TECHNISCHE UNIVERSITÄT DRESDEN

Lessons Learned

Spin Offs digitaler Lehrerfahrungen

1&2

Volume 1 | 2021

FAKULTÄT MASCHINENWESEN

About the Journal

Due to the sudden and huge restrictions in face-to-face teaching brought about by the Corona pandemic starting with the summer term 2020, an unprecedented change and renewal of teaching formats has occurred. Even though these changes were forced by the restrictions due to the pandemic, the experiences and concepts that were developed are of enormous value for a renewal of teaching towards modern, digitally supported forms of teaching and learning and towards more competence-oriented learning. At the beginning of the winter term 2020/21, a conference entitled "Lessons Learned - Spin Offs of a Digital Semester" was held at the Faculty of Mechanical Engineering at the Dresden University of Technology to support this renewal through the exchange of experiences. A conference series has emerged from this first conference and at the same time the journal "Lessons Learned" was launched. The aim of this journal is to discuss new forms of teaching and learning not only in the mathematical and natural sciences and technical sciences, but far beyond in all subject disciplines and thus to create a platform where teachers can inform themselves about new concepts and adapt them for their own teaching.

The journal is deliberately published in two languages, both to make the experience gained accessible to an international audience and to ensure that the linked examples are accompanied by a text in the language of instruction in which they were produced. This means no additional work for the authors, as articles can be submitted in either German or English. Once an article has been accepted, the journal translates it into the other language, so that the authors only have to proofread the translated article.

Editorial Board

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Editorial

Lessons Learned - that was probably a quasi-compelling thought for many teachers at the end of the summer term 2020.

Forced by the Covid 19 pandemic, ways had to be found in the shortest possible time to maintain university teaching - without any form of face-to-face teaching. Lectures had to be digitised and made available. Exercises had to be pressed into new formats in order to be able to hold them at all. Seminars, which are often based on discussion, had to be moved to virtual rooms, and concepts had to be developed for practical courses, which actually require the use of experimental facilities at the university, in order to avoid interrupting the course of study.

All of this required the use of new techniques and technology as well as learning processes for the teachers, which often took place in stages, in which offers were optimised piece by piece and made available in ever new ways. In the process, many ***Lessons Learned*** appeared, many new insight was gained that made this first Corona term possible at all. At the end of the term, the need to offer digital exams added a new challenge that had to be overcome.

This comprehensive learning and development process was not limited to individual universities or individual countries, it was a worldwide necessity that the university teaching sector had to face. In the end, formats emerged that made it possible to conduct the summer term 2020 without attendance and largely successfully. At the end of the term, it was clear to everyone involved that the work done, regardless of the pandemic, did not mean a purely temporary change in teaching. In a few months, a development process to modernise teaching and learning had emerged that would normally take years, if not decades. That the two following terms would also be marked by the pandemic was not yet foreseeable at that time. Nevertheless, it was clear that the further development of digital teaching formats could not take place at individual professorships, in individual faculties or locally at individual universities. Rather, the exchange of those who have set up, developed and used these formats is crucial in order to bring about a profitable further development of the digital revolution in teaching.

Against this background, the ***Lessons Learned - Spin Offs of Digital Teaching Experiences*** conference was launched at the Faculty of Mechanical Engineering at TU Dresden in autumn 2020. It serves as an exchange forum where teachers can share and discuss their experiences, their successes, but also the failures of attempts to develop new teaching concepts in the digital space. To further the dissemination of these digital developments, the journal ***Lessons Learned*** has been created to share information and stimulate discussion on a completely free open access basis.

In this first issue, which is deliberately a double issue, the contributions of the first two ***Lessons Learned*** conferences in autumn 2020 and spring 2021 are summarised. In its further development, the journal will both continue to accompany the conference and shed light on specific problem areas of digital teaching and its further development via themed issues.

With the first 240 pages of digital teaching experiences, we hope that you will enjoy studying the experiences presented here and that you will have the courage to experiment with adapted formats and present them at one of the next ***Lessons Learned*** conferences.

Stefan Odenbach

Lectures, exercises, exams - courses are complex overall constructs whose transfer into a coherent digital format that stimulates learning is a great challenge. The ideas and concepts with which the transfer to the digital world was accomplished in the first two semesters of the Corona crisis are correspondingly diverse. The concepts presented here also give an impression of the creativity of the teachers in this difficult phase.

In addition to the normal canon of formats, there are also special formats in many places whose conversion to digital brings with it special challenges, which we highlight with four examples.

Spectrum of topics

Overall concepts

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K. Naumann, K. Köpferl
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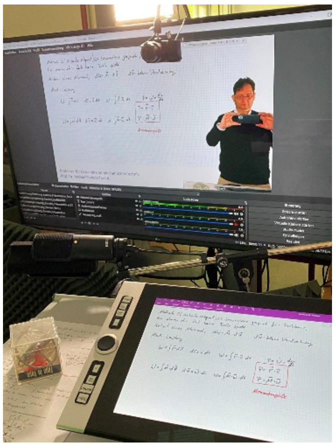
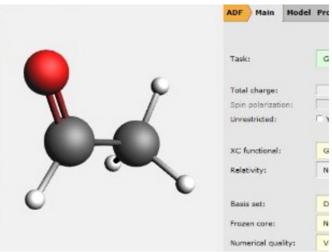
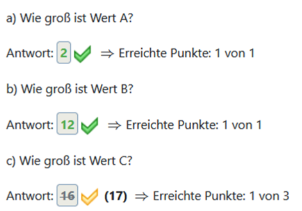
From the face-to-face to the hybrid event. Experiences with the transformation of a conference series to online network research



The technical effort required to hold digital lectures should not be underestimated. And with the further development of the tools, the comfort for learners and teachers increases.



Practicals must provide the practical connection to the subject matter. But is that possible at home? Hands on - whether on the computer or on concrete experiments - provides variety and fun for learning in the lockdown.



And at the end of a semester, there are always exams - even the ones now in digital form - and the focus is quickly on the problems with the exam software and the associated workarounds.

Technology for digital lectures

Practical courses

Exams

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Heat and Flow in times of Corona

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Abstract

Dieser Artikel beschreibt den Aufbau des Kurses „Heat and Flow" im zweiten Jahr des Bachelor-Studiengangs Maschinenbau der Technischen Universität Eindhoven. Vor der Coronapandemie und der damit verbundenen Sperrung wurden verschiedene Maßnahmen ergriffen, um die Erfolgsquote dieses Kurses zu erhöhen, die früher sehr niedrig war. Insbesondere wurde neben den normalen Kurselementen von Vorlesungen, Instruktionen und Übungen eine vollständige Online-Version des Kurses entwickelt. Auf diese Weise werden Studierende mit unterschiedlichen Lernstilen bedient. Um die Studierenden zu motivieren, lange vor der Prüfung genügend Zeit für den Kurs zu verbringen, wurde ein System obligatorischer Fortschrittstests entwickelt. Ein gutes Ergebnis für jeden Test ist die Voraussetzung, um die Prüfung des Kurses zu bestehen. Die Anzahl der Versuche für jeden Test ist innerhalb eines bestimmten Zeitrahmens unbegrenzt. Die Kombination beider Entwicklungen verbesserte die Erfolgsquote des Kurses erheblich. Während der Coronapandemie wurde das gleiche System aufrechterhalten, indem alle Elemente des Kurses synchron, jedoch online angeboten wurden. Die schriftliche Prüfung wurde durch eine online beaufsichtigte Prüfung ersetzt. Die Studierenden waren mit dieser Art des Unterrichts zufrieden, aber die Teilnahme an den Übungsstunden war sehr gering. Sie kann verbessert werden, indem sie in kleinen Gruppen mit jeweils einem persönlichen Tutor organisiert werden.

This paper describes the set-up of the course Heat and Flow in the second year of the bachelor program in Mechanical Engineering of Eindhoven University of Technology. Before the corona pandemic and its associated lockdown, several measures have been taken to increase the success rate of this course, which used to be very low. In particular next to the normal course elements of lectures, instruction and exercise sessions, a complete online version of the course has been developed. In this way students with different learning styles are served. In order to stimulate students to spend sufficient time on the course well before the exam, a system of compulsory progress tests has been developed. A good result for each test is a requirement to pass the exam of the course. The number of attempts for each test is unlimited within a certain time frame. The combination of both developments significantly improved the success rate of the course. During the corona pandemic, the same system was maintained by offering all elements of the course in a synchronous way, but online. The written exam was replaced by an online proctored exam. Students were satisfied by this way of teaching, but the participation in the exercise sessions was very low. This can be improved by organizing them in small groups, each with a personal tutor.

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1. Introduction

In this contribution I will describe the teaching and assessment methods used in the course Heat and Flow of the second year of the bachelor program Mechanical Engineering at Eindhoven University of Technology during the corona pandemic in the Spring of 2020. In order to put this in the right context I will first present the history of this course in section 2, where I will in particular show how the course has been changed over the years to increase the success rate of the course. Next, in section 3, I will detail the teaching methods applied in academic year 2019-2020 during the corona pandemic, when all on-campus teaching was not permitted due to the lockdown. In section 4 I will discuss the lessons learned from this experience and the measures taken in the next academic year, when the corona measures were partly relaxed, to improve teaching and learning. In the final section the most important conclusions are presented.

2. History of Heat and Flow

In 2012 Eindhoven University of Technology (TU/e) started a completely new set-up for all bachelor programs, named Bachelor College. This was both meant to increase the number and the diversity of students and to improve the study success. One of the measures taken to increase the study success was a change in the size of all courses from 3 EC to 5 EC, in order to reduce the number of exams (1 EC corresponds to a study load of 28 hours and one full year has 60 EC).

For this reason two existing courses, one on transport phenomena and the other on heat transfer, were combined to form the new course Heat and Flow in the fourth quarter of the second year of the Mechanical Engineering program. From the start, I have been the responsible teacher for this course and I give the lectures on the flow part. The teacher of the heat part was already the responsible teacher for the old course on heat transfer, while I was the teacher of a first-year course Introduction to Heat and Flow. The flow part of the new course was partially based on another existing course on physical transport phenomena.
The topics treated in the course are:

- Repetition of differential operators, material derivative and cylindrical coordinates;
- Integral conservation laws for mass momentum and energy and Bernoulli's equation;
- Derivation of continuity equation and Navier-Stokes equation for incompressible flow and some simple solutions;
- Scaling and similarity;
- Flow in pipes, around objects and in boundary layers, including the Blasius solution for laminar flow and separation;
- Basic mechanisms for heat transfer, conduction, convection and radiation;
- Steady and unsteady heat conduction;
- Convection and thermal boundary layers;
- Basic definitions for radiation and radiative heat transfer.

The course is mandatory for all students of the bachelor Mechanical Engineering, and elective for a smaller number of students of the bachelor Sustainable Innovation and for a group of students that follow a premaster program after having finished a bachelor at a university of applied sciences. The total number of students enrolled in the course is typically around 350.

In the course we loosely follow a textbook [1], but for some parts we made our own lecture notes and we developed a book of exercises, partially composed by ourselves and originating from other courses and partially taken from a number of different textbooks. There are not so many textbooks that combine fluid mechanics and heat transfer and are suitable for students at bachelor level. The textbook we selected is one of the few. It has some drawbacks, in particular the combined use of SI and American unit systems. The main advantage of this book is that the level of mathematics required to understand the theory is not too high for our students.

Initially Bachelor College had the requirement that the final exam of every course counts for at most 70% of the final grade of the course. Interim exams count for the remainder of the final grade. The idea behind this is to encourage students to start learning sooner than a few days before an exam in order to increase the success rates. The first three years the course was taught we had one or two interim exams to comply with this requirement. However, it turned out that the effect of this was rather opposite to what was intended. Students with a bad grade for the first interim test were demotivated by their result and usually did not pass the course. Apart from this, it is a big task to organize and grade interim exams for such a large number of students.

As soon as the requirement was lifted, we stopped the interim exams and replaced them by formative assessment in the form of digital quizzes, one for every topic of the course, so that students could monitor their progress. However, only a minority of the students actually made these quizzes and the pass rate of the course did not change, but remained around 40% after the first exam.

By that time, around 2017, our university more and more promoted the use of blended learning by combining various learning methods for a course. It is well known that some students prefer to learn individually at the time and place they want, while others prefer the structured way of learning by attending lectures and exercise sessions at the time they are scheduled and like to work in a small group of students on an exercise [2]. For that reason we made the plan to develop an online version of the course and offer the students the choice to attend all scheduled activities or use the online version of the course.

