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Digital teaching and examination in the basic subject Machine Elements

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Abstract

In Vorlesungen, Übungen und auch Praktika steht neben der Vermittlung von Wissen mit Hilfe von Tafelbildern, Folien und Präsentationen das kontinuierliche Einholen einer Rückmeldung von den Studierenden im Mittelpunkt, über die man als Lehrender bewerten kann, inwieweit die Ausführungen durch die Zuhörer auch verstanden wurden. Im Seminarraum ist dies ohne Einschränkungen möglich. Bei großen Vorlesungen können in den meisten Fällen nur die ersten Reihen für ein solches Feedback einbezogen werden. In drei Semestern der Lehre über verschiedene digitale Wege musste schlagartig akzeptiert werden, dass eine Rückmeldung zu den Lehrveranstaltungen nicht direkt und zumeist erst mit Evaluationen am Ende des Semesters durch die Studierenden gegeben werden. Die Überführung bewährter Lernkonzepte in einen Lehrbetrieb ohne Präsenzunterricht unter den ungünstigen zeitlichen wie auch technischen Randbedingungen erforderte enorme Anstrengungen, erwies sich jedoch auch als eine wirksame Antriebskraft, die Art und Weise zu Lehren und die Bedürfnisse der Studierenden aus einem anderen Blickwinkel zu sehen.

In lectures, exercises and practical courses, the focus is not only on imparting knowledge with the help of blackboards, slides and presentations, but also on continuously obtaining feedback from the students, which the teacher can use to assess the extent to which the audience has understood the explanations. This is possible without restrictions in the seminar room. In large lectures, in most cases only the first rows can be included for such feedback. In three semesters of teaching via various digital channels, it had to be abruptly accepted that feedback by the students on courses is not given directly and mostly only with evaluations at the end of the semester. The transfer of proven learning concepts into a teaching mode without face-to-face teaching under the unfavourable time as well as technical boundary conditions required enormous efforts, but also proved to be an effective driving force to see the way of teaching and the needs of the students from a different perspective.

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1. Introduction

Teaching without a lecture hall and seminar room for the duration of several semesters! This challenge was never up for discussion before the spring of 2020. As in many other courses, teaching content in conventional courses requires a coordinated concept between lectures, exercises and, if necessary, practical courses, which is not always successful due to limited time capacities. The sudden need to provide proven forms of teaching in a completely new format in the shortest possible time, using only the existing technical possibilities that were not intended for this purpose, required a complete change in the otherwise well-established semester schedule in spring 2020.

2. The academic year in presence

In the second year of study, the almost 500 students enrolled in the Mechanical Engineering degree programme are taught the basics of machine elements in lectures (3 credit hours per week) and exercises (2 credit hours per week). Building on the theory of strength of materials, the students learn the procedure for designing and dimensioning shafts, shaft-hub connections, bolts, springs, couplings, roller bearings, plain bearings and gears (Fig. 1).

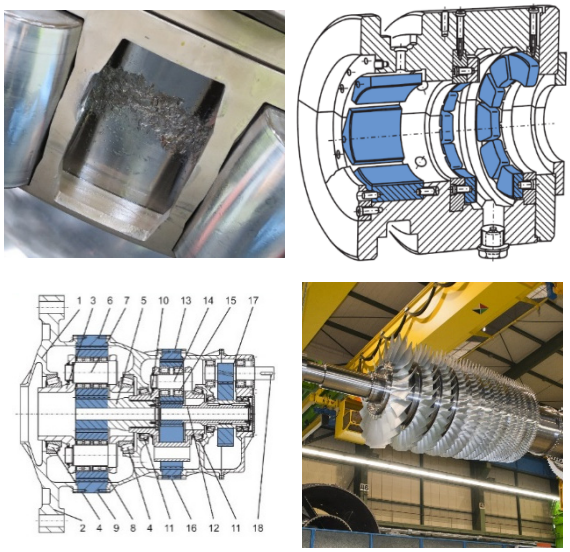

Fig. 1: Machine elements - examples of use

By means of presentations, the teaching content is explained to the students and the slides are supplemented with notes and sketches if necessary. The lecture materials are available for download in the OPAL learning management system. In the individual topics, the relationship between what has been learned and how it is applied in practice is continuously provided using various application examples.

