

USE OF SEQUENTIAL BLENDED LEARNING FOR THE IMPARTING OF CAD ACQUIREMENTS ON THE FACULTY OF MECHANICAL ENGI- NEERING

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Abstract: As part of the course “Technical Drawing”, a sequential blended learning course has been offered by the department of machine elements at TU Dortmund University. Students are able to acquire the whole knowledge that is required to handle the CAD program “AutoCAD” by Autodesk. In order to increase learning effects, this course offers a combination of e-learning and in-class lecture. Further the students are asked for a responsible participation to get part of the course. Thanks to intensive transfer of knowledge a significant improvement of the results of the exam could be identified. Therefore the using of the named method, additional to scripts, videos with teaching contents, tests, exercises and tutorials, which are supervised by teachers, are valuable tools, which increase the motivation of students.

Keywords: e-learning, distance learning, online, Mechanical Engineering, technical drawing, CAD

1. INITIAL SITUATION

At the department of machine elements at TU Dortmund University many teaching contents are taught in terms of blended learning, also integrated learning, [1], for more than eight years. Blended learning combines the advantages of traditional courses with new ways of teaching by the omnipresence of the internet. The required media are available at home as well as mobile at any time. This allows the students to work on the educational content at an individual pace according to the personal needs, as well as to rework missed lectures. A learning platform, including the accompanying material of lectures, video files in the form of annotated PowerPoint presentations for lectures and exercises, as well as materials for controlling knowledge, is provided. All e-learning videos have been recorded outside of the classroom, without listeners, and hence without noise. Still, the students have the opportunity to interact with each other in forums.

This form of blended learning, which is also called parallel blended learning [2], has been very well proven in several subjects.

But for the course "Technical Drawing and CAD", which is offered in the first semester, no appropriate blended learning course for the CAD part was available so far. In the technical drawing part students can change individually between e-learning and presence lesson.

The content of teaching of the CAD part was introduced by a script for self-study as well as weekly offered consultation hours.

The knowledge of technical drawing is examined as follows:

Part 1: Classic paper exam (90 minutes) with the following contents: creating and dimensioning of technical drawings, hands-free on paper: development of one of the three views front view, side view, top view, creating a drawing in isometric or dimetric projection, complete dimensioning and tolerancing of a shaft.

Part 2: Online exam on the PC:

- theoretical knowledge examination: 15 multiple choice tasks about the course of "Technical Drawing" (estimated processing time: 20 minutes)
- AutoCAD test: drawing of a shaft with complete dimensioning by means of the program AutoCAD by Autodesk (estimated processing time: 60 minutes)

In the first part the knowledge of the practical application and the capabilities of freehand drawing are examined. This exam performance is independent of the online exam.

In the second part the theoretical knowledge, for example, the correct representation of machine elements (such as screw connections, shafts, axles) and components is examined by the multiple-choice method on the PC. The tasks are taken from an item pool, so that all students receive the equivalent, in terms of content, but different tasks. This examination performance arrives with 60% in the overall score. Image 1 shows an example.