For all elements of the course an online variant was made. The course consists of three elements:

1. The first element of the course are the lectures. The course consists of 13 lectures of two hours each. The online variant of each lecture is a document with a short summary of the course material and links to video lectures selected from YouTube. We asked the authors of the movies permission to use their material in our course. In this way we can download it and still use it in case a video is no longer available in YouTube. All authors responded very quickly and positively to our request and some of them asked to be kept informed about our online efforts.
2. The second element of the course is the so-called instruction, in which the lecturers make a number of selected exercises on the blackboard to give extended examples of each type of exercise that is important and of exam level. Usually there are seven instruction sessions of two hours each. The online variant of the instruction is a set of pencasts is which the same example exercises are treated and explained. Figure 1 shows a still from a pencast.

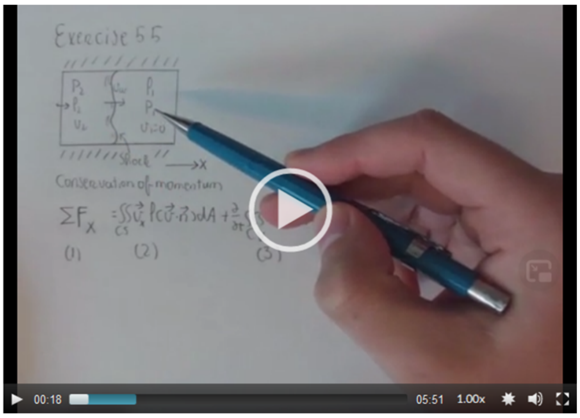

Fig. 1: Still from a pencast. The pencast also has sound. The video is available at https://youtu.be/4xrsQbQUEmE

3. The third element of the course is the so-called guided self-study (GSS), where students work individually or in small groups on exercises. A number of teacher assistants and the lecturers are present to answer questions. Attendance of the GSS is usually rather low, between 25% and 30% and shows a decrease towards the end of the course. Usually there are seven GSS sessions of two hours each. The important aspect of the GSS is the possibility of feedback, which is more difficult to give online. For this we used an online assessment system called Cirrus [3]. A number of exercises have been composed in Cirrus, usually with random numbers. The students can provide their answers and in case of a wrong answer automatic feedback is given. An example of automatic feedback is shown in figure 2. Not only numerical questions are possible, but also multiple-choice and mathematical questions, in which the students have to enter formulas.

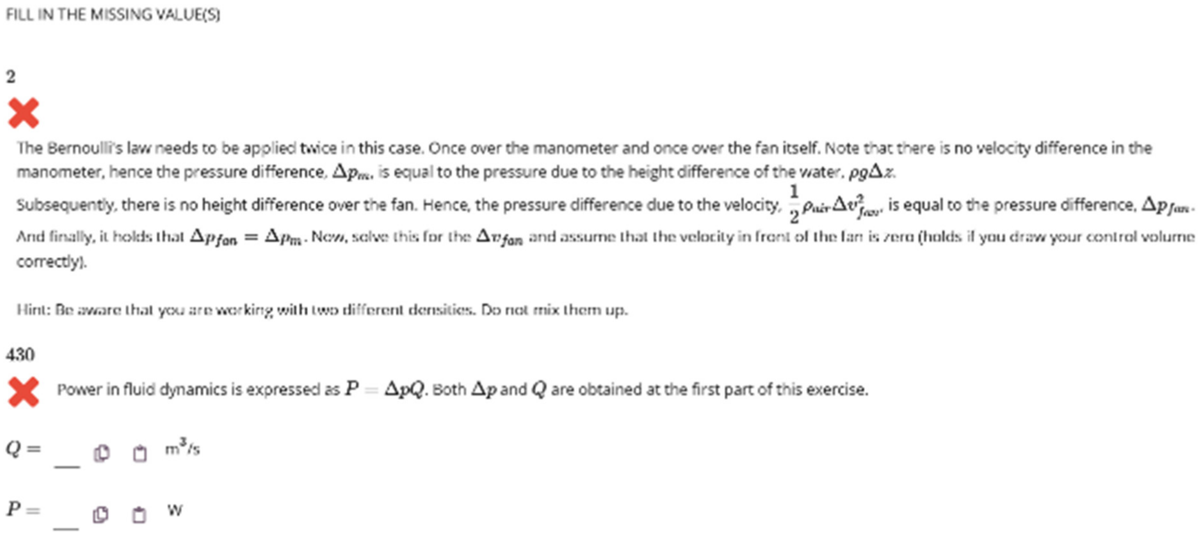

Fig. 2: Example of automatic feedback on wrong answers to digital exercises in Cirrus.

The first two elements of the online version of the course are available in our learning management system Canvas. In order to develop everything, two teaching assistants have been employed for a total of 800 hours. The financial means for their salaries have been provided by the educational innovation fund of Eindhoven University of Technology. The teachers of the course checked the video material selected, the pencasts and the online exercises. A teacher supporter from the university supported them in setting up a user- friendly organization of the course in the learning management system.

The material in Canvas is organized in the 13 lectures of the course and provides links to the Cirrus exercises. At the end of each lecture an online quiz has to be made with sufficient result (80%) in order to get access to the next lecture. In this way we ensure that students spend sufficient time on each lecture.

Finally, every lecture has a discussion forum that enables students who follow the online version of the course to ask questions. Usually, teacher assistants answer these questions, but in some cases also other students respond.

We tested the first version of the online course on a group of six students, who failed the exam several times. They provided feedback and were offered an extra exam directly after this test. Most of the feedback was positive and in a few cases they even suggested better video material than selected by the teacher assistants. They all passed the extra exam that was offered to them with remarkably high grades.

This showed that the online course prepares well for the exam and in this sense satisfies one of the criteria for constructive alignment [2]. However, the students participating in the test could be monitored well, because of their small number, and they were all very motivated because of the extra opportunity to pass the course, which was for most of them the last hurdle to finish their bachelor program.

We knew that for the normal group of students the incentive to keep on track during the course would not be so high. Therefore, we decided to develop an assessment method that forces the students to spend time on the course well before the exam without the disadvantage of interim tests that a bad result cannot be repaired [4].

We found a solution in the form of so-called progress tests. During the course students have to make three progress tests which are offered digitally in Cirrus. Each test can be made as often as they want, but within a limited time span of about a week. Automatic feedback is provided on wrong answers in the form of a reference to the corresponding theory. Students need a score of 80% or more for each of the three tests to obtain the grade for the final exam. They can work together on the tests, but random numbers are used, which makes copying of answers useless. The first progress test already starts in the first week of the course and is about the prior mathematical knowledge required in the course. The second progress test is about lectures 2-5 and the third and last progress test is about the basic mechanisms of heat transfer and steady and unsteady heat conduction. Each test consists of ten questions. Most of them are numerical questions and a few others multiple-choice questions. The first test also has a number of mathematical questions in which the answer is a formula. However, this type of question is rather sensitive to errors; for example multiplication signs between two symbols should not be forgotten.

This method of assessment is not in accordance with the regulations of Bachelor College. Therefore, we asked permission for this pilot and also consulted the examination committee of our department and the students in the program committee, who all agreed with this pilot.

The first time the new system was in use was in the Spring of 2019, so one year before the corona pandemic started. Our main goal was an improvement of the success rate of the course. Success rate can be defined in various ways, but no matter which definition we used, the increase of the success rate was significant. The success rate of all registered students increased from 34% in 2017 and 2018 to 50% in 2019. Quite a number of registered students decide to postpone the course to a later year. Therefore, it is better to consider the success rate of all students that did a serious attempt in the exam (score of 15% or more). This number increased from 48% to 70%.

The distribution of exam grades is shown in figure 3 for the years 2017-2019. The grades range from 0 to 10, where 10 is the maximum and 6 is sufficient to pass the course. The figure shows that the distribution of grades in 2019 has a shape closer to a normal distribution. The almost absence of very low grades in 2019 has a different reason, but this does not influence the conclusion about the success rates, since the very low grades are not taken into account in the success rates.

Students who did not pass the requirements of the progress tests, could make them again in the weeks between the first exam and its resit. Only one student participated in the first exam without satisfying the requirements and he or she passed the requirement later and then received the exam result. Some additional students only participated in the resit and made the progress tests after the first exam.

During the standard evaluation of the course a remarkable observation was that the students indicated that they have spent less time on the course than in the years before. This clearly shows that the progress tests help the students reach the learning goals of the course. The evaluation also showed that students are satisfied with the feedback offered by the progress tests (score 3.8 on a scale of 1-5). The progress tests not only help the students know what to learn, but they also result in a better spread of the workload over time.

The results of our pilot stimulated teachers of other courses to also change from interim courses to digital progress tests in their courses. At present all major courses in Mechanical Engineering in the first year and another second year course use this assessment method, and a third-year course will follow in the next academic year.

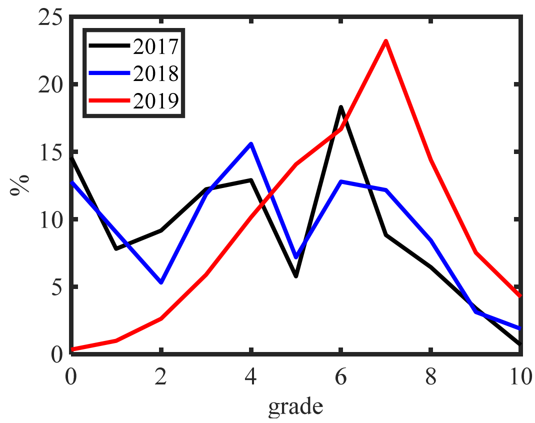

Fig. 3: Distribution of grades of the first exam of Heat and Flow in the years 2017-2019. A minimum grade of 6 is required to pass the course.

The details of the system of progress tests differ from course to course, as for instance the number of tests and the criteria used to pass them. In the near future we will propose to adapt the regulations of Bachelor College to allow progress tests for all courses. Several other departments showed their interest in this system, as it appears a better method to engage the students during the time a course is running and it does not result in procrastination behavior.

3. Heat and Flow during corona pandemic

When the corona pandemic reached the Netherlands in March 2020 and the lockdown was announced, the executive board of our university decided to cancel all teaching activities during one week to give the teachers time to change their courses to an online format. For some courses, which required experimental facilities, this was not an easy job, but for all courses organized by our department an acceptable solution was found, for instance by using and analyzing experimental results from a previous year instead of performing new experiments.

Many teachers decided to teach from home, using either Microsoft Teams, or the learning management system Canvas. Others used the livestream facilities in the lecture rooms at the campus, which were still available, or recorded their lectures in the studio at the campus or at home.

A bigger problem was to find a solution for the exams that were scheduled already three weeks after the start of the lockdown. For some courses, in particular those with a small number of students, it was possible to replace the written exam by an assignment. For courses with 100 students or more and in courses where mathematics plays an important role this is not a solution due to the enormous amount of work to grade the assignments or because of the learning goals of the course.

Therefore, it was decided to opt for online proctored exams in cases where other solutions are impossible. Online proctoring is not only a sensitive issue because of privacy regulations, but the university also lacked any experience on a larger scale. Within a short time a company was found that offered online proctoring facilities which satisfied our privacy regulations [5]. Apart from that guidelines were agreed upon with the students in the university council that met most of the objections against online proctoring. For example, a student can choose for on opt-out and is offered an alternative exam on campus in that case. As a result, protests against online proctoring, which happened in several other universities in the country, did not happen in Eindhoven.

Online proctoring means that the webcam is switched on and all images are recorded and stored. Moreover, all activities on the computer are monitored and, depending on the settings of the exam, some things are not allowed, for example using a web browser for other websites than the exam. Deviations from normal behavior are noticed statistically and can later be studied in detail by watching the recorded images. A team of people was available to perform this task. In addition, at the start of the exam the student has to prove his or her identity, a room scan is made by means of the webcam and the students have to show the contents of their table to verify that there are only permitted items. The permitted items depend on the exam and are determined by the responsible teacher of the course, for example a calculator, a book, empty sheets of paper, etc.

Nevertheless, some problems occurred during the exams, in particular in cases where students had to upload files with their solutions, and some exams suffered from technical problems due to very large numbers of students. In two or three cases an additional exam was scheduled a few weeks later.

The course Heat and Flow could profit from experience obtained in other courses, since it only starts after these first exams in corona time, end of April.

It certainly was an advantage that we had a complete online version of the course that had already been tested in the previous year. However, we decided that this online version is not sufficient, since there is also a group of students with a different learning style, who benefit much more from synchronous learning. Therefore, apart from the online version we also scheduled lectures, instruction sessions and guided self-study sessions in the usual way. Apart from that the students could view the recorded lectures of the previous year, but they were in Dutch while from 2020 onwards also a number of international students follow the course.

