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INDIVIDUAL LEARNING OF CAD ENHANCED BY TEAMWORK

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ABSTRACT
This paper presents how individual learning of CAD can effectively be enhanced by teamwork in nearly all phases. 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 can be kept within limits that allow him or her to spend the majority 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 has been developed.
Key elements of this concept are the following:
- Building up and maintaining the student´s motivation by teamwork
- Ensuring favourable conditions for a successful teaching performance inside teamwork
- Orientating knowledge transfer at the storage system of the human brain
- Clearly defining content and aimed at level of competence
- Presenting contents and methods via hands-on projects to be performed in teamwork
- Systematically addressing geometrical topics at optimal stages [1]
- Using 150 short videos to convey principles, content and methods
- Utilizing a graded system of exercises for building up individual competence in all teams
- Employing a comprehensive system of individual support for the students inside teamwork
- 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, teamwork, learning processes, soft skills.

1 INTRODUCTION

An increasing number of online courses offered by various institutions suggests that high quality knowledge can be easily offered to an increasing number of people. However, university lecturers are frequently not too pleased with the outcome.
Easy access to the courses not necessarily facilitates learning success, as indicated by a large drop out quota. It appears that in many cases further optimization of the course material requires even more self-discipline on the student's side.
In this paper, we illustrate how introducing teamwork is able to compensate for existing drawbacks. Furthermore, we show that collaborating on one common project requires specific knowledge and interpersonal skills.
Our concept aims at providing optimal support to an individual in his/her way of learning while minimizing organizational overhead at the same time. The advantages of individual work on one side and the advantages of teamwork on the other side are combined. At the same, the drawbacks of either approach are minimized.

2 FIRST STEPS IN THE LEARNING SITUATION

It is well known that the start in a new institution, especially in view of our large classes of about 200, brings students into an unsettling mood [2]. However, results from brain research show that an individual learns best when feeling comfortable and socially integrated [3]. Therefore, even before start of the classes we assist our students in building working groups of four each (Figure 1). These

groups will grow together when mastering unfamiliar situations thus preventing the upcoming of feelings of isolation within large groups from early on. Speaking scientifically we create an optimal environment for the growth of powerful neural networks in the students' brains.
The learning group as the main feature of our concept provides support for the individuals throughout the course assisted by supervising teaching personal when necessary.

Figure 1. Students in lecture-hall and in learning group of four

3 COMMON PROJECT OF THE LEARNING GROUP

Throughout the course, we will deal with one single, challenging project taken from practical applications (Figure 2). This will prevent students from questioning the practical meaning of the course contents. The project is chosen in such a way that teamwork will obviously be the only promising approach. Each of the four group members will design different elements within the project, thus enabling a rather complex final result [4]. Students will experience different ways of collaborating within a team and connect them to the results produced in a comprehensible way. If everything works well they will be rewarded with the experience of having achieved a rather complex project in joint work.
From a didactical perspective, the main goal is the optimal facilitation of students' progress in his/her ability to acquire knowledge and use different learning and working techniques. When we manage to cooperate this way of thinking into their working on a CAD project, the course will promote the development of their personalities at the same time on a higher level [5].

Figure 2. Pallet truck in action and in CAD project

4 KNOWLEDGE ACQUISITION USING VIDEOS

The acquisition of knowledge takes only place on an individual basis. Each individual has its own pace of learning and therefore there is a need for an individual control of the progress. Videos are ideally suited for that purpose (Figure 3 left).

In view of students' limited attention span, the videos need to be as brief as possible. Our goal is that most students view the complete video fully focused. Here we face the dilemma that repetitions appear tiring but are essential for incorporating new knowledge. Therefore, in our concept the use of repetitions is only intended during an individual's application to the new knowledge (see 6). Only in the exceptional case, that someone is not able to grasp the idea after a one-time view of the video a second view of the video may be helpful.

If the topic is still unclear, a discussion within the group will usually achieve a deepened comprehension for all group members.

Knowing that a certain piece of information is required promptly activates the human brain considerably. Therefore, we let the students know in advance that right after viewing the software inputs shown in the brief (2-5 min.) video they will solve the task illustrated in the video on their own.

