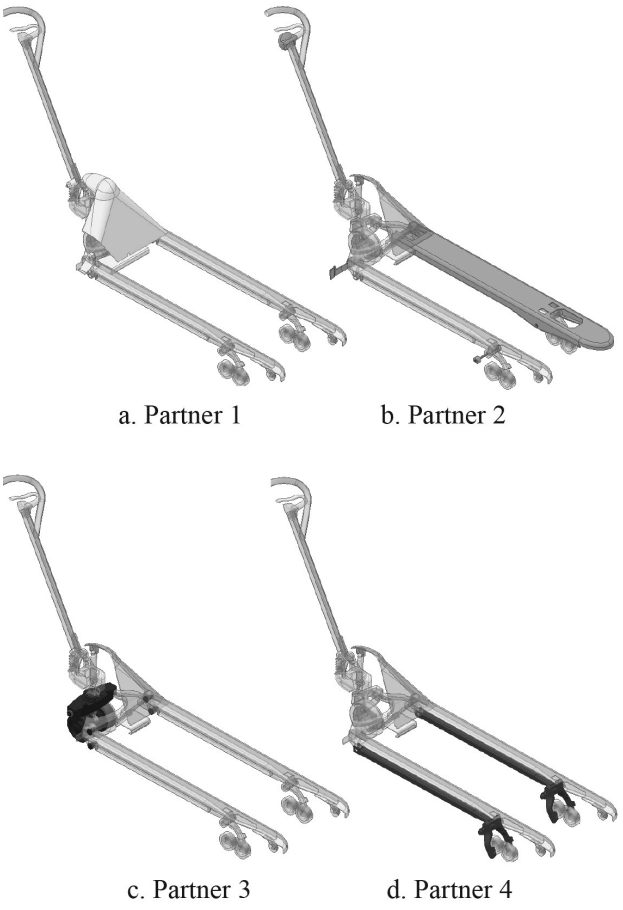


Fig. 6 Different tasks for each partner.

As quality control of the software competence acquired a final project will be created. Without being given new contents in videos, the four team members will create a model of the New National Gallery in Berlin within 90 minutes (Fig. 7). Based on the given structuring the project will be implemented in four phases in direct cooperation.

11. COURSE FORMATS

This course can be adapted to various circumstances while maintaining the didactic concept:

In Aachen, we run a compact course for one week with 248 students working in parallel in 4 rooms from 9 am to 5 pm. During these times the students watch the videos and work on the tasks. The students report that they feel looked after very well even though 32 students have to share one teaching assistant.

In Göppingen (University of Applied Sciences), three professors run the course on a weekly basis for circa 400

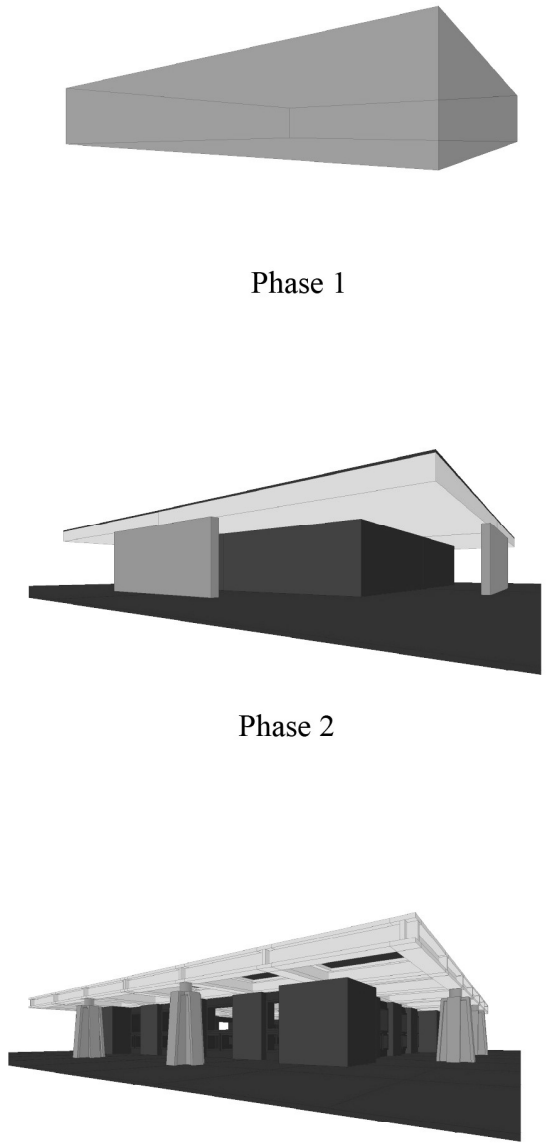


Fig. 7 Final team project: New National Gallery (Berlin).

students with only 1-2 teaching hours/week. Thus, they have reduced the size without changing the didactic concept. The professors report that their work has been tremendously facilitated by taking up the course and students come up with better results.