The online lectures were given from home in MS Teams. Students could ask questions through the chat function, or at the end of each lecture by opening their microphone. The capacity of MS Teams is 300, which is less than the number of registered students, but this did not present a problem, since a large number of students does not follow the lectures live. The lack of a blackboard necessitated to explain almost everything by using slides, which is a far less effective way to explain longer derivations and examples. In order to increase the interaction during lectures, we used to ask multiple-choice questions, to which students answer by raising their hand. We replaced this by mentimeter questions (see figure 4) [6], which proved to be an even more effective way of interaction.

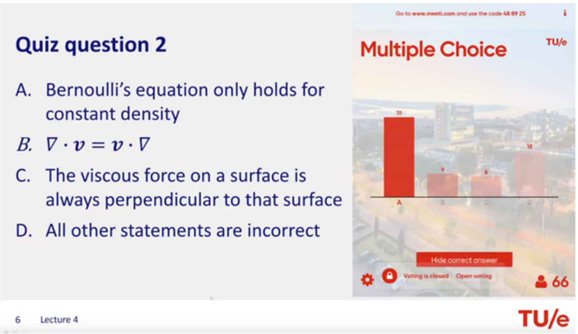

Fig. 4: Example of a mentimeter question used during the live online lectures.

The number of students that attended the lectures decreased in time, as usually, starting with almost 200 in the first lecture and dropping to approximately 100 in the last lecture. The lectures were recorded and made available to the students in a private channel in YouTube. The number of views ranged between 100 and 200, but the average view has a duration much shorter than the duration of the lecture.

For the instruction sessions I bought a whiteboard, which enabled me to explain the exercises in a better way than by using slides. However, the webcam does not focus on the reflecting surface of the whiteboard and I needed to use one of my hands to focus the webcam on the right spot (see figure 5). The size of the whiteboard is much smaller than the size of a blackboard in the lecture room, which also has consequences for the way to explain exercises. MS Teams has the functionality to show the image from my webcam full screen, but this is not the case in the recordings. Fortunately, at the time of the course, the number of screens shown in the recordings was limited to four, so that the text was still well readable.

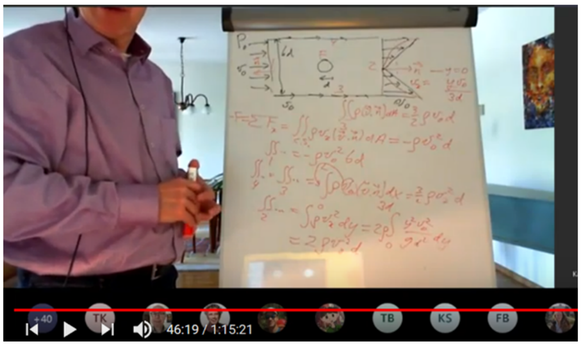

Fig. 5: Whiteboard used during instruction sessions. The figure shows a recording of the MS Teams session of the instruction. See also https://youtu.be/59BLi94VFms

The biggest problem was the GSS. We organized this also in MS Teams and usually 6 persons were available to answer questions. However, the number of questions was so low, that most of the teacher assistants were hardly occupied. Furthermore, at that time we did not yet have good solutions for writing or drawing on a whiteboard.

The exam of the course was scheduled on July 1, when the campus was just in the process of starting up laboratory activities for PhD and MSc students and staff was allowed to work in the office for one day a week. All other activities, including meetings and exams, were still online. For the exam of a course like this, the only option was an online proctored exam.

Based on experience of the exams of the previous quarter, we decided not to use the upload function, but organize the questions in such a way that the answer could be given digitally. As in the previous years, the exam had two types of questions. Half of the time was spent on multiple-choice and numerical questions in which only the answer should be given. In the system we used, Ans Delft [7], these questions are automatically graded. The remainder of the exam consisted of two larger exercises with multiple questions. The equations that need to be typed could be given symbolically, for example alpha for the Greek letter α and int(f(x),0,1) for $\int_0^1 f(x)dx$. Students could test the system and this way of writing equations in the week before the exam was held.

The exam differed in two other aspects from earlier years. In view of a necessary sanitary break, the exam was split in two parts of 90 minutes each with a fifteen minutes break in between. Also, we allowed the use of the book, or other material on paper, while normally we only provide a list of the most relevant formulas. The reason for this change was to reduce the possibilities for cheating. A drawback is that open-book exams are usually more difficult, since the examples from the book cannot be used. Only one student made use of the opt-out and made the same exam on paper on campus. His results were uploaded in Ans Delft to be graded in the same way as the results of the other students.

The use of digital assessment has large benefits in the process after the exam. First of all, instead of a huge pile of paper of all individual exams, which requires a few hours to sort everything out and make sure that no exam has been lost, all results are available directly after the exam and ordered per student and question. Multiple-choice and numerical questions are automatically graded and for other questions grading criteria can be set, which is a good guarantee for consistent grading and accelerates the grading process. Also, it is possible to perform the grading by multiple persons at the same time.

After the grading has been finished, students can inspect their exam during a fixed period of time and see which errors they have made and how their grade is determined. If they have any questions about the grading, they can ask them in the same system and the person who graded that exercise receives a notification. We noticed that the number of students who used the opportunity to inspect their exam is way bigger than in case of a paper exam.

After the exam, students complained that the division of the questions over the two parts was not good. The multiple-choice questions required far less time than the open questions. Therefore, in the resit we split the questions according to the topic: part 1 about flow and part 2 about heat, while both parts had multiple-choice questions and one open exercise.

During the exam no technical problems happened, although a few students were automatically expelled since they tried to do something that was not allowed. After the exam no deviations from normal behavior were detected.

The results of the exam were not as good as the year before, but clearly better than in previous years. The success rate of all students who made a serious attempt during the exam was 61%, while the distribution of the grades was comparable to the year before (see figure 6). A better distribution of the exercises over the two parts of the exam would probably have resulted in a higher success rate. Moreover, the very limited attendance of the GSS, which is the best preparation for the exam, will certainly have influenced the results and is an important point for improvement in the future.

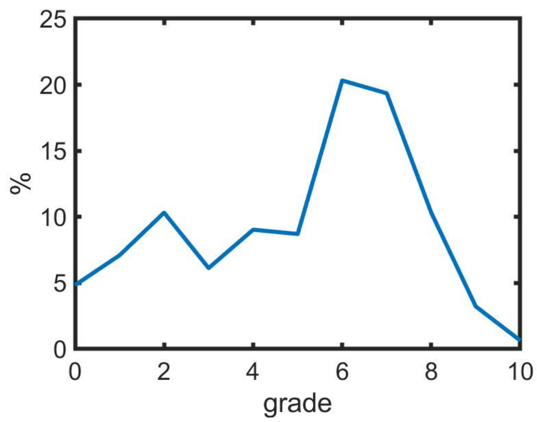

Fig. 6: Distribution of grades of the first exam of Heat and Flow in 2020. A minimum grade of 6 is required to pass the course.

The evaluation of the course, which is always performed directly after the exam in digital format, revealed that the students would have appreciated a study guide to choose their way into the available course material. There is so much material available, that they need a guide that provides different ways to study the topic. We took this into account in the set-up of the next academic year. Moreover, there were some complaints about the exam, in particular about the way to type equations and the time required to finish the exam.

In one of the lectures I also used mentimeter to ask questions about the set-up of the course and the exam. On a scale of 1-5 the question

"Are you satisfied with this way of teaching" scored 4, which is satisfactory given the circumstances. On the question about the exams, 96% of the students indicated that they prefer an online proctored exam at the normal scheduled day over an on-campus exam postponed until November.

4. Academic year 2020-2021

At the start of academic year 2020-2021, the corona situation had improved so much, that students were again allowed to have education on campus, but only in smaller groups and keeping a distance of at least 1.5 m. Especially experimental work, construction and testing were allowed in small groups, but it was also possible to organize GSS sessions for small groups. For every lecture room a maximum number of students was determined, which usually is about one fifth of the normal capacity. At that time on-campus lectures were not allowed, since this was considered an inefficient way of knowledge transfer.

This situation of relaxed corona measures did not last long, however. By December the number of infections and hospitalizations increased so much that all on-campus teaching apart from a few practical trainings was forbidden again. However, on-campus exams were possible in most cases with an exception for the largest courses for which no suitable space was available.

During this time, experiments were conducted to find ways to organize online GSS sessions in such a way that student participation increases. The department bought a number of writing tablets for the teacher assistants in order to facilitate explaining the exercises, writing formulas and drawing pictures. Experience from the first-year course calculus, which is taught to approximately 2000 students, indicated that student engagement increased by working in small groups with a personal tutor, who has a more direct and personal interaction with the students in his or her group(s).

At the time Heat and Flow started, end of April 2021, small-scale on-campus teaching was possible again and we decided to teach the lectures and give the instruction sessions in a lecture room for a very limited number of students, while the others can follow this through a livestream. The livestreamed sessions are also stored and can be watched any time later.

As in the year before, the students that are not present can use the chat function in MS Teams for questions, and questions in mentimeter are used for increased interaction. Although the number of students that attend the lectures is small, those who do are very satisfied with the increased possibilities for interaction and benefit from the lesser opportunities for distraction in the lecture room than at home. One issue the teacher of a combination of on-campus presence and livestream has to deal with is that the livestream has a delay time of 20 seconds. This is necessary to put the video stream in the correct high-quality format. This delay has to be taken into account especially in the mentimeter questions. Also, direct interaction with the students that follow the livestream by speech is not possible, in contrast to the MS Teams lectures of the year before.

Since on-campus lectures are still not allowed, we chose for the format of so-called studio classroom, which is a mixture of lecture, instruction and small exercises made by the students. Students who want to be present have to register for every session they want to attend in our learning management system. In the four-hour session once a week there is only space for 20 students, while in the two-hour session 50 students are permitted. Experience in the first part of this academic year has taught us that students prefer to be on campus for a longer duration. For a sessions of two hours the travel time is sometimes longer than the time actually spent on campus. That is the reason why most on-campus sessions are in blocks of four hours.

The online guided self-study is organized in the following way. Students can choose between two ways of participation. They can either register for participation in a small group of five students with a personal tutor, or they can participate in one large group. In the first option they are expected to attend almost every time. Every session the tutor explains one of the exercises in detail and stimulates the students to work together on the other exercises. In order to facilitate this, we hired 13 teacher assistants, each of which is responsible for one or two groups. The tutors followed a short course to learn methods to increase student engagement. For our course 25% of the students indicated that they want to participate in a small group and a similar percentage had a preference for the large group. The number of questions in this large group is very small. Most students in the large group work individually and are able to solve the exercises with the help of the online material.

Of course, the number of teacher assistants is significantly higher than in other years. The university provided the necessary money to facilitate this way of teaching as one of the measures to cope with the consequences of the corona pandemic.

At the moment of writing we are halfway of the course and the attendance of the online GSS is still rather good. Students who registered for participation in a small group, tend to be there almost every week and they work until the end of the session, which is at 17:15 on Friday afternoon.

Fortunately, the exam can and will be held on campus. Only for students who cannot attend the exam on campus because of corona reasons, an online proctored exam will be organized. This exam is the same as for the other students and will be held at the same time. The exam is no longer split into two parts. Students are allowed to have a sanitary break during the exam. Valid reasons for this type of exam are medical complaints that could be related to corona, belonging to a high-risk group, or being in quarantine. International students who chose to return to their home country do not get the possibility of an online exam, since students are expected to be able to come to the campus for several educational activities, including exams.

The benefits of the digital assessment in Ans Delft made us decide to use the same system for the on-campus exams. The exams are not directly taken in digital form, since this would make the use of equations more difficult. Instead the exams are printed, leaving sufficient space for the answers after every question. After the exam, all papers are scanned and uploaded in Ans Delft. Multiple-choice questions are still automatically graded and for all other types of questions grading criteria can be applied. The benefits of synchronous grading by multiple persons and digital inspection of the exam by the students remain. Also, the administrative process is greatly reduced, since the system knows where the answers to all questions are and it is possible to grade all answers to a question in consecutive order. Only in case a student needs more space to answer than anticipated by the teacher, the person that does the grading has to search for the answer.

5. Conclusions

Over the past years the course Heat and Flow has been adapted in several ways with the objective to increase the success rate, but without changing the learning goals and the level of the exam. Taking into account different learning styles of students, the possibility has been created to learn the course material in different ways. Students who prefer to learn individually at the time they want, can now make use of an online version of the course, which consists of a set of short texts and small video lectures, a number of step-by-step recorded solutions to selected example exercises and a set of online exercises with automatic feedback on wrong answers. Students who prefer attending lectures and instruction and exercise sessions can still do so.

