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"Mechanics is fun" Course Technical Mechanics - Statics/Strength of Materials - after 2 years of Corona

M. Sähn* , U. Gebhardt, M. Kästner

Professorship for Numerical and Experimental Solid Mechanics, Institute of Solid Mechanics, Faculty of Mechanical Engineering, TU Dresden

Abstract

Since the winter semester (WS) 2016/17, the established and technically sophisticated teaching concept of technical mechanics at the Chair of Numerical and Experimental Solid Mechanics has been continuously expanded with digital components in order to improve the understanding of the content and increase the attractiveness of the course. These goals were achieved with a combination of classroom teaching and additional digital offerings.
The complete transition to online teaching in winter semester 2020/21 and the parallel provision of face-to-face and online courses in the following semesters led to an increase in failure rates. Two theses can thus be derived from the experiences of the years 2020 to 2023: On the one hand, online or hybrid teaching in undergraduate studies will lose students, especially from the midfield, and on the other hand, open-ended online courses will promote high-performing students and overburden those with difficulties.

Seit dem Wintersemester (WS) 2016/17 wird das etablierte und fachlich ausgefeilte Lehrkonzept der Technischen Mechanik an der Professur für Numerische und Experimentelle Festköpermechanik stetig durch digitale Komponenten erweitert, um das Verständnis der Inhalte zu verbessern und die Attraktivität der Lehrveranstaltung (LV) zu steigern. Mit einer Kombination aus Präsenzlehre und zusätzlichen digitalen Angeboten wurden diese Ziele erreicht.
Der komplette Übergang in die Online-Lehre im WS 2020/21 und die parallelen Angebote von Präsenz- und Online-Angeboten in den darauffolgenden Semestern führten zu einer Erhöhung der Durchfallquoten.
Damit lassen sich zwei Thesen aus den Erfahrungen der Jahre 2020 bis 2023 ableiten: Zum einen gehen mit Online- bzw. hybrider Lehre im Grundstudium Studierende vor allem aus dem Mittelfeld verloren und zum anderen werden durch unbefristete Online-Angebote die leistungsstarken Studierenden gefördert und diejenigen mit Schwierigkeiten überfordert.

*Corresponding author: Michael.Saehn@tu-dresden.de

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1. Motivation

In mechanical engineering studies, the courses in technical mechanics (TM) - statics and strength of materials - always take place in the first to third semester. Students of Materials Science and Process and Natural Materials Engineering complete these courses after 2 semesters. In addition, students of mechatronics, electrical engineering, renewable energy systems, transport engineering and industrial engineering are also taught TM in separate courses.

Based on the established, solid, technically sophisticated and coordinated teaching concept of Professors H. Balke and V. Ulbricht, the courses are taught alternately by Professors Wallmersperger and Kästner and conclude with the module examinations after the first (TM Statics) and third semester (TM Strength of Materials). The courses are a prerequisite for the TM Kinematics/Kinetics course in the foundation course (one semester) and various courses in the advanced course, e.g. Numerical Methods, Elastic Structures, Continuum Mechanics and Materials Theory.

To increase the attractiveness of TM lectures, Professor Kästner's team developed various conventional and electronic course offerings and implemented them from the winter semester (WS) 2016/17. These include illustrative and practice-oriented examples and lecture questions to improve students' ability to absorb lecture content. The exercises were supplemented by learning groups for active preparation and more time for students to solve exercises independently. In addition to the quality of teaching, the aim is to make mechanics fun.

2. Teaching concept statics/strength of materials

Various further training courses within the faculty and through the e-learning area of TU Dresden have led to a continuous change in the teaching concept since the winter semester 2016/17. In a first step, the organization of the course was designed with OPAL courses.

Lectures:

The digital user interface of OPAL enables the preparation of lectures by means of corresponding reprints and illustrative animations as well as the publication of the digital script after the lecture.