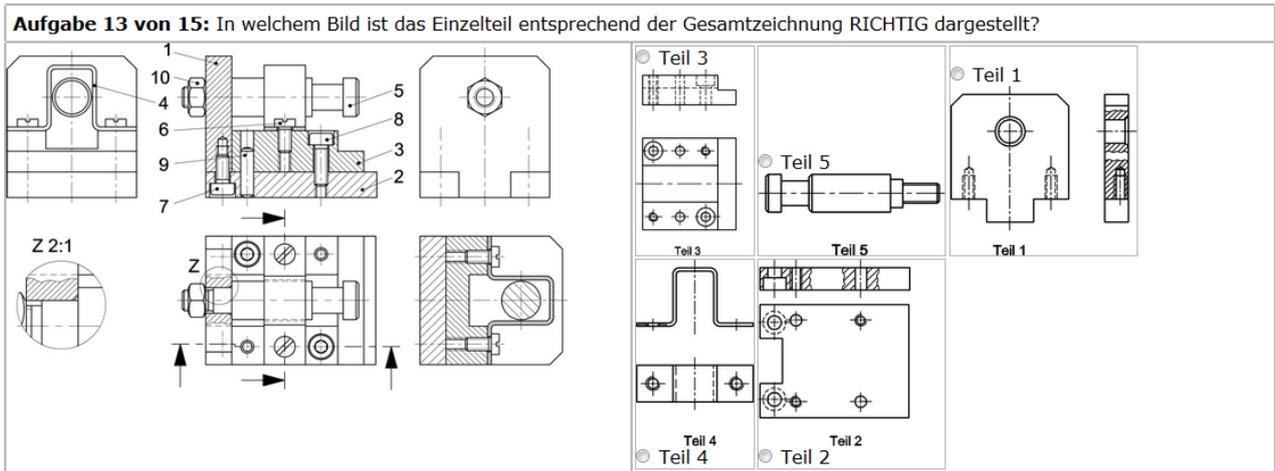


Image 1: Example of task out of the multiple-choice-test with images in question and answer

The knowledge and skills of working with the CAD system are tested in the CAD part. This part accounts for 40% of the overall score.

The mark of the entire online exam consists of the results of the two online parts. In the exam two PCs are available for each student. Therefore, it is possible to switch freely between the tasks of multiple choice test and the CAD part. The processing time is a total of 80 minutes. This time can be distributed individually by the students on both parts of the exam.

In the past, the number of students who have not passed the exam was relatively high and thus not satisfying. To remedy this situation, the causes were investigated first. In the winter semester 13/14 283 students were examined. 34 students (12.01%) reached 0% in the CAD examination and 3 students (1.06%) achieved 0% in the online exam.

Table 1: Results of the students in the winter semester 13/14

283 students	online	CAD	result total
CAD exam, best result	75%	94%	mark 2.0; position 4
online exam, best result	100%	0%	mark 3.3; position 54
best result of all students	90%	80%	mark 1.7; position 1

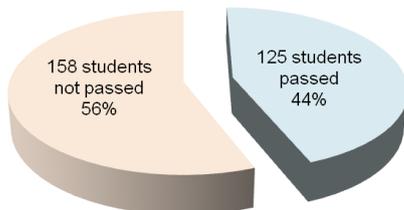


Image 2: Exam results online exam (multiple-choice questions and CAD), total, in the winter semester 13/14

The investigation of the causes for the high failure rate shows that on the one hand only the multiple choice test has been elaborated and on the other hand only the CAD part. In exclusive evaluation of the multiple choice test, the score improves for 196 students (69.26%). In exclu-

sive evaluation of the CAD part only 87 students (30.74%) would improve their score. Image 3 shows these results.

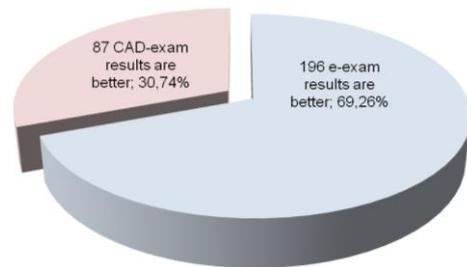


Image 3: Improving the results by exclusive evaluation of both parts of the exam

This result shows that the biggest difficulties exist in working with AutoCAD. Obviously, the few courses, as well as the offered consultation hours, were not enough to convey the contents sufficiently. Especially the consultation hours were used rarely, so the supervisors got the wrong signal, that the students needed seemingly no help in dealing with the CAD system.

The problem had to be taken into account in the development of remedial action, that participation had to be enabled on the one hand for about 300 students, on the other hand, the number of existing workstations and the support capacity for the required number of groups does not exist.

As a solution, a blended-learning course for the CAD part was developed and offered.

2. WAY OF SOLUTION

Because of capacity reasons, only two three-hour maximum presence lessons can be offered, it is essential to work there effectively. The use of a sequential blended learning course was chosen as an appropriate course of action.