In order to ensure that students starts learning well before the exam, a method of digital progress tests has been developed. During the quarter in which the course is taught, students have to make a number of these progress tests with sufficient result to obtain the final grade for the course. The number of attempts of the progress tests is unlimited, but within a restricted time. This system together with the use of the online version of the course resulted in a significant increase in success rate and has since been transferred to a number of other courses within the department.

In 2020 the corona pandemic resulted in a lockdown in which on-campus teaching was not permitted. Still, the dual way of learning, both synchronous and asynchronous, was maintained by giving the lectures and instruction sessions fully online in MS Teams. Written exams were replaced by online proctored exams. Although the success rate was lower than in the year before, it was still significantly higher than before the progress tests were introduced.

Apart from the progress tests as a method to encourage the students to learn in time, the way to best organize sessions in which the students practice exercises is a lesson learned during the corona pandemic. The most important element of these sessions is the possibility to obtain feedback, next to the possibility to work together on the exercises in small groups of students. The method to organize these exercise sessions in very small groups of around five students, each with a personal tutor, appeared to work well, at least for the students who have the need to work in this way. The tutor plays an important role in stimulating the group to work together and in starting each meeting by explaining one of the exercises. This method is, however, not very cost effective, as many tutors are needed for big courses. The costs can be reduced by allocating one tutor to two groups. Moreover, by letting the students choose between participation in a small group or not before the course starts, less tutors will be required.

The department noticed that in the time of the pandemic the study success of the students in general did not deviate from other years. Although at first sight remarkable, this can be explained from the fact that studying is one of the few things that are still possible. Many other activities in which students normally participate have been cancelled, for instance group sports, events organized by student and study associations and part-time jobs in pubs and restaurants. Also less time is spent in traveling to and from university, since (almost) all teaching activities can be followed from home. Average grades and pass rates of courses are very similar to other years and the percentage of first-year students that fulfil the requirements to enter the second year is also unchanged.

This does not mean, however, that students do not suffer from the corona pandemic. Apart from corona infections, which usually only have mild consequences at the typical age of a student, many students suffer from loneliness and lack of perspective. Especially the group of international students who entered in September 2020 did not have any serious opportunity to get settled and make sufficient contacts with other students. Several of them moved back to their country of origin, which could have serious consequences for their study, since in several occasions attendance of teaching activities on campus is obligatory, in particular in practical trainings and written exams. But also other students experience psychological problems. Academic advisors, who can refer students to student psychologists in cases of problems, report that they get many more requests for advice from students than in other years.

A survey among first-year students in Mechanical Engineering revealed that almost 2/3 of them feel lonely sometimes or often. More than 50% indicated that the workload of the program is too heavy because of online studying and loneliness, although almost all of them would still have chosen the same study.

Finally, online proctoring is a useful method to organize written exams, if good care is taken of privacy rules of students. To this end, students should be well consulted and taken along in the process of setting up online proctoring. Also, it is very important to give students the opportunity to practice with this method of exams. In case students need to make drawings or write a large number of mathematical equations, an online proctored exam is only possible, provided that students can scan and upload their written papers. Uploading often leads to problems, especially in exams with a large number of students. Problems can be avoided by organizing on-campus exams in a safe way for almost all students. In that case, only those who have corona-related complaints need to make use of the online proctored exam.

A lesson learned during the corona pandemic related to exams is that an online exam system has large benefits in the process of grading and inspection of the exam by the students after grading. Not only a lot of time can be gained because of reduced administration, but also consistent grading is easily facilitated.

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Teaching at schools and universities in times of a pandemic - A field report from the perspective of physics didactics

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Abstract

Die Einschränkungen in der Präsenzlehre sind insbesondere für experimentelle Wissenschaften wie die Physik eine besondere Herausforderung. In diesem Beitrag wollen wir einige Hilfsmittel und Konzepte vorstellen, die sich in der Ausbildung von angehenden Physiklehrer*innen bewährt haben. Wir werden getrennt auf die verschiedenen Veranstaltungsformen (Vorlesungen, Seminare, Praktika) eingehen und diskutieren, wie sie in einem Online-Format umgesetzt werden können. Tools wie Zoom, Ilias, Mural etc. können dabei insbesondere kooperative Lernformen unterstützen, die in der Online-Lehre besonders nützlich sind, um ein Mindestmaß an sozialer Interaktion zu gewährleisten. Außerdem stellen wir Konzepte vor, die zu einer reflektierteren Auseinandersetzung mit den Inhalten der Veranstaltung führen. Schließlich werden die Probleme bei Online-Prüfungen diskutiert, bei denen ein Kompromiss zwischen bestmöglicher Überwachung und der Wahrung der Privatsphäre gefunden werden muss. Hier schlagen wir mögliche Lösungen vor, die sich bereits in der Praxis bewährt haben.

The limitations of face-to-face teaching are a particular challenge for experimental sciences such as physics. In this paper, we will present some tools and methods that have proven successful in Cologne for the preparation of prospective physics teachers. We will look separately at the different types of courses (lectures, seminars, practical labs) and discuss how they can be implemented in an online format. Tools such as Zoom, Ilias, Mural etc. can support cooperative learning groups in particular, which are especially useful in online teaching to ensure social interaction. We also introduce methods that lead to students' more reflective engagement with the content of the course. Finally, we discuss the problems of online examinations, where a compromise has to be found between the best possible supervision and the preservation of privacy. Here we suggest possible solutions that have already proven themselves in our practice.

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1. Introduction

The need for online teaching poses enormous challenges for schools and universities. At the same time, it offers teachers the chance to test ideas and concepts on a large scale. This paper will discuss the opportunities but also the risks that this brings, using some examples from this large-scale experiment.

An important question is the appropriate format for the course. Lectures cannot be translated 1-to-1 into an online format. What are the possibilities here? And how can the students or pupils be engaged?

There are special challenges for the experimental sciences, especially when the pandemic conditions do not allow physical presence in laboratories. New ideas are needed here if these practical lab courses are to be interesting, instructive and safe.

Finally, there is the question of the future of teaching in the post-Corona era! Will everything be the same as before? Are there innovations that have proven their worth and will continue to enrich teaching after the current pandemic?

2. Preliminary technical remarks

The success of online teaching naturally depends to a large extent on the technical conditions. The problems associated with this (e.g. quality of the internet connection, data protection, etc.) will only be discussed here in passing.

The University of Cologne (UzK) positioned itself relatively conservatively with regard to face-to-face teaching during the Corona crisis, so that teaching would be carried out almost exclusively online since March 2020. In order to create the technical conditions for staff and students here, the UzK acquired 50000 Zoom licences. This made it possible to negotiate favourable conditions with the manufacturer, especially with regard to data protection regulations. For example, the data is only processed on servers within the EU.

Another reason for the decision to use Zoom was the members of the University of Cologne, Institute for Physics Education had previously good experiences with using Zoom over several years and under different circumstances. This meant that staff members could also be used as instructors for internal university training in the use of Zoom.

Even before the suspension of face-to-face teaching due to the pandemic, we used mobile whiteboards (approx. 80 x 60 cm plastic-coated wooden boards that can be written on with erasable markers or pens) for group work in seminars, lectures and laboratories for formative assessment. Formative assessment is the continuous examination and survey of the learner's level of knowledge in the learning process. For the instructor, it provides a way to determine the students' level of understanding of the material. At the same time, it is a tool to facilitate the assessment of your own teaching and curriculum material. Formative assessment, then, is not only about checking whether students are correct, but is also intended to explore students' underlying conceptions and competencies at the same time. A very clear introduction and discussion of the advantages and disadvantages of formative assessment can be found in [1].

With the whiteboards mentioned above, lecturers could see at a glance what understanding students had developed. After implementing online courses, we tried using the whiteboards integrated in Zoom. While the whiteboards were useful for discussion purposes, it was not easy to see all the boards at a glance and to organise and document boards. After testing several alternatives, we selected Mural [2] to replace the physical whiteboards. We found that the large lectures can be divided into Zoom Break Out Rooms (BORs) and that the lecturer can use duplicated group murals to see in real time what students are working on and what understanding they can achieve. This also allows easy sharing of work results by students in seminars, lectures and practical labs. The real-time mode allows all activities up to cursor/mouse movements of all students and teachers to be followed. However, this requires more computing power in the browser on the computer or on the tablet app for all participants. This mode can be deactivated, however.

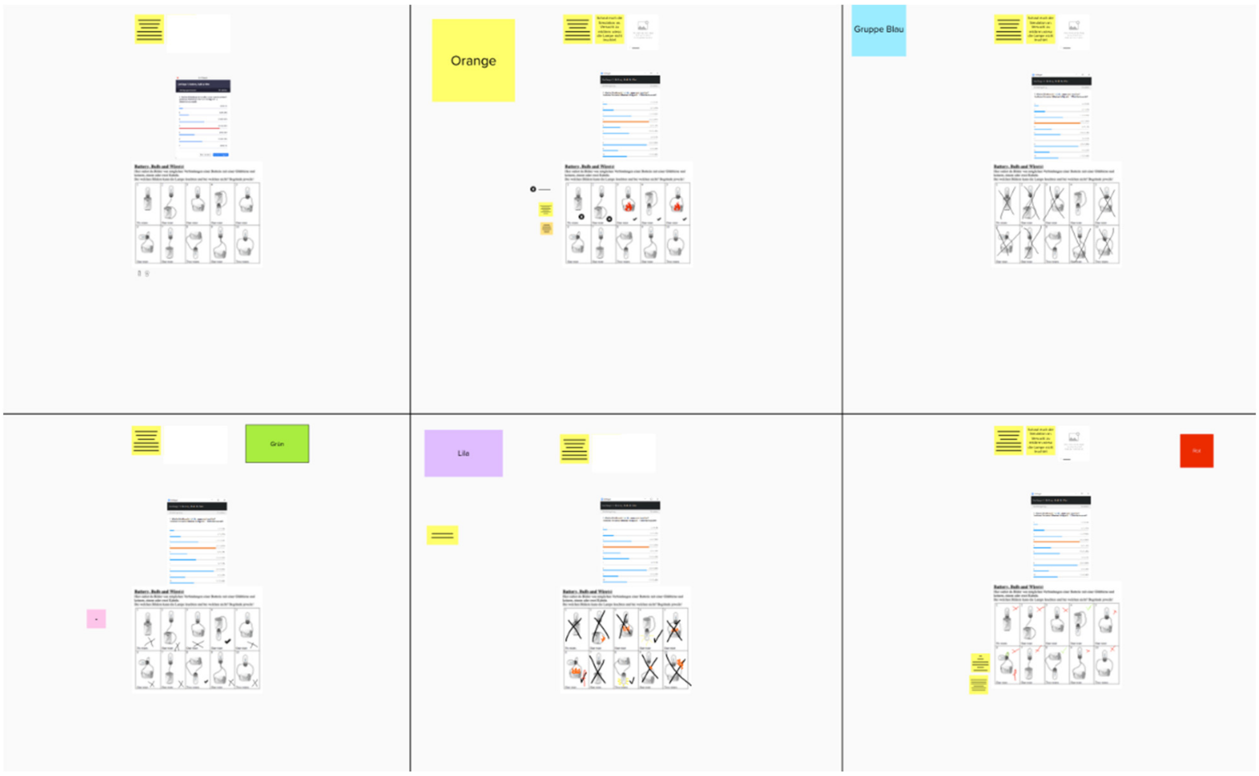

Fig. 1: Use of murals in a physics didactics (content and pedagogy) seminar: Students develop a different understanding of simple electrical circuits in groups. The figure shows the teacher's view. Each field simultaneously represents the mural of a different group (or a breakout room). The teacher therefore has an overview of the activities of all groups and can intervene if necessary. An enlarged section is shown in Fig. 2.

Another tool that has been used as standard in teaching for many years is the learning management system (LMS). Our LMS is *Ilias* (Integrated Learning, Information and Work Cooperation System) [3], with which internet-based teaching and learning materials can be created and made available. It offers a wide range of possibilities from planning events to monitoring learning progress with various test formats. The Ilias LMS also supports communication with students via email, chats or forums. The Ilias LMS was very familiar to our students, which has made the transition to online formats much easier.

3. Lectures

Lectures are the central course format at universities. There are numerous options for realising this in the context of online teaching. The simplest option, of course, is to change as little as possible. The lecture then takes place live via Zoom, with the lecturers either standing in front of a blackboard in a lecture hall or working from their home office with a PowerPoint presentation, for example. The obvious advantage is that not much has to be changed here (apart from the technical boundary conditions) compared to the classic lectures. The lack of formative assessment is major disadvantage. The communication between lecturers and students becomes even more difficult online. From the lecturers' point of view, direct feedback via facial expressions and other non-verbal interactions is missing. Therefore, it is very difficult to assess how well the lecture is "received". This is further exacerbated by the fact that most of the audience switch off the cameras and therefore only look at black tiles in Zoom. There is no feedback from the audience. Questions are rarely asked as this interrupts the flow of the lecture. The functions in Zoom ("raise hand") are no real help here, as you often cannot keep an eye on them.