In the weekly exercises, the design and recalculation of machine elements are explained in detail at the beginning of each lesson by coworkers of the Chair of Machine Elements based on various tasks and illustrative objects and practised by the students on their own with the help of the assistant lecturers and tutors (Fig. 2).

Fig. 2: Model of a single-stage gearbox

Thereby, the transcripts of the students serve for the documention of the way of solution, to prepare for the examination and to work on the examination tasks, as the documents can be used during the calculation part of the examination. When presenting the exercises, the individual steps are successively explained and written down so that the students can practice using the standards and guidelines and document the results when calculating the solutions on their own. For the exercises, the 14 seminar groups are divided into 12 exercise groups so that tutors and assistant lecturers can address individual questions of the students. The exercises also include the supervision of the Semester Thesis, in which the students have to design various machine elements individually on the basis of the loads to be calculated, select the required standard parts and combine them in an assembly. At the end of the academic year, technical freehand

drawings and CAD drawings of the assembly and the individual parts as well as the calculation documents must be submitted.

In addition to the lectures and exercises, an additional course is offered to explain the calculation path in detail every summer semester. In nine sessions, further exercises are solved step by step for all students in the lecture hall and the calculation method as well as the handling of formulae, tables and diagrams are explained in detail (Fig. 3). The transcripts prepared by the students during the course are also intended to serve as a basis and preparation for the examination.

Fig. 3: Pre-calculations in the subject machine elements

For the degree programmes Mechatronics, Regenerative Energy Systems, Economics and Textile and Confection Technology, the teaching content of the subject Machine Elements is taught in a condensed form. Weekly lectures and exercises are offered for this purpose. The previous knowledge of the students is partly different depending on the field of study. The scope of teaching that mechanical engineering students learn over the course of two semesters must be taught in a greatly shortened form in only one semester. This results in the necessity to systematically teach the procedure for solving the tasks, especially for the exercises.

The students of the field of study General and Constructive Mechanical Engineering attend the module "Mechanical Drives" in the 5th semester. With the 2019 examination regulations, the subject "Drive Elements" and the "Construction Thesis" are combined in this module. Within the framework of weekly lectures and 6 exercises, students learn the basics of the design, layout and calculation of planetary gearboxes, special high-ratio gearboxes, multi-stage gearboxes, belt and chain drives, continuously variable gearboxes and manual gearboxes in the subject Drive Elements (Fig. 4). The second module achievement is obtained by the students by submitting a thesis in which they dimension and construct a complex drive system. The weekly consultations serve to hand out the thesis, to teaching the procedure for processing and the individual discussion of solution approaches with the students.

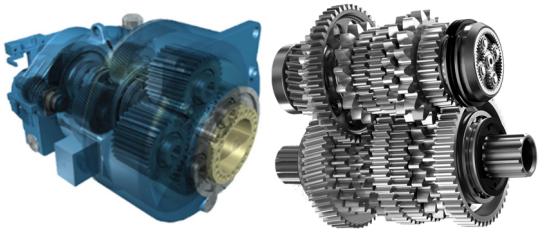

Fig. 4: Spur and planetary gearboxes

In addition, the Chair of Machine Elements offers the lecture "Drive Systems" to the students of the 5th semester in the modules "Advanced Fundamentals in Mechanical Engineering" and "Fundamentals of Internal Combustion Engines and Drive Systems". In the weekly lectures, the interaction of input and output machines, the properties and possible applications of different types of couplings and the possibilities of vibration analysis are taught to the students (Fig. 5).

Fig. 5: "Drive system" bucket wheel excavator

The applicability of the knowledge already learned in the course to various problems in

drive technology and the possibilities of dimensioning drive train components by means of manual calculations are presented to the students in additional exercises during regular lecture times. In addition to the teaching in the listed courses, the staff of the Chair of Machine Elements also supervises an average of 20 project works in the practical internship, 10 project works in the research internship and 20 diploma theses per year.