In opposite to parallel blended learning or flipped classroom, the parallel blended learning or inverted classroom [3] not only content will be made available, that can be obtained by students at any time. Rather dependencies and conditions between the part of e-learning and the presence lessons are created, so that it is guaranteed that

at defined points in time, some progress is achieved and certain knowledge must be present. In addition, there may be communication between students and teachers at any time via the learning platform moodle. Weekly consultation hours are offered for further support. Better planning of capacities and resources for the presence lectures (62 workstations) a registration for an appointment and for the presence lesson via the learning platform moodle is required. An improved and more efficient use of both class lectures should be achieved that the students must provide inputs for this purpose. These represent the conditions to participate in the presence lectures.

For this purpose teaching materials in the form of a script have been created, which contains numerous examples of exercises to be worked with by the students. As another tool, video tutorials were developed and made available to the students about the structure of the program and the application of its commands.

The content of the exercises is already known by the students because it is similar to the course "Technical Drawing", so that now the implementation by the CAD technology is in the foreground. These exercises are structured in that way the students get comprehensive knowledge in dealing with the most important commands of the CAD system, which are also relevant in the exam.

Next task was to check whether the students have indeed sufficient basic knowledge and whether the exercises required as prerequisite have actually been processed before the presence lecture.

First, an online knowledge control was introduced as a solution to the problem. Once students had completed the knowledge check properly, they could sign up for the first presence lesson. For the control of knowledge, students had as many attempts as they needed.

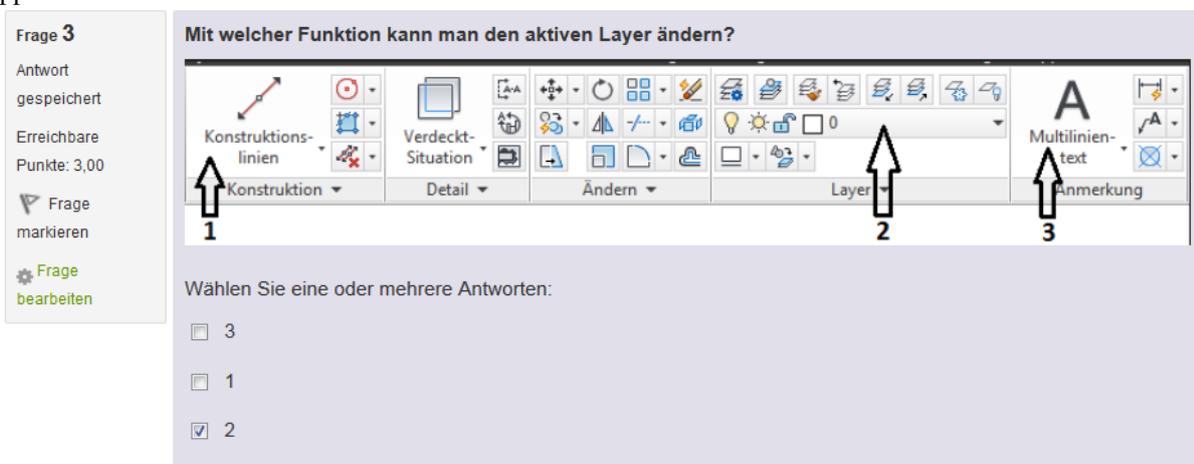


Image 4: An example of a question of the online knowledge control

In the presence lecture two simple drawings using AutoCAD were drawn and dimensioned. The necessary steps have been presented previously by teachers.

At the department of machine elements, the particularly positive situation exists that four apprentices to the technical product designer are involved. Because the contents of training largely coincide with the content of the course "Technical Drawing", there are excellent synergy effects, which can be used for the benefit of all stakeholders. In consulting of the students the apprentices also have opportunities for stand-alone presentation of content and to advise the students in solving their tasks.

The examination regulations of the training of apprentices to the technical product designer stipulates that an operational order is executed and then presented to a committee in the final exam. A good preparation for obtaining the

necessary safety and skills is therefore presenting to groups. Because the presence lessons in the course of CAD, which is a subject in the first semester with limited number of participants in one group and in a field in which the apprentices very well know, this is a very good opportunity to practice the presentation. For any problems an experienced supervisor is available at any time.