A first step away from live lectures over the internet are lecture recordings. In the simplest variants, these are essentially live lectures that are recorded and ideally still edited. From a teaching point of view, the length should be adapted to the usual attention span. Several short videos, ideally with thematically self-contained content, are more effective than a 90-minute recording. This effect is further enhanced if such a short video is followed by an adapted exercise that further deepens understanding.

Lecture videos, with student controllable review, have been rated very highly by students in surveys. The main advantage is seen as an individual learning pace. It is easy to watch parts of the lecture more than once, which is particularly important for very "dense" presentations. However, a big problem, especially with live lectures, is the lack of engagement of the students. Here, cycles of frequent breaks with short video segments should be built in. The students have to be active themselves during the lecture break, be it in discussion groups or with working with smaller tasks.

A completely different approach is the *flipped* or *inverted classroom*. Here, the classic roles of (classroom) lectures and exercises to be worked on independently (usually as homework) are reversed. The contents of the lecture are made available, for example, via course lecture notes or course text. The time in which the lecture would normally have taken place is then used for questions, discussion and working on exercises. The Flipped classes makes it easier to identify basic comprehension problems. The concept can also be combined very well with lecture recordings.

How can one ensure that students regularly study the course text or view the lecture videos? Regular tests or quizzes have proven to be a suitable method here and can be easily achieved in Ilias, for example. Ilias offers a test environment with different types of questions, e.g. single- or multiple-choicefill in the blank questions or questions with free text answers. The evaluation of the test or quiz is done automatically (not recommended for free-text answers). Therefore, the students can receive feedback immediately after completing the test or quiz.

Such tests can be used very well for assurance of the coverage of content. There is (at least) one test or quiz for each chapter of the course text, whereby the questions can be answered with the course lecture notes alone. On average, 1-2 questions should be asked per page of the notes. A deadline for completion ensures that the students "stay on the ball" and do not lose touch with the lecture. In addition, the questions should serve as orientation for the students. On the basis of lecture notes or books, it is often very difficult for beginners to recognise what is really important and what is more of an accessory. This can be controlled a little better by asking appropriate questions. Passing all tests is one of the criteria for awarding credit points. By setting a high minimum score (at least 75%) for passing, one can also ensure that this cannot be passed "by chance". However, this cut-off score requirement should be ameliorated by the possibility of repeating a test (several times).

Experience and research (Force Concept Inventory (FCI), etc.) has shown that students - despite having passed the tests - have only superficially dealt with the content to be prepared. Often, just enough is done to be able to pass the test. Therefore, in the second online semester, we replaced or supplemented these tests with a new tool that promotes a *reflective* engagement with the text content. The students had to keep a kind of *logbook (Reading Log)* [4,5] in which, among other things, certain guiding questions had to be answered. In the first version, Reading Logs, which have already been used successfully at American universities for years, were adapted to the conditions at a German university.

The students should read the prepared part of the course lecture notes or text (at least) twice. After the first reading, the essential contents are then to be summarised in a very short form in key words or by sketches etc. In addition, a glossary should be used to summarise the newly encountered terms and quantities and their definition or a description. In order to arrive at a more reflective engagement with the contents, open questions that have arisen during reading should also be noted. This should focus the perspective for the second reading. After the second reading, the three most important new ideas should be listed again. Furthermore, the new knowledge should be placed in a larger personally meaningful lived context, e.g. possible applications or already known content from other fields. Finally, the students should briefly discuss which new insights have emerged from the rereading and whether there are further questions that should be discussed in the lecture. In addition, the time needed for reading and filling in the logbook should be noted down.

Logbooks are to be submitted via Ilias the day before the lecture. Students will (usually) receive feedback on their logbook before the lecture. In the sense of just-in-time teaching [6], the submitted logbooks are addressed in the lecture. This procedure gives a very good overview of whether the students have really recognised and understood the essential content. Above all, an attempt is made to address the questions in order to illustrate the meaningfulness of the logbooks.

4. Exercises and lab practicals

Exercises live very much from the interaction of the students with each other and with the exercise instructor or supervisor. The socially construction of knowledge is difficult to achieve online.

One way to do this is to work in small groups, e.g. in breakout rooms (BORs) within Zoom meetings. The supervisors regularly switch between the rooms to answer questions and ensure that the work is focused. In the teacher preparation programmes in particular, it has proven successful that complementary tasks are worked on in the BORs. All students then come together in the main session to present and discuss their results. This also leads to a necessary diversity of ideas and improves student attention, as new ideas are explored and valued.

Exercise elements can also be incorporated directly into lectures. This provides immediate feedback on possible comprehension problems. At the same time, students are engaged and do not remain passive in their role as listeners. For example, multiple-choice questions can be used for formative assessment in face-to-face lectures. For this purpose, we have already used software such as ILIAS live voting, *Plickers* [7] or *Kahoot* [8] in face-to-face courses. There are already numerous concept and application questions in multiple-choice formats (concept tests [9]).

In the online courses, some of these tools could be used as well. In addition, we use the survey function of Zoom (Fig. 2), which has the advantage that it is integrated into the Zoom user interface and opens automatically for the students in the foreground. The disadvantage, however, is that no illustrations can be inserted into questions or answers. The Zoom chat proved to be just as frequent a quick means of individual feedback.

The Mural platform offers a so-called "private mode" in which students no longer see what changes other teachers and students are making. This allows individual predictions to be queried and discussed later.

Practical labs are probably the most affected by the restrictions on face-to-face events. The necessary experience in handling equipment in particular can really only be taught in face-to-face events. If limited presence is possible, various stopgap solutions can be found. For example, a kind of "jig saw" is possible, in which students carry out experiments individually instead of in small groups. However, this is very stressful for the supervisors. Therefore, some experiments were carried out with one group member in the lab and 2-3 other students connected via Zoom. Here, however, one must ensure that they have enough meaningful activities to support them and are not just spectators. The evaluation of the experiment results then takes place as in the in presence mode.

An alternative approach tries to use the creativity of the students and guide them into a suitable path to solve content problems. For example, one can assign relatively general tasks (What are the factors which influence the period of a pendulum?), which are then to be solved with the respective means available (e.g. in the household). The students then have to design the experiments themselves instead of working on ready-made experiments, as is unfortunately often the case in

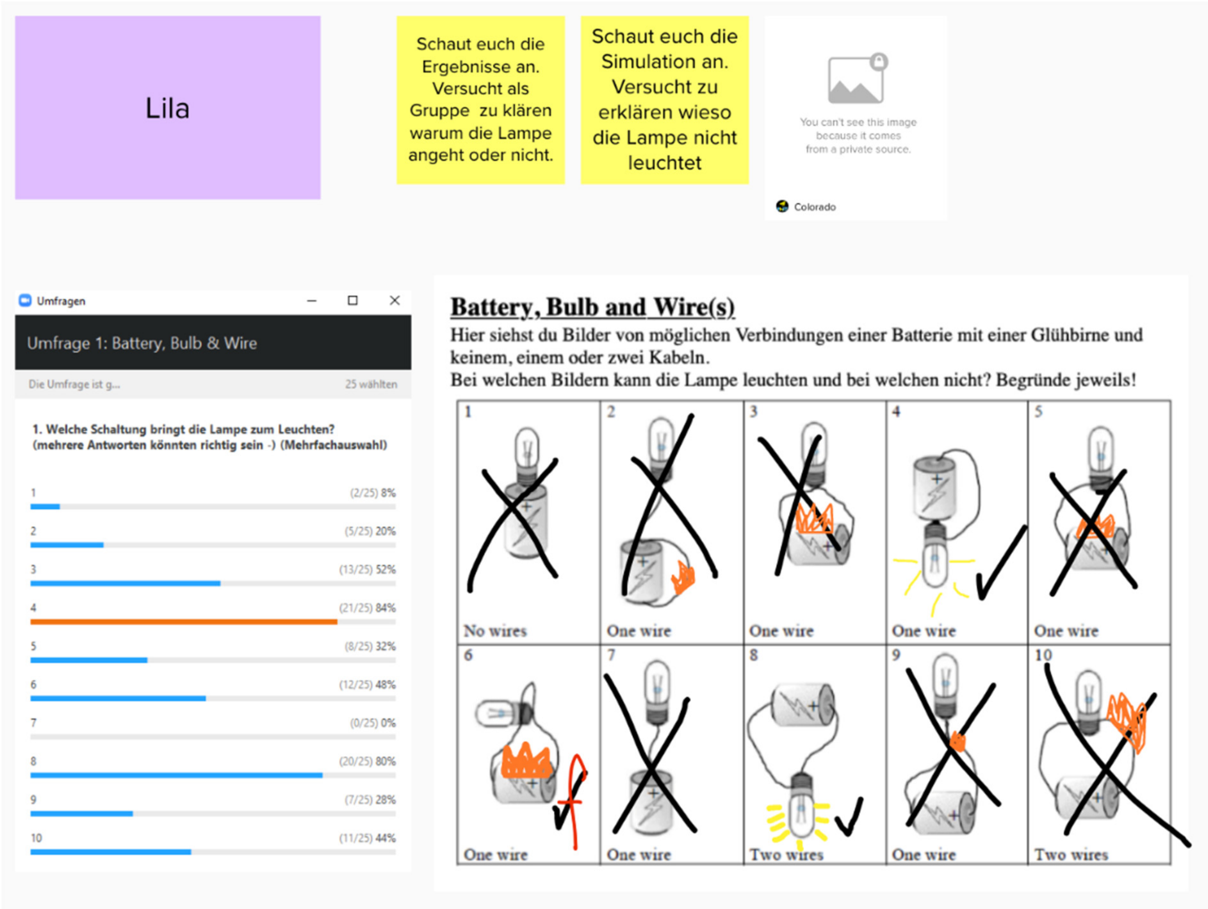

Fig. 2: This enlarged section from Fig. 1 shows the processing of the task "Which circuit makes the light bulb light up? Record your predictions in drawings and check them with the PhET simulation "Switching circuits: Direct Current" [10]." by a group of students in a mural. The highlighted image shows details of a group's processing, e.g. comments recorded on virtual Post-It notes and the result of a zoom poll (left), which serves as a basis for discussion, and the result of the subsequent discussions.

practical lab courses. For such experiments, the possibilities of modern smartphones or tablets, which are equipped with a variety of sensors, can be used very well. These can be read out with software such as *phyphox* [11]. With apps like Vernier's *Video Physics* [12], movements can be filmed and evaluated. These are only two examples of the possibilities offered by the use of smartphones. This is very attractive, especially for students, because it allows them to work on examples from their immediate world. Also, students love to use their cellphones.

Another possibility, which will usually be a supplement rather than a substitute for real experiments, is the use of simulations. For the natural sciences, especially physics, *PhET* [13] is highly recommended here. PhET was founded almost 20 years ago by Carl Wieman, using his Nobel Prize in physics money, and now includes more than 150 simulations with almost 3000 examples of use by practitioners from schools and universities. In addition to simulations from the field of physics, there are also simulations on chemistry, mathematics, biology and the earth sciences. The apps on electrical circuits or optics are very helpful for physics education at university, as

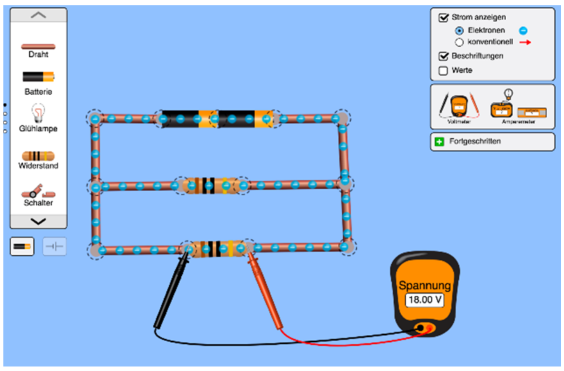

Fig. 3: PhET app for DC circuits [10].

their design makes them very close to real experiments. One can perform "real" measurements, e.g. on simple circuits (Fig. 3).

An alternative that is very attractive for students is working with programmable robots. Here we have had good experiences with the robots ("*Codey Rocky*") from *Makeblock* [14] (Fig. 4). These can be programmed with the simple programming language *Scratch* [15], which was developed at MIT especially for younger children. The robots can be equipped with numerous sensors, enabling them to carry out physical projects. We will present a concrete example in section 6.

Fig. 4: A programmable CodeyRocky robot from Makeblock. The robots are movable and can be equipped with various sensors.