3. Online teaching over three semesters

In the winter and summer semesters, the Chair of Machine Elements offers lectures of 9 resp. 11 semester hours per week and exercise supervision of 33 resp. 29 semester hours per week as part of the regular teaching programme. In consideration of the time and technical possibilities of the students and with the aim offering the full teaching content in all courses, all materials for the courses are made available via OPAL in time during the semesters. Information on courses are sent to students via OPAL before each lecture week and are also available in OPAL throughout the semester. The implementation of teaching under the changed boundary conditions will be explained in more detail below for the various courses.

For teaching the content of the lecture on Machine Elements and Drive Systems, it is very helpful that all lecture notes are already available as PowerPoint slides and can thus form the basis for digital teaching in these subjects. In the lecture on Drive Elements, the handwritten scripts from the winter semester 2019/20 serve as a template. Depending on the content of the course, sections of varying scope are not included in the template in order to achieve a better understanding of complicated issues through writing them down on their own. These transcripts are made available to the students before the lecture and the existing passages are then presented, discussed and missing formulas, diagrams and texts are added in the lectures. In addition to the transcripts, facts are explained with the help of models and a visualiser as well as through videos and presentations (Fig. 6 to 8). In contrast to the summer semester 2020, in which the lectures were made available as PowerPoint presentations set to sound via OPAL, since the winter semester 2020/21 all lectures have been held in GoToMeeting with the video image of the respective lecturer. The recording of the lectures can be done directly in GoToMeeting comfortably and well compressed. The videos of the lectures will be published in OPAL during the current week after conversion in VideoCampus. The slides for the lectures can also be downloaded as PDF files in OPAL.

Fig. 6: Recording of the exercise instruction in the summer semester 2020

The number of participants during regular lecture times corresponds to about 30 to 50 % of the students enrolled in OPAL, but the recordings of the lectures in VideoCampus are used intensively.

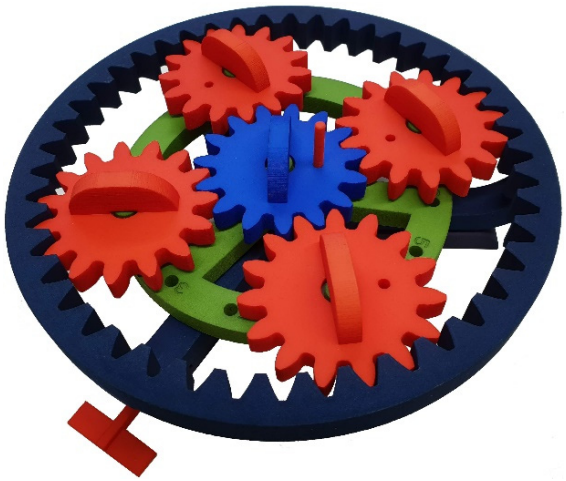

Fig. 7: Model illustrating different planetary gearboxes

Questions and comments during lectures via chat are rather rare, unless technical difficulties arise. This was especially the case at the

beginning of 2021 when using GoToMeeting. Connection interruptions, poor sound and image quality did not allow the course to run smoothly at times. Towards the end of the semester and in the summer semester, however, the problems described only occurred sporadically and hardly disrupted teaching.

For independent work on the exercises in the subject Machine Elements, students are provided with a video at the beginning of each week in which the procedure for solving the problem is explained step by step. The video camera used in the summer semester for recording and converted into a visualiser, including lighting, was replaced by a writable convertible and the videos were recorded with OBS (Fig. 6). The post-processing of the videos serves to eliminate slips of the tongue and makes it possible to shorten the length of the instructions. In the consultations for the subject Machine Elements, questions about the instruction videos are answered by several assistant lecturers and tutors during the regular course times.

The students emphasised the relaxed atmosphere in the consultations with simultaneous good professional support, got along well with the video instructions for the most part, but also wished for the videos to be made available before the actual lecture week, more individual support in smaller groups and to have already heard the background knowledge to the exercise in the lecture.