The course content is divided into five sections comprising 22 videos each [6]. Each section progresses through the modules described below.

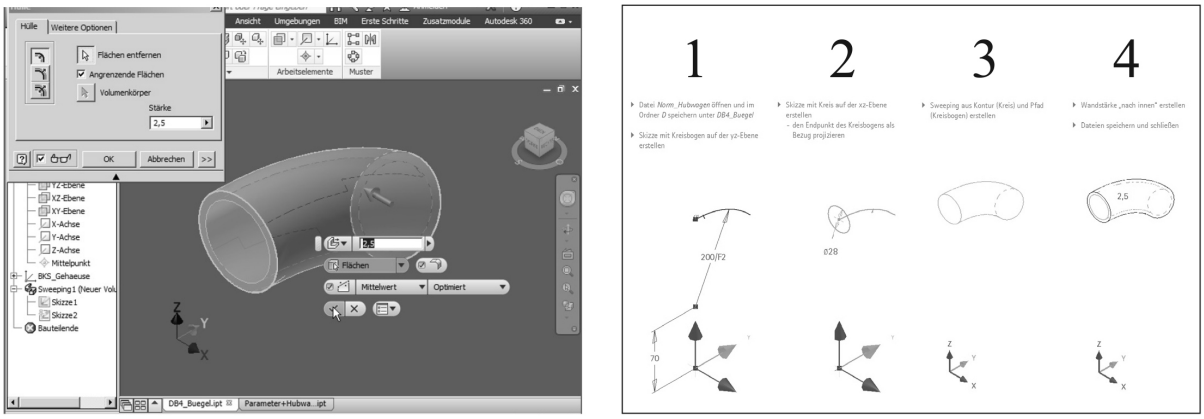

Figure 3. Tutoring via video presentation and application via structuring

5 FIRST APPLICATION OF NEW KNOWLEDGE BY REPRODUCING

After viewing the full video, the student reviews his/her learning progress by immediate application of the new knowledge. In particular, he/she will check if he/she has memorized all aspects addressed in the video and if he/she is able to reproduce the procedures illustrated. Doing this individually in his/her own pace and independently of the other group members, is essential for a stable memorization of the topic. In addition, it is crucial that this is not done simultaneously while watching the videos (tempting to some students). This way it is enforced that the new information needs to be buffered in their own brain thus avoiding delays in later working phases.

Guided by previously seen videos each student designs the front elements of the pallet truck on his/her own and composes them.

During this phase, the purpose of the group is as follows: Each student realizes that the other group members are making progress in a concentrated way. Since nobody wants to lag behind within the group everybody is motivated to overcome difficulties in a timely way and take care not become distracted.

6 REVIEW, STORAGE AND DEEPENING OF ACQUIRED KNOWLEDGE BY REPETITION

After completing the section, the student is required to repeat all steps once more. Students tend to underestimate this phase completely. In particular, when they feel time pressure they are unwilling to repeat steps they had completed right before. Therefore, many students move on to the transfer phase too early and thus not fully prepared.

The repetition serves students to check if they are able to complete the task successfully without video support and if they have fully memorized every single step. Of course, the repetition supports further and deeper memorization of the task. Ideally, each student should repeat the task over and over again until he/she can complete it smoothly. Then he/she will be optimally prepared for the next step.
Experience shows that we should be prepared here to encounter students' resistance and thus risking success. Ideally, students realize that a paradigm shift would increase their success significantly: They would notice that repetitions are much easier than tackling new topics. Later on, they would see that with each repetition they would take less time to complete the task thus experiencing their own progress. The more they master the basics in a solid and smooth way the less problems and need for supervisions they will require further on.

Figure 4. Front of the pallet truck done by each of the four partners

It is important to us that each student experiences this phenomenon. Therefore, we employ a software tool that is able to distinguish newly created files of the front part of the pallet truck from copies of the first phase. This way of technical control should not be necessary within university education where we are supposed to train future professionals. Graduates should be able to do what is necessary and not be restrained by inadequate emotions [7]. As long as this high level of self-discipline is not achieved for sure, these technical methods help to support the individual process of learning.
During this repetition phase group members support each other should one of them deviate from the right path. Each member is supposed to complete exact the same steps (Figure 4) so that they can help each other to move on. Also they are able to compare their own abilities to the others', therefore ideally motivating them to take measures to keep up.