5. Examinations

Studying always includes examinations. In order to avoid major delays, it is of course not possible to do without any examination activity for a year or more.

All participants have had good experiences with oral examinations via Zoom (and other video conferencing systems). The procedure here is relatively similar to that of a face-to-face exam. LMS such as Ilias often provide options for electronic tests (see above in the section "Lectures"), usually with the option for automatic evaluation of multiple-choice tests. At first glance, this seems very practical, but it is associated with numerous dangers. The authentication of the participating students can be a problem. The quality of such tests for performance review stands and falls with the quality of the questions and especially the distractors, i.e. the wrong answers offered. To create a good and meaningful multiple-choice test, one must already have a very good idea of the students' prior knowledge ("misconceptions"). One must therefore anticipate the possible errors and choose distractors accordingly. In many areas of physics, the typical students' prior knowledge is very well studied and very helpful, e.g. in mechanics and electricity.

Conducting classical examinations in online formats is inevitably fraught with major problems, especially due to the conflict between the necessary monitoring and the protection of privacy. However, there are ways to manage this balancing act here as well. It should be noted, however, that students know the capabilities of modern media very well and know how to use them for themselves. This has led to large-scale attempts at cheating in less well-designed online exams [16]. Such cheating, e.g. through communication between the participants (including a "division" of the tasks [17]) is also possible in formats such as *open-book examinations, in which* the use of external aids such as books and/or internet sources is permitted.

Fig. 5: Permitted form of video surveillance during online examinations via the camera of a mobile phone.

In consultation with the legal department of the University of Cologne, we have developed a format that enables the holding of examinations with simultaneous video surveillance of the participants within the framework of the legal possibilities. Such monitoring is possible if only one camera is used and the image section preserves privacy [17]. A quick camera pan through the room is also permitted for control before the examination or in cases of suspicion. An illustrative example is shown in Fig. 5. A smartphone, which practically all students have today, is usually used for video transmission. It is mounted in such a way that it allows a view over the examiner's shoulder, always showing the hands and the screen of the computer on which tasks are provided. There are many creative ideas for holding the smartphone that make use of household objects (Fig. 6).

To conduct the exam, the participants are divided into BORs, with a supervisor assigned to each BOR in addition to a participant. The supervisor authenticates the identification of each participating student. The photo id, school id and the matriculation number of the student are compared and matched. Then the matriculation number is compared to the log in data for the examination on the computer screen. The computer is checked for programs and apps with the students sharing their computer desktop via Zoom. The division into BORs makes it possible to transmit the video as well as the sound without disturbing other participants. The participant's microphone is active. This prevents communication with other people who may be in the same room and give unauthorised support. It also makes it easy to ask questions.

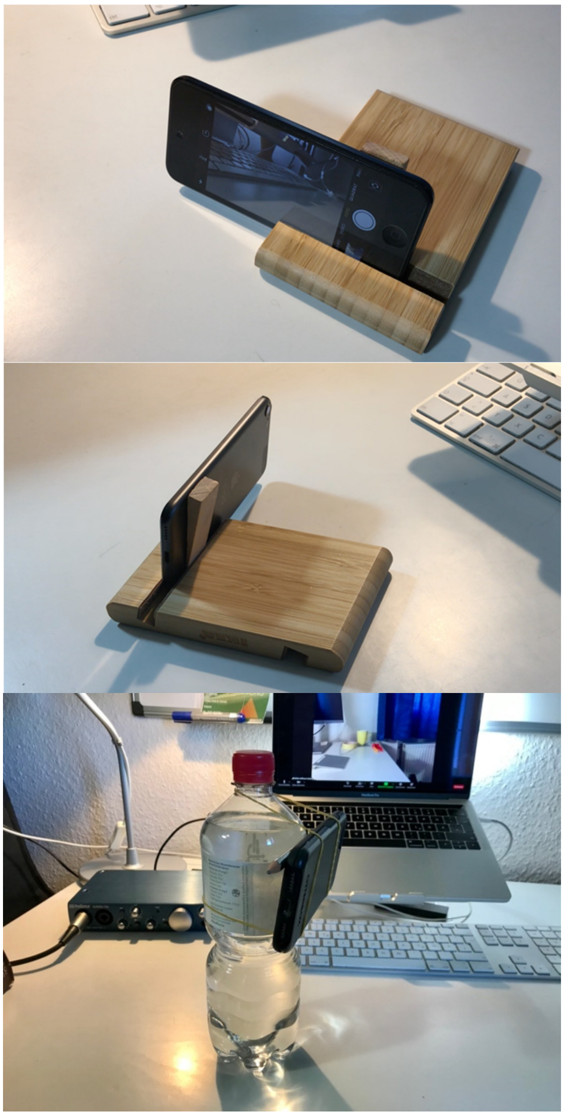

Fig. 6: Excerpt from the instructions for examiners with creative solutions for the self-made holder of a smartphone as a camera. Further ideas can be found in YouTube videos, for example.

The speaker on the side of the participants is also permanently switched on so that questions and comments from the supervisors can be heard. The supervisors only switch on their microphones when necessary, as they monitor several BORs at the same time with several devices.

Of course, even this procedure does not offer 100% security against attempts at deception. But that is not desirable at all! In principle, the online examinations should offer a level of security comparable to that of the classic face-to-face examinations.

We have successfully conducted such examinations several times in the past semester. The students were very cooperative and showed full understanding for the measures. Technical problems occurred only very rarely. They were about as frequent as in classical examinations, where, for example, disruptions in local transport more often lead to students starting examinations late or even missing them altogether.

Furthermore, in the examinations conducted according to the procedure described above, there were no obvious attempts at cheating.

6. Concrete examples

In the following, we would like to demonstrate with some concrete examples how often unexpected positive results can be achieved through online teaching.

In the course "Mathematical Methods", prospective physics teachers at the secondary or middle and high school levels learn the necessary mathematical tools for their studies. In this case, it goes only slightly beyond the usual material in an advanced mathematics course (which, however, is usually only attended by a small proportion of the participants!). This course has been held in the inverted classroom format for many years, with mixed results.

With the switch to an online format, BORs will work with a maximum of 5 people. In each room, a student tutor is responsible for discussing all assignments and resolving any problems. Support staff are available as mentors to answer questions that arise and to provide other assistance. It is evident that students work in a much more focused manner in such a format and the usual attrition in participation over the course of the semester is much less than in the face-to-face version. For example, a significantly higher percentage of students took part in the final exam than in the face-to-face version. This had no influence on the pass rate, which was even slightly better than in previous years.

In a seminar on the use of media in physics teaching, we introduce students to object-oriented programming with *Scratch* [15]. Scratch is a free programming environment that is easily accessible for children and young people and is used all over the world. The students created simple individual programs in Scratch in groups to learn how to use the tool and to understand the objects used in programming. As a transfer task, the students were shown the robot *Codey Rocky* (see Fig. 4) later in the semester, which can be programmed with mBlock5. The mBlock programming environment supports both a Scratch-based and a Python-based version of mBlock. Both programming languages are available free of charge via the mBlock website [18]. The transfer task included a programming challenge in which the students competed against each other in programming teams.

The programming task was first presented in the plenary session of the seminar (Fig. 7). During the rest of the seminar session, the students were able to try out parts of their programmes in BORs of the Zoom event meeting by submitting the programme files to the seminar supervisors via Zoom chat. The supervisors played the programmes on the Codey Rocky robots available in the lab and ran the programmes live in ZOOM, so that the students received more precise feedback on how their programme parts worked and could thus make targeted changes to the code. Based on these tests, the teams had two weeks to complete and submit the challenge programmes. The groups' five completed programmes were uploaded to five different Codey Rockys before the seminar session and could compete live in the Zoom event meeting. For the second part of the semester, some project groups were able to borrow a Codey Rocky and materials to create their project.

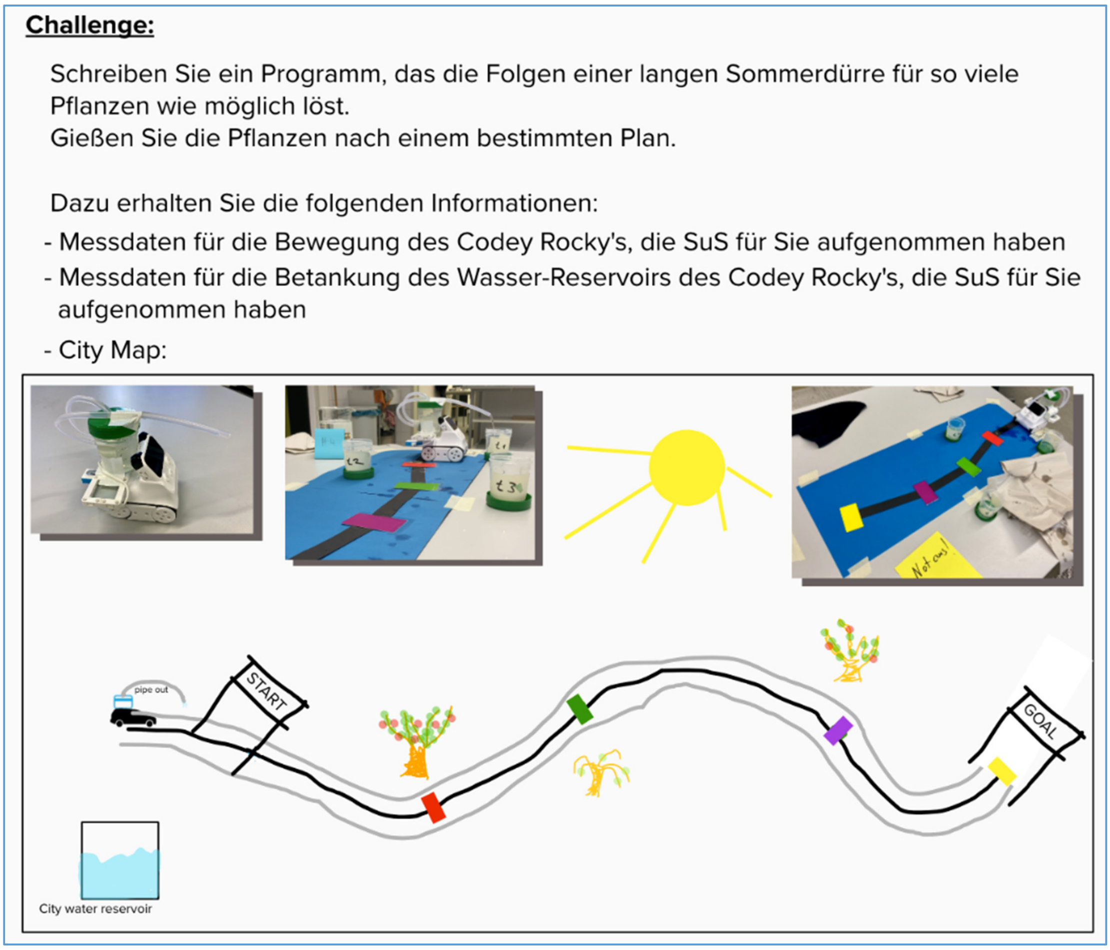

Fig. 7: Programming challenge: profile of the kinematics *task to be solved; Codey-Rocky modified for* pouring water*; test track; carrying out the challenge live in ZOOM.*

7. What will remain?

Will we return to the old forms after the end of the pandemic? We don't think so, because many colleagues have discovered new forms of teaching (inverted classroom etc.) and their advantages during the crisis! This will certainly also be reflected in future face-to-face teaching. Lecture recordings are especially popular with students, as they support an individual learning pace. This tool will remain with us, as many universities have also upgraded to create the technical conditions for it. However, lecturers should make sure that the old recordings are not taken out of the cupboard every year, but that the courses are always developed further. Overall, we expect that face-to-face teaching will remain very important, but will be used more consciously and purposefully. Formats from online teaching will continue to play a role, but in many cases as a supplement rather than as the main form of teaching. This idea of supplementation is supported by the history of instructional innovations like printing, recording, film, TV, internet, etc. not replacing the previous strategies but enhancing.

In our view, the quality of teaching will improve overall as a result of online teaching! This is mainly because many lecturers and teachers have had to come to terms with new teaching concepts and have experienced their advantages in concrete implementation. All of these new ideas and methods help support a wider variety of learners and may support a more inclusive learning environment. On the other hand, online teaching has also shown how important social interactions between students and with teachers are.