In order to increase the absorption capacity during the lecture, practically relevant lecture questions are asked in the middle of the lecture, which the students can answer together and upload their solution via a QR code. Once the correct solution has been evaluated, it is possible to return to the lecture without any problems. The Particify software used is an EU-funded ARS system that guarantees compliance with EU data protection guidelines.

In parallel to the lectures, 4 online lecture quizzes, each with 10 questions on technical mechanics, are set each semester, which students can solve independently. After initially being offered on a voluntary basis, the evaluations showed that the majority of students only accepted the use of these tests when they had the opportunity to gain bonus points for the upcoming examinations.

Exercises:

In the TM, the exercises take place weekly in parallel exercise rooms, usually on 2 dates. The respective tutors introduce the topic of the exercise in a 15-30 minute lecture. Afterwards, the focus is on solving the exercises independently with appropriate help from the tutors.

At the suggestion of Professor Odenbach, the formation of learning groups among the students and the joint solution of practical tasks was promoted. On the one hand, this was intended to facilitate joint learning, the solution of practical examples and, on the other, better preparation for the respective exercise. The latter in particular was achieved in conjunction with the offer of a bonus point for the respective examination.

One focus of the TM course is the calculation of internal reactions in different load-bearing structures. In order to convey this to the students in a clear and playful way, a browser-

based program (game) was created with which the students are interactively shown the effects of different loads on a beam.

Examinations:

Checking the examinations traditionally represents a major effort for the staff of the professorship. For this reason, the format of the examinations was changed from winter semester 14/15. The focus of the exams is now on mechanical questions and the weight of mathematical problems has been reduced. At the same time, short, structured tasks have been introduced to reduce the problem of subsequent errors and avoid complex tasks. We are aware of the implications of this decision and the discussion within the professorship is still ongoing. The disadvantage of dispensing with complex tasks must be accepted.

The advantage of this approach is the possibility of querying more mechanical content. This is supported by the lecture quizzes, which open up an additional list of questions for the exams. At the same time, this reduces the amount of checking required.

Results:

The implementation of this concept with the expansion of lectures and exercises through e-learning offerings and the change in examination formats primarily increases the attractiveness of the courses and acceptance by students and takes into account the number of budget employees without reducing the quality of teaching. This is reflected in the evaluations of courses by students and the awarding of the prize for innovation in teaching to Professor Kästner in 2017 and 2023.

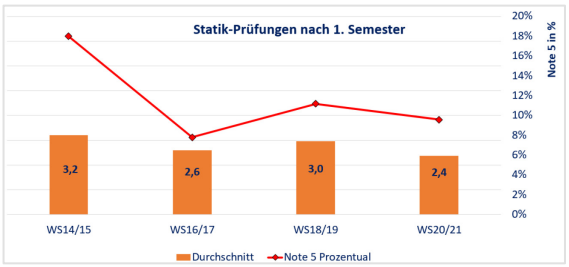

Fig. 1: Comparison of static tests from WS14/15 to WS20/21

A comparison of the examination results from WS14/15 to WS20/21 only reflects this success to a limited extent, see Fig. 1. It is clear that although the average grade has only changed marginally, the failure rate has fallen. It should be noted that significantly more mechanical content was tested in the examinations.

3. Online offers

With the start of the corona pandemic, the use of online offerings for teaching became unavoidable. Based on our previous experience and the expansion of the teaching concept with e-learning methods, we were not unprepared for this change. Nevertheless, the creation of further courses was necessary and the implementation had to be updated.

For some of the lectures, it was possible to use video recordings for distance learning. However, it was necessary to record further courses from the home office. The experience that video recordings are better accepted by students when the lecturer or trainer is visually visible was taken into account.

As a result, digital recordings of all lectures and introductory tutorials were created during this time, which took a very long time. It is worth noting that recordings of Power Point applications set to music lagged behind the live recordings of lectures and exercise introductions in terms of acceptance by the students.

The implementation of the lecture questions, the learning group tasks and lecture quizzes required a corresponding update, but did not present us with problems in terms of content, only time.