In Munich (Technical University), the course is being implemented for 1500 students. They prepare the course at the home with the help of videos and exercises. Every fortnight they have to work on selected elements of the pallet truck in the classroom in form of an examination.

The teaching evaluations show that all parties profit from switching to the new course.

12. CONCLUSION

Applying the pedagogical concept has shown that it is possible to enable a large group of students to implement a demanding CAD project in a very short time. In spite of the high standard, a single lecturer is sufficient to support 250 students very well. By way of future cooperation with other colleagues, we will further optimize key elements of the concept. Involving other colleagues will reduce start-up costs and will provide suggestions for improving both the approach and the material. If colleagues wish to adapt this course to an alternative engineering software, the service range for the students can be multiplied with significantly less effort.

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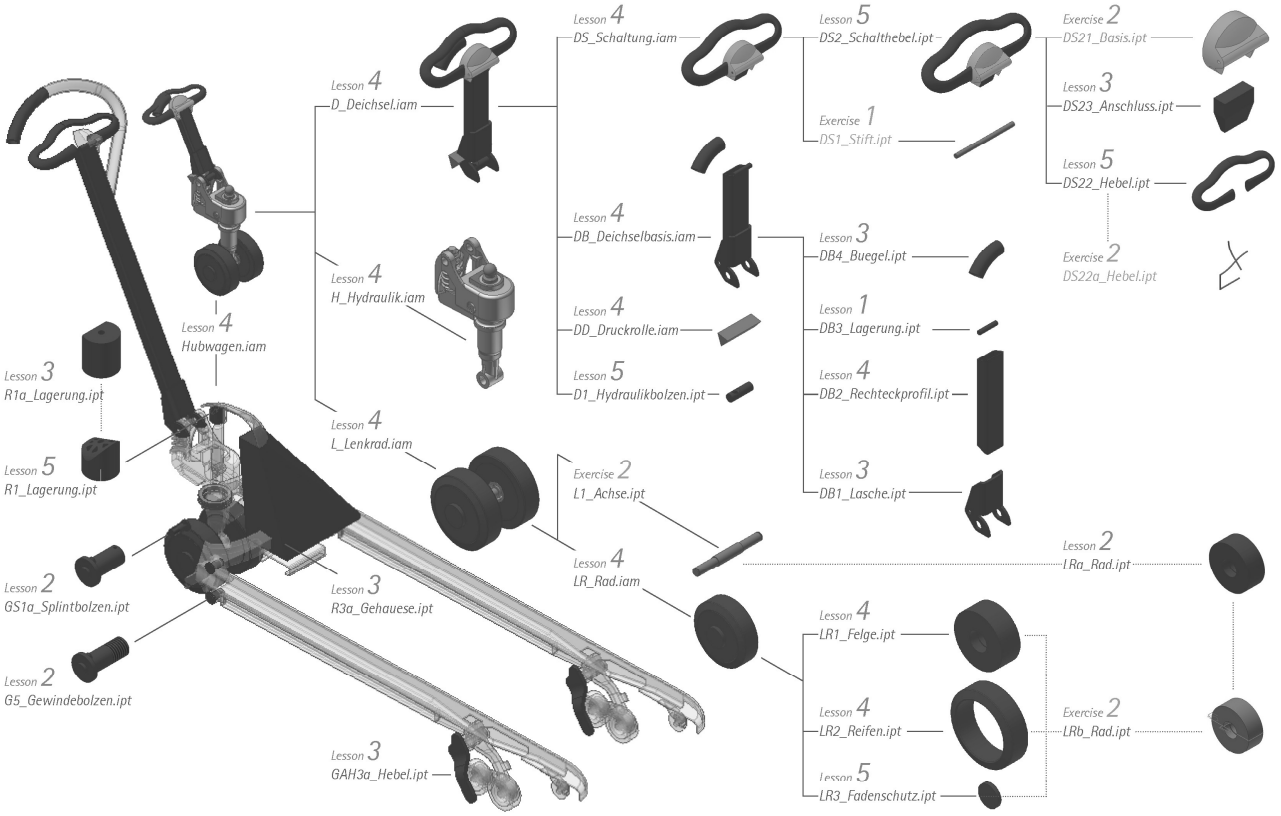

Fig. 8 Project pallet truck - overview of parts created in lessons.