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The (Scientific) Digital Culture

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Abstract

Die Rede von der „Kultur der Digitalität“ ([7] Stalder 2019)sorgt in Universitäten regelmäßig für Unruhe. Der Titel löst dann Irritationen aus, wenn damit die Implikation verbunden ist, dass von einem Umbruch, von einer Ablösung auszugehen ist, dessen Folge es sei, dass die Universität, wie wir sie kennen, fortan nicht mehr existiere. Das Gegenteil ist der Fall – denn, wenn man das eine tun kann, bedeutet es nicht zugleich, dass man das andere lassen muss ([1] Lasch 2020). In meinem kurzen Beitrag möchte ich deshalb (1) das Konzept erläutern, es (2) auf unsere Communitas Universität übertragen und (3) ein Projekt vorstellen, das sich konsequenterweise genau dann etablieren kann, wenn man Universität als Universitas in einem umfassenden Sinn als Institution einer „(Wissenschafts-)Kultur der Digitalität“ versteht ([2] Lasch & Schoop 2021): „virTUos“ (Virtuelles Lehren und Lernen an der TU Dresden im Open Source-Kontext).

Talking about a "digital culture" ([7] Stalder 2019, in translation: the digital condition) regularly causes a stir in universities. The phrase causes irritation insofar as it implies that there is an upheaval, a replacement, the consequence of which is that the university as we know it will henceforth cease to exist. The opposite is true - because if you can do one thing, it does not mean at the same time that you have to leave the other ([1] Lasch 2020). In my short contribution, I would therefore like to (1) explain this phrase, (2) apply it to our communitas university, and (3) present a project that can be established precisely when university as universitas is understood in a comprehensive sense as an institution of a "(scientific) digital culture" ([2] Lasch & Schoop 2021): "virTUos" (Virtual Teaching and Learning at the TU Dresden in an Open Source Context).

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1. Digital Culture

Living in a *digital culture* (according to [7] Stalder 2019, in translation: under *the digital condition*) means that transformations and distortions of forms of social interaction with knowledge are not only in the offing, but are *already a reality.* This means that established processes of knowledge appropriation, the production and communication of knowledge, as well as the status of knowledge itself and forms of its adequate transmission are at stake. The question of what knowledge is and to whom it belongs has never been as open as it is today. A retreat to a pre-digital culture is not an option. So if this option is ruled out, the only question that remains is *how to* relate to the transformation process that is currently taking place and *whether* and *how one* wants to help shape it. I am of the opinion that universities must act and position themselves as actors in this process.

Stalder speaks of three central characteristics that shape a digital culture and that bring down traditional cultural orders: *Referentiality*, *Communality* and *Algorithmicity*. According to Stalder, our society and its institutions are at a crossroads: "Our actions determine whether we will live in a post-democratic world of surveillance and knowledge monopolies or in a culture of commons and participation. "([7] Stalder 2019, blurb, own translation) By *referentiality,* Stalder addresses the fact that knowledge (as knowledge of domination) can no longer be hegemonically owned, locked away, managed and accounted for, or guarded like a treasure, but becomes available and re-referentialised quite independently (e.g. of discourses on copyright). Digital practices drastically accelerate this process, which has long been known and named in cultural techniques such as copying and collage: "Cultural works of all kinds become freely available in a comprehensive, practical sense, despite existing legal and technical restrictions. " ([7] Stalder 2019: 112, own translation) Communities in digital space have a similarly catalytic effect, which he addresses with the principle of *communality.* Stalder emphasises that new epistemic communities of practice, in which knowledge is processed in a new way, in alternative ways and fields of practice, compete with the established institutions and communities of pre-digital culture. "They [sc. communities of practice as epistemic communities] emerge in a field of practice, characterised by informal but structured exchange, are focused on the generation of new possibilities of knowledge and action and are held together by the reflexive interpretation of one's own practice. Especially the last point [...] constitutes the central role of community formation." ([7] Stalder 2019: 136, own translation). And *algorithmicity* is the hallmark of techniques that open up completely new possibilities of exploration and analysis as well as modes of production, but also confront us with new challenges that relativise our practised cultural practices: "Activities that not long ago seemed unquestionably reserved for human intelligence, for example the composition of texts or the content analysis of images, are now increasingly being taken over by machines. " ([7] Stalder 2019: 173, own translation)

The last aspect in particular should be an incentive for us and should always make us think about the fact that consistently closing ourselves off to the outside world and sticking to established forms of knowledge transfer will lead to a solidification of institutions that have dedicated themselves to the elaboration, preservation and transmission of knowledge for centuries, not to their vitalisation.

2. Universities in the knowledge society of the 21st century

So, as a communitas whose most important characteristic is to create and process knowledge, we see ourselves exposed to cultural processes that permanently challenge our institutionalised approach to knowledge. A university is, at its core, a (high) medieval institution. The more recent universities in the Federal Republic of Germany in the 1970s or the foundations and expansions after 1990 have also adopted this order and understanding. A university is a self-governing communitas, a literally *universal community of* research, teaching and learning. A university creates hybrid and volatile forms of knowledge: it is always this, provisional, in its self-image. Interestingly, this correlates in a special way with the principles Stalder identifies for a digital culture, in which universities as institutions have long been placed. Not only do they carry the traditions of inherited communitisation and produce new communities that Stalder speaks of, but they also carry the conflicts that go with them internally and externally: "The old orders in which cultural material has so far been filtered, organised and made accessible [...] can channel this flow neither on a small nor on a large scale. They hardly function any longer as gatekeepers between the realms that were once defined as 'private' and 'public' with their help. " ([7] Stalder 2019: 114, own translation) What opportunities open up if we think of universities *again* as places where only *one way* was never the right way? The initial observation, and one that has been particularly brought to the fore in the last year, is that technology-sceptical debates obscure the need to address the question of what the university can and wants to be. There is much more at stake here (cf. [1] Lasch 2020: 241-244):

- Participation: Universities are places of exchange where not only work is done together, but also community is shaped together.
- Transparency: We value traceability. How can research data be generated in such a way that its genesis is transparent? How should the interpretation of research data be designed so that it is not hermetic?
- Visibility: How can research data and results be made visible? How can teaching be opened up? How can visible research data and teaching and learning materials or results be made open and still be protected?
- Interconnectedness: How can data and results from research and teaching be effectively related? How can this be anchored in academic understanding?
- Generosity: What is the status of our data? How can we benefit from them together? How to promote willingness to share in academic education?
- Collaboration: What research data and results and what teaching and learning content can be developed jointly? How can collaboration be motivated in research and teaching?
- Goal orientation: Which goals can only or more effectively be achieved through collaborative work? Can new objectives (for one's own or joint work) be created through collaboration? How and where can objectives be made explicit?
- Value orientation: How can we promote these principles in research and teaching?

The answers to this question all converge here: *Openness*. I would like to present three examples in detail in this section, which I would like to understand as expressions of a *scientific digital culture* and which are committed to the principles mentioned, each with a different weighting. One is, by way of example, the blog *Lingdrafts. Linguistic Workshop Reports*. The other is *Open Educational Resources* (OER). The third is *collaborative projects* with students. As I will try to show before presenting the *virtTUos* project (section 3), it is above all the field of action of academic university teaching that opens up creative freedom for us.

2.1 Lingdrafts

Two years ago, we set up *Lingdrafts*, a blog project with interested academics without regard to status group differences, in order to position ourselves *at the interface to* the *public, to visibly* present our research questions and to seek *connection to* current topics. Our editorial team is now colourful and large, communicates via messenger and, above all, at *eye level*. It's a real *community project*, one of those epistemic *communities of practice that* Stalder talks about. Blog communication is characterised by visibility, topicality, reciprocity and resonance, hybridity and volatility as well as a specific mediality (cf. [1] Lasch 2020: 238). It thus runs counter to established academic mediation practices, but on the other hand follows the principles of the new communities just outlined. In a scientific digital culture, we can therefore help develop the forms and exploit the possibilities of processing knowledge in an alternative way - *in* the university community. We are sure that it is the right way to bring new impulses into the discussions of our universities, as is happening with this contribution.

2.2 Open Educational Resources (OER)

Participation and re-use in the common pursuit of goals succeeds especially well when *content is shared freely,* without any interest in gain. This is precisely the concern of *Open Educational Resources* (OER). Two challenges are associated with this: What content may be made available as OER and how can quality assurance be realised? Both questions touch our university as an institution at its core: how do we make our provisionally developed knowledge visible, usable and communicatively connectable? The same applies to *Open Access* (OA), the mode in which this article appears, and *Open Educational Practices* (OEP) in general. In order to put the OER discussion at our university on a sound footing, an OER display was created with interested academics from the Humanities and Social Sciences Department (GSW) and the Saxon State Library - Dresden State and University Library (SLUB), which not only explains OER, but also presents best practices. An important element is OER advice, which all staff and students can take advantage of. Further training offers from the Centre for Interdisciplinary Learning and Teaching (ZiLL) flank these efforts.

2.3 Collaborative work

In practice, *collaborative work with students,* the third example, can reveal new potentials. Prof. Dr. Simon Meier-Vieracker from the Chair of Applied Linguistics at the Institute of German Studies, for example, is, like me, massively promoting forms of open academic culture. He blogs "fußballlinguistisch", is active on Twitter, Instagram and TikTok. He produces vid and podcasts that he keeps openly accessible. WiKis and podcasts are created with students - as a matter of course, at eye level. Much of this linguistic content is OER and is on the aforementioned display, some is not. Some we discuss on *Lingdrafts,* others not. And we are currently busy creating collections (e.g. under TelekollegLinguistik) that document the diversity of offerings and establish *interfaces to the public (*also as new forms of scholarly communication), without advancing the claim that the offerings may then please be perceived by the public(s) (cf. on this expectation in the context of blog communication [1] Lasch 2020: 239).

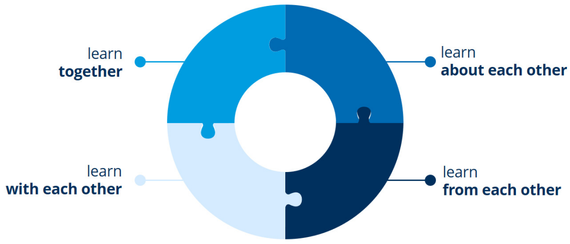

Fig. 1: Learning in open communities under the auspices of the (scientific) digital culture. CC BY 4.0 International.

They are experimental spaces that we use to show what is provisional and also to have it evaluated: For several years, I have been using forms that allow anonymous feedback by students at any time. Since the 2020 winter semester, I have decided to make this feedback public for reasons of transparency. The feedback flows directly into the formulation of objectives, at the heart of which is the effort to inspire the idea of an open Communitas University, where learning takes place together, about each other, from each other and with each other.

Openness cannot be prescribed. Openness must be worked out together. Our universities faced massive challenges last year under the auspices of the pandemic; a great deal was demanded of everyone, sometimes beyond measure. We have learnt a lot and it is to be hoped that some of the developments in higher education didactics will be consolidated. It is worth the effort for the medium-term anchoring of digital examination formats, as well as for the stronger interlocking of institutions with comparable concerns in the matter (in Dresden, these are the TU Dresden, TUD, the Dresden International University, DIU, the SLUB, and the Carus Academy at the University Hospital Carl Gustav Carus Dresden, CA/UKD). In the future, digitally supported university teaching should always be possible where it is didactically indicated. This can also extend to distance formats, for example to anchor blended learning formats in the curriculum. In this way, international teaching, learning and research cooperations are easier and, in many cases, even possible in the first place, and barriers can be lowered that previously made participation in knowledge processed at universities unnecessarily difficult.

3. *virTUos*

As I have tried to show, academic teaching in particular brings with it ideal conditions for experimenting with new forms of collaboration, documentation and presentation. These experiences and the consistent further development of digitally supported formats are now the focus at the TUD in cooperation with the DIU, SLUB and the CA/UKD in the inter- and transdisciplinary teaching and learning project *virTUos* (Virtual Teaching and Learning at the TU Dresden in an Open Source Context), which I have the honour of presenting on behalf of all those involved in the project - Henriette Greulich, Simon Meier-Vieracker, Antje Neuhoff, Stefan Odenbach, Ingo Röder, Beatrice Schlegel & Eric Schoop.

Fig. 2: virTUos. CC BY 4.0 International.

virTUos is one of 139 projects that will be funded by the Foundation for Innovation in Higher Education (Stiftung Innovation in der Hochschullehre) from mid-2020 as part of the initiative "Strengthening Higher Education Teaching through Digitisation" for a total of three years in order to provide an institutional framework for the possibilities of change and design of digitally supported higher education teaching.