After the first presence lecture tutorial videos are uploaded for the students, who were not able to take part in the presence lecture or still have difficulty with the solution of the handled tasks. In these the explanations of AutoCAD drawings, created in the first presence lesson, are drawn and dimensioned. In addition, click-instructions were created, which explain step by step the most important commands, shown in image 5.

Schritt	Button/Aktivität	Kommentar
3	Mit dem Mauszeiger über den Befehlsbutton fahren 	Ein Rechteck lässt sich mit Hilfe des Rechteck-Befehls auch schneller Zeichnen
4	Befehlsbutton anklicken 	Wie auch beim Linien-Befehl wird der Rechteck-Befehl durch Linksklicken auf den Button aktiviert

Image 5: Part of the click-instructions

3. EXPERIENCE WITH PREREQUISITE

As a prerequisite to the first presence lecture, the successful completion of a knowledge check was required in a first step. Hereby, however no good experience could be gained. Despite successful participation in knowledge checks, some students have extremely low previous knowledge and could hardly follow in the presence lecture. Here is the surmise that these students have not completely independently performed the knowledge checks.

Students self study should specialise in dealing with AutoCAD on the basis of exercises for the second presence lecture. This was the simplified drawing of a shaft. To prevent a possible sign-off from others, different drawings regarding geometry and dimensions had to be created by all students. This drawing had then to be uploaded to an online system (moodle).

In the next step, these drawings were assessed by responsible persons of the department of machine elements. Based on the result of the respective students their registrations for the second presence lesson were unlocked and associated with a group of beginners or intermediate.

Two differently designed courses were offered to meet the different knowledge levels of the students. The basics were treated more comprehensively in a longer event for beginners. In an event for students with larger basic knowledge in CAD was the opportunity to meet the advanced features in more detail. In addition, the temporal scope of this event was low.

For the correction of the uploaded drawings numerous expenditure on staff was necessary. In this respect, this solution was still much in need of improvement.

The second problem was in the assignment of the students to the class lectures for beginners or advanced. Here, some students complained about the requirement of deep skills, while others criticised a too slow pace of work.

Thus a new approach was followed in the next year: knowledge checks were used for the first presence lecture in the winter semester 15/16 just as a voluntary element. This tool should serve the students to assess their own abilities. Based on this, they could allocate for the first presence lecture by themselves to a group of novice or to an advanced course. A side effect was that they could complain about the assignment to a group no longer.

As prerequisite to participate in the second presence lesson, students had to draw all the same shaft, where at first a dimension was not required. This drawing had to be uploaded by the students. The correction was considerably simplified due to the uniformity of the task. Incorrect drawings had to be corrected by the students and uploaded again. This achieved a better learning effect.

The motivation of the students could be increased significantly by this: the own drawing was processed in the second presence lecture under the guidance of the supervisor to a full production drawing with dimensioning and tolerancing. Because the drawing was already finished and uploaded into moodle before the presence lecture, the topic

of dimensioning could be treated significantly more intensively.

The edited item represents a standard problem in the field of machine design. It resembles also the task, which is to edit in the examination. It includes all commands that are required for processing the exam task.

After the second presence lecture, a solution video was created for the preparation for the exam, and more exercises in the online platform were being provided for the students. In addition, consultation hours were offered once a week, where students could ask any questions about technical drawing and the CAD system.

4. EVALUATION OF THE RESULTS

Based on the results of the exam the following conclusions have been found: in contrast to the previous examination, all students (274) in the CAD examination achieved a positive result. Nobody reached 0%. Only one student (0.36%) achieved 0% in the online exam. Table 2 shows the main results.

Table 2: Results of the students in the winter semester 14/15

274 students	online	CAD	result total
CAD exam, best result	0%	100%	mark 3.3; position 91
online exam, best result	91.5%	74.5%	mark 1.7; position 3
best result of all students	82.9%	92.5%	mark 1.3; position 1

The failure rate, which previously stood at 56%, improved significantly and now stands at around 39%, shown in image 6.