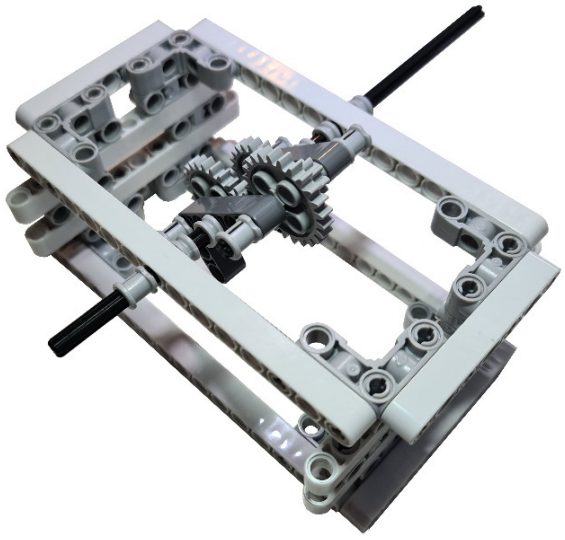

Fig. 8: Model explaining the self-locking effect

Instruction videos and consultations are also offered for the exercise in the subject Drive Elements. In the first half of the consultation, the students have time to watch the instruction video and already ask their questions. In the second part, the solutions to the tasks are presented and further questions about the solution path are discussed. The digital implementation of teaching in the subject Drive Elements was evaluated positively by the students, but at the same time the wish was expressed to be able to download documents and videos with more lead time.

Consultations are also offered for the Construction Thesis and for the Semester Thesis in Machine Elements and Design Theory. Forums are set up in OPAL to discuss questions about the thesis. Even though a higher number of participants would be desirable and certainly helpful in achieving better results, a relatively large number of thesis are submitted by the deadlines.

4. Performance assessment and examinations in presence and online

At the end of the summer semester, the taught course content is tested in a performance assessment as part of the exercise and as preparation for the examination. The examination with a duration of 4 hours consists of two parts. In the first two hours, the students have to make a technical drawing without documents and answer questions about the content of the course. In the second part of the examination, all documents can then be used to solve the calculation tasks.

After initial concerns about conducting the performance assessment and examination digitally and the first attempts to set up a test in OPAL, the possibilities of automated correction were the main reason for conducting the performance assessment digitally. Through the participation of all employees in the formulation of the questions, a comprehensive collection of tasks was created, which served as the basis for the creation of the performance assessment. When the test was conducted for the first time in the summer semester of 2020, a variety of problems arose. These were partly due to the overload of the system, but also to

incorrect settings and the access authorisations granted. The second performance assessment went almost without a problem after the experience gained from the first attempt, so that preparations for the digital examination in the 2020 summer semester began.

In the shortened three-hour examination, the students had to create drawings by hand, digitise them and upload them to OPALexam, answer questions and solve calculation tasks. OPALexam was overloaded during the examination, operation in the browser was only possible with delays and examination results were partly not saved. A rather unsuccessful digital exam thus ends a rather successful lecture period in the summer semester 2020.

After the negative experiences in the previous examination period and the discussions on fair examination conditions during the first "Lessons Learned" conference, it was not planned to conduct examinations in OPALexam again at the beginning of the 2020/21 winter semester. From that point of view, the effort required to prepare the exams and the enormous technical difficulties in conducting them could not outweigh the time saved in the correction.

Since at the turn of the year it was not predictable if a presence examination would be possible at all, the decision to conduct the examination had to be revised. With the help of engaged coworkers, four digital examinations with a duration of 60, 90, 120 and 180 minutes were newly developed or existing questions were revised and could be released to the ZiLL for review in time. For three of the four exams, sample exams were offered without a deadline. The students were free to choose when to take the test to check their own technical prerequisites and to become familiar with the various answer options. In the subject Drive Elements, a mock exam was conducted on the date offered in OPALexam and supervised in parallel in BigBlueButton. Both the type of questions in the multiple-choice test and the input options in the calculation tasks were to be familiarised to the students during the test. There was no feedback on problems with the test, but not all enrolled students took advantage of the opportunity to take the mock exam.

There were almost no technical difficulties in conducting the examinations in OPALexam during the examination period in the winter semester 2020/21. Only a few students had to be enabled to restart the test after connection problems. The examination was supervised in smaller groups with the aid of BigBlueButton and, in an emergency, by telephone. There were complaints about the exam regarding the time available to work on questions. This was not sufficient to look up all the questions in the documents. However, a large number of students who had already gained experience with digital exams in the previous semester seemed to cope well with the tasks, the uploading of drawings worked well and the distribution of grades is comparable to exams in presence.