7 KNOWLEDGE TRANSFER TO NEW TASKS

Having successfully acquired routine each of the four group members will be assigned different tasks (Figure 5).
This task requires the transfer of the knowledge gained in the earlier video phase to a new task for which they will not be specifically prepared. We provide teaching material that guides them in structuring the constructions (Figure 3 right).
Each group member faces now two challenges: First, he/she is to provide his/her own contribution to the pallet truck project, this time the rear part. Second, supporting team members requires different abilities than before and supports at the same time the individual's learning process.
Discussions within the group will support each group member. He/she who needs help will get it promptly thus minimizing the risk of losing someone along the path towards the learning goal. He/she who supports others will encounter new questions and the need to adapt to different situation thus deepen his/her own understanding. With four students working collaboratively, a solution within the group is very likely (Figure 6) and supervision by professional staff is hardly needed.

Figure 5. Different parts of back of the pallet truck done by the four partners

Ideally, the level of competence within the group should be rather homogenous. In case it is not, there are two common scenarios to be dealt with: If one member lags significantly behind the rest of the group, the other members will be provided with completed solutions of the task of this particular member. Then the rest of the group can continue at their pace while the one member with slower progress can continue finishing his/her task independently. Second, if one member is significantly faster than the rest of the group, he/she will be provided with a sample of the completed pallet truck where only the parts are missing that this member is supposed to produce.

Figure 6. Team shown in different learning phases

8 KNOWLEDGE TRANSFER TO A FINAL PROJECT

At this point the students have acquired all presented knowledge and have completed the project pallet truck with all parts and assemblies. Finally the learning outcome will be tested on a completely new project, a model of the New National Gallery in Berlin (Figure 7). As before the project is subdivided by us into four different tasks so that each team member will work on his/her own task.

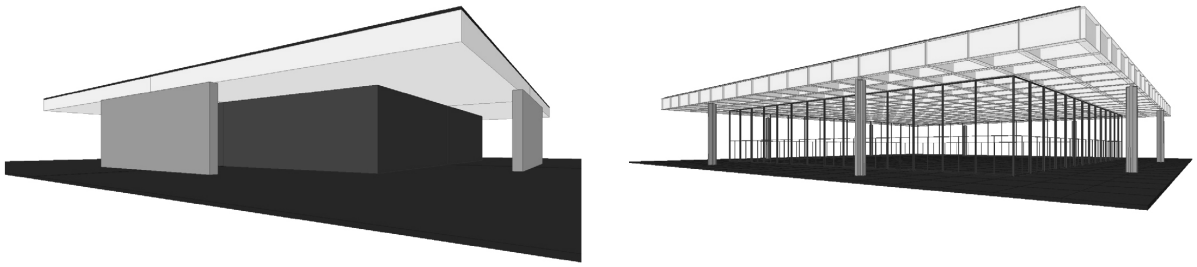

Figure 7. Final team project: New National Gallery (Berlin)

Without video assistance (compare Figure 3 left) but based on a given structuring provided by us (compare Figure 3 right) the project will be completed in direct cooperation within the group.

In the winter term 2017, 52 out of 62 teams were able to finish this project successfully within 90 minutes.

9 SUMMARY

The didactic concept presented in this paper provides an optimal learning environment for students. Using a pallet truck as application CAD skills will be acquired as well as effective learning and working techniques.

The compact teaching concept allows the acquisition of many facts and complex methods in a brief period. Our experience shows that participants will succeed even in challenging situations thus providing a solid base to approach and manage situations that are even more complex.

Our teamwork concept provides the students with mutual support so that smooth progress is made. Therefore, teaching staff can concentrate on providing supervision only in special situations on an individual basis. In general, all frequently arising questions are dealt with within the group.

The group setting provides the student with a concentrated work experience thus enabling him/her to reflect upon his/her own abilities and learning progress. The main feature here is the group's stimulating internal discussions.

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