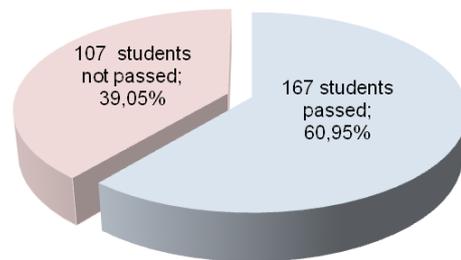


Image 6: Exam results online exam (multiple-choice questions and CAD), total, winter semester 14/15

For further review it was investigated again how the results change when on the one hand only the CAD results as a valuation basis are used and on the other hand only the results of the multiple choice tests. It showed that with 60.22% of the students the mark would improve, if only the CAD part would be assessed. Thus succeeded, to come to a part of exam performance with consistently good results by this part with previously rather weak results, shown in image 7.

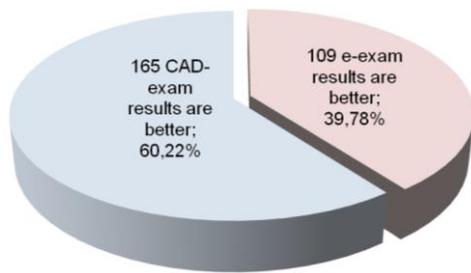


Image 7: Improvement of the results depending on the scoring of the exam

As further review exam scores of those students (231 of total 274, 84.3%) were evaluated, who have not taken part in the presence lectures, but have used only the blended-learning material. Although these students have not fully exploited all possibilities for exam preparation, 63.20% of them have passed the exam, shown in image 8. This is to recognize that the developed teaching / learning materials are suitable for a self-study.

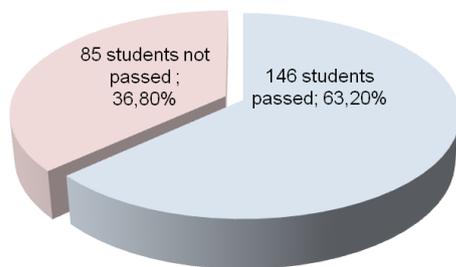


Image 8: Exam scores of those students in the winter semester 14/15, which have not taken part in the presence lectures

In the winter semester 15/16 a similar result was reached. 158 of 248 students (63.7%) have passed the examination, 90 (36.3%) have not passed the exam.

Table 3: Results of the students in the winter semester 15/16

248 students	online	CAD	result total
CAD exam, best result	48.7%	100%	mark 2.2; position 12
online exam, best result	82.9%	74.5%	mark 1.7; position 3
best result of all students	74.3%	96.5%	mark 1.3; position 1

In the winter semester 15/16 87 of 248 students (35.1%) have not participated in the presence lessons. 54 of them (62.1%) have passed the exam, 33 (37.9%) have not. Thus, similar results were achieved as in the previous year.

5. CONCLUSION

With the blended learning course exam results could be improved significantly. So this is a very well suitable tool to improve the learning experience.

As a result the motivation of students increased significantly, that now as input to the second presence lecture a basic drawing had to be created. They had to be corrected

before the lessons as far as they could be finished in the lesson.

As a result that the prerequisite are used as milestones, students are required to comply with a defined scheduling. It was also possible to use only the blended-learning materials in the self-study to acquire knowledge in the handling of the program, without having to use the presence lessons. By the dates specified by means of the presence lessons, students have a guideline until when, what skills must be present.

By the fact that the students were divided in beginner or advanced groups by themselves based on the level checks, a significantly greater satisfaction with the grouping was achieved.

Due to the consistently positive experiences a similar integrated course will be created in future along the lines of the AutoCAD course, is conveyed in the dealing with the 3D CAD software Autodesk INVENTOR.

It has been proven that the developed concept is suitable to be able to take care of relatively large numbers of students with a small number of presence lessons. The presence lessons can be used considerably more efficiently by combining with blended learning courses.

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