Only the TM Statics exam in WS20/21 had to be implemented as an online exam. The implementation showed that this variant of the exam with the means we chose could not fully realize the necessary competencies of a mechanics exam with sketches and free individual solution paths. The result of this exam cannot be used for an evaluation, as our own experience with online exams was too limited and the exam questions were therefore perhaps too easy.

Comparison of presence - online - teaching

Irrespective of the above information on the examination formats, the effect of online teaching in times of Corona can be compared with the results from pure face-to-face teaching. This enables the examination of TM

Strength of Materials from WS19/20 and WS21/22, see Fig. 2.

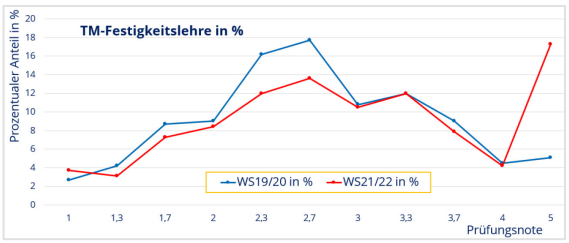

Fig. 2: Comparison of online versus face-to-face teaching

Both exams took place in person and the same exam with identical tasks was deliberately written on both dates.

The percentage results (the number of examinees is different: WS18/19-347 and WS21/22-191) show that online teaching on the one hand greatly increases the failure rate and on the other hand reduces the midfield. This leads us to the following thesis: ***"With online or hybrid teaching, students are mainly lost from the midfield in undergraduate studies."***

Following the requirements for online teaching, it was possible to return to face-to-face teaching in the last few semesters. This step was a great relief for everyone involved on the teaching side. It was finally possible to look at faces again and not just at black screens. Nevertheless, a return to full face-to-face teaching does not appear to be expedient in view of the many online offerings. For this reason, in WS22/23, in addition to the lectures and exercises in presence, the available lecture videos were also made available to students in TM Statics from the presentation date until the examination.

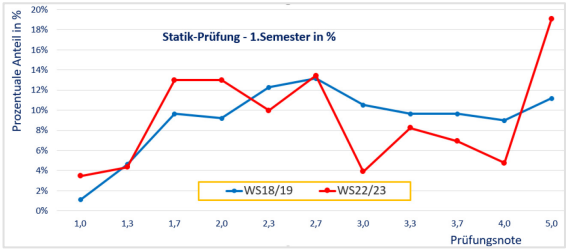

Fig. 3: Comparison with/without online offers

This enables individual learning without restrictions in the acquisition of knowledge and a wider range of courses. This is in line with our understanding of teaching - a wide range of options and students can choose the best way for them to acquire knowledge.

However, a comparison of the examination results of TM Statics from WS18/19 and the last semester WS22/23 shows a different result, see Fig. 3.

It is clear that the number of above-average grades is increasing, while the failure rate has doubled. Apparently, the greater choice of courses on offer for acquiring knowledge leads to a higher failure rate, as not all students make use of the wider range of courses on offer. Some limit themselves to the online offerings (the number of participants in the face-to-face courses is significantly lower than the number of exam participants). An alternative could be temporary online courses that require more continuous learning. These results substantiate another thesis: "***With open-ended online courses, the high-performers are encouraged and students with difficulties are overburdened!"***

4. Outlook

Even if some of the results are very sobering, the online offerings for students should be continued. There will be no problems with the further implementation of the lecture questions as concentration breaks in the lectures, the descriptive animations, the accompanying online tests and the interactive applications. The introduction of new examination regulations is imminent and provides for a significant reduction in technical mechanics in the foundation course as well as restrictions in the assessment design of modules. Against this background, it will be more difficult to anchor the learning group tasks in the future course of study. Due to the reduced scope of our courses in the faculty's training concept, concentrated knowledge transfer must be strengthened in order to provide students with comprehensive and competitive basic mechanical knowledge in the future.

Irrespective of this, our focus will continue to be on conveying the joy of studying technical mechanics. This will automatically increase

students' willingness to be active and work independently.

With this in mind, **"Mechanics should be fun in spite of unstable equilibrium!"**