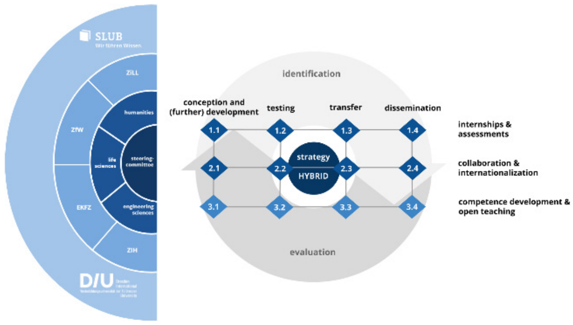

Fig. 3: virTUos structure. left: Orchestrated interaction of virTUos departments, support and transfer partners. right: Project matrix with work packages that can be assigned to three fields of action (rows) and four project steps (columns) and whose results are integrated and implemented in a university-wide strategy HYBRID. A high-resolution version of the structure can be viewed here. CC BY 4.0 International.

For up to now, the ideas and implementations, as outlined in section 2 with three examples, are largely insular without anchoring in curricula and regulations. Hybrid teaching and learning can be a pillar of a collaborative higher education development strategy in the fields of *internships and assessment formats (cf. for* example [3] Pfeiffer et al. 2018), *collaboration* (exemplary [2] Lasch & Schoop 2021) & *internationalisation (exemplary* [6] Schoop, Clauss & Safavi 2019) as well as competence development *(cf. e.g.* [5] Röhle, Horneff & Willemer 2021) & open teaching (cf. [4] *Redecker* & Punie 2017).

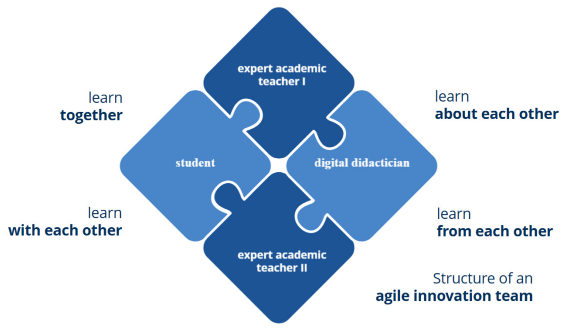

Fig. 4: Structure of an agile innovation team. CC BY 4.0 International.

Students accompany and help shape a process in which novel teaching and learning scenarios are tested, tried out and constantly developed further by interdisciplinary *agile innovation* *teams* (cf. Fig. 4) from mechanical engineering, medicine, linguistics and economics, each with concrete project plans.

Concepts of open teaching as OEP are developed interdisciplinarily and further developed and used across the universities (DIU and CA/UKD); results can be re-used as OER (SLUB). An *integration team* coordinates scaling as well as transfer and, in the *HYBRID strategy,* develops the interlinking of central and decentralised support structures, which include the ZiLL, the Centre for Continuing Education (ZfW), the Centre for Information Technology and High-Performance Computing (ZIH) and the Else Kröner-Fresenius Centre for Digital Health (EKFZ), along the requirements for study programme development and examination law interpretation. In order to make the innovative ideas visible at the university, the institutional anchoring and realisation of the solutions developed in *virTUos* is necessary in close consultation with the university management. In this way, a relevant contribution can be made to the university-wide harmonisation of digital teaching and learning approaches, which at the same time represents the structural prerequisite for strengthening a culture of digital learning in the targeted fields of action and promoting a (scientific) digital culture.

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It's all in the mix - Asynchronous, synchronous, inverted ... from annotating of presentation slides to the experiment

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Abstract

Die Übertragung klassischer Präsenz-Lehre in den digitalen Raum erfordert durch die veränderten technischen Randbedingungen meist zwangsläufig eine Auseinandersetzung mit den Lernzielen und den Methoden der Lehrveranstaltung. Im Zuge dessen wurden die Erfahrungen der zunächst erfolgten Umstellung auf asynchron bereitgestellte kommentierte PowerPoint-Präsentationen bis hin zu einem anschließend testweise durchgeführten dreiteiligen Vorlesungskonzept reflektiert. Dieses Konzept sieht eine Kombination aus 1.) asynchronen Vorlesungen mit kommentierten Präsentationen, 2.) synchrone Vorlesungen mit „klassischer" Erläuterung von vorbereiteten Präsentationsfolien als *Webmeetings* und 3.) Vorlesungen nach dem Prinzip des *Inverted Classrooms* vor. Die Evaluation der verschiedenen Vorlesungsformen durch ein und dieselbe Gruppe an Studierenden zeigte eine selbstkritische Wahrnehmung des *Inverted Classrooms* als geeignetes Element zur selbstständigen, semesterbegleitenden und tiefgreifenden Beschäftigung mit den Lehrinhalten. Die weiterhin vollzogene Adaptierung einer Experimentalvorlesung im digitalen Raum belegte die Bedeutung von *Audience-Response*-Systemen zur Förderung der studentischen Wahrnehmung aktiv Einfluss auf die Veranstaltung nehmen zu können.

The transfer of conventional face-to-face teaching into the digital space usually requires an assessment of the learning objectives as well as the methods used owing to the changed technical boundary conditions. In this context, the experiences of the transition to asynchronously provided audio annotated PowerPoint presentations and a three-part lecture concept, which was subsequently implemented on a test basis, were reflected upon. This three-part concept combines 1.) asynchronous lectures with annotated presentations, 2.) synchronous lectures with "conventional" explanations of prepared presentation slides as web meetings and 3.) lectures according to the inverted classroom principle. The evaluation of these different lecture types by one and the same group of students showed a self-critical perception of the inverted classroom as a suitable element for independent, semester-accompanying and profound engagement with the course content. Furthermore, the adaptation of an experimental lecture in the digital space proved the importance of audience response systems to support student perception of actively influencing the lecture and experiments.

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1. Introduction

The framework of classical teaching formats with a lecture hall, a blackboard and a projection screen as well as the direct verbal and non-verbal interaction between teachers and students cannot be transferred one-to-one into the digital space. This means that at least an examination of the technical conditions and possibilities is necessary, which in turn opens up a broad spectrum of didactic methods including their adaptation to non-presence-based teaching. In the course of integrating new methods that particularly address motivation, attention and interaction with students, it is advisable to rethink the usual lecture, seminar and practical course procedures and, if necessary, to reformulate the learning objectives. For the current generation of students, for example, the use of web communication platforms, web presentations and digital group meetings should be an essential part of their education. Knowledge and handling of audience response systems and web-based tools for exchanging ideas, questions, etc. is also taken for granted and should therefore be a subject of higher education.

In the context of adapting courses to the digital space, various concepts were compared and evaluated on the basis of the students' own reflections and feedback. The course concepts considered in the following are 1) asynchronous lectures with annotated presentations and videos created from them, 2) synchronous lectures with the "classic" explanation of prepared presentation slides as web meetings and 3) lectures according to the principle of the inverted classroom with individual self-study assignments for the students and subsequent consultations to clarify questions and deepen the subject content.

In addition to the experiences regarding the digital implementation of lectures, the transfer of practical teaching units will be presented and discussed. Additionally, the question will be discussed, if and how a laboratory practical course can be replaced by a synchronous demonstration lecture and how the students perceive such a live experimental lecture.

2. General conditions

The findings and suggestions for improvement are primarily based on students‘ feedback and personal assessments of the following modules:

<u>Applied biomechanics</u>

- Asynchronous digital lecture & seminar
- Synchronous digital consultations
- Semester 8
- Participants (summer semester 2020): 17

<u>Dental materials</u>

- Asynchronous and synchronous digital lecture & synchronous experimental lecture
- Semester 9 (Materials Science)
- Participants (winter semester 2020/21): 18

The presented comments of students and evaluation results were collected anonymously within the framework of mid-term and final evaluations within the modules using the ONYX test environment in the Online Platform for Academic Teaching and Learning (https://bildungsportal.sachsen.de/opal/; OPAL). Some of the questions could be answered with free-text entries others with single-choice assessments.

3. Three-part lecture concept

The implementation of different lecture methods within the framework of one module (here using the example of the lecture on dental materials, Table 1) was chosen in order to obtain feedback from the same group of students on the course itself and the implementation of the lectures in the digital space by means of the evaluation. The alternating sequence of various lecture methods was also selected in advance in order to be able to react immediately during the semester to suggestions for changes and initial experiences. This resulted, for example, in the accumulation of synchronous events in the second half of the semester and the change of the web meeting platform on request of the students.

Table 1: Course of the lecture Dental Materials with the tools and platforms used

No.	Lecture method	Tools	Platform
	Welcome video and expectations survey	Video common word cloud	OPAL / Video Campus Sachsen Answergarden.ch
VL 1	Asynchronous Lecture (Procedure: *Inverted Classroom*) Kick-off experiment	annotated PowerPoint* pdf file; video	OPAL / Video Campus Sachsen padlet.com
VL 2	*Inverted Classroom*	Learning success questions Live consultation	OPAL (ONYX test) Zoom
VL 3	*Inverted Classroom*		
VL 4	Asynchronous lecture	annotated PowerPoint*	OPAL / Video Campus Sachsen
VL 5	Asynchronous lecture		
VL 6	Asynchronous lecture		
VL 7	Asynchronous lecture		
VL 8	Synchronous digital experimental lecture and mid-term evaluation	Live lecture; shared notice-board and questionnaire	Zoom; padlet.com OPAL (ONYX)
VL 9	Synchronous digital lecture Evaluation	Live lecture Forum	Zoom OPAL
VL 10	*Inverted Classroom*	Live consultation; shared whiteboard	BigBlueButton
VL 11	*Inverted Classroom*		
VL 12	*Inverted Classroom*		
VL 13	Synchronous digital lecture Final evaluation	Live lecture	BigBlueButton OPAL (ONYX)
	Summary	annotated PowerPoint*	OPAL / Video Campus Sachsen

** saved as video file on request of students and shared via OPAL after upload on Videocampus Sachsen*

3.1 Asynchronous lectures (annotated *PowerPoint presentations* and videos)

In order to welcome the students before the upload of the first lecture and to familiarise them with the procedure, videos were recorded (approx. 15 min each, Fig. 1). An overview of the content was given, as well as organisational details on the seminar, the seminar thesis and its assessment.

The videos were published in the OPAL course before the start of the semester and were available there after enrolment in the course.

Advantageously, the welcome video can be viewed individually by the students before the start of the semester and a personal connection to the lecturer can be established, which would only be possible to a limited extent with an annotated PowerPoint presentation for the introduction and getting to know each other. This should lower the hurdle for queries and strengthen the bond to the lecturer.

Fig. 1: Two exemplary stills of the welcome video; on the left recorded via zoom (with virtual background) and on the right a pptx presentation explaining the course of the semester and the content

The time required to create the videos is comparatively little, which means that it is also possible to update several modules before the start of each semester. As a disadvantage, it should be noted that making the video available before the start of the semester suggests that the students have to watch a video, which should not be used to artificially prolong the semester. Furthermore, there is no direct feedback from the students within the framework of this form of welcome, as would be possible, for example, through a synchronous web meeting at the beginning of the semester.

After the asynchronous welcome by video, initially (as part of the module Biomechanics; summer semester 2020) only annotated presentations were recorded for the asynchronous delivery of the lectures and made available for download via OPAL. This was positively evaluated by the students: *"I think it's very good that I can listen to everything several times if necessary thanks to the slides with sound."*

"I particularly liked the fact that the (...) presentations were annotated."

The teaching evaluation further revealed that the technical implementation was rated as good by 71% of the students with regard to the quality of speech. Furthermore, the degree of stimulating language used by the lecturers was rated as mainly appropriate. In addition, the students commented, that the lecturers should strictly stick to the university's time grid, since: "*the amount that there was, to catch up on (...) was too high in the meantime*". On request of the students, the lectures, which were initially provided as annotated *PowerPoint presentations* and pdf files, were saved as videos (from the winter semester 2020/21), uploaded via Videocampus Sachsen (https://videocampus.sachsen.de/) and integrated directly into the OPAL course (Fig. 2). This solution caused the least compatibility problems for Windows, Linux and Mac users.

The evaluation and reflection of asynchronous teaching presentations with respect to knowledge presentation and scope of subject content suggests that multiple listening (or the opportunity to do so) increases the amount of impotent information perceived by students. According to the author's own assessment, missing single parts in asynchronous formats, which is quite common in face-to-face lectures, must be learned and accepted by students as an active process. In the flow of a face-to-face lecture, this ability to actively overhear is not necessary, as it arises naturally through digression in one's thoughts or the distractions caused by mobile phones, fellow students, etc. Thus, the asynchronous lecture requires a self-confident assessment by students with a certain amount of courage to leave gaps. This is partly offset by the fact that the annotation of PowerPoint slides entails less repetition and variation of explanations by the lecturer. The lack of students' questioning faces also contributes to the absence of repetition leading to re-explanation or a supplementary anecdote. However, the reduced tendency to repeat things increases the density of the content. This was shown in the evaluation, in which 57% of the students rated the amount of content and 28% the pace as rather too high (Fig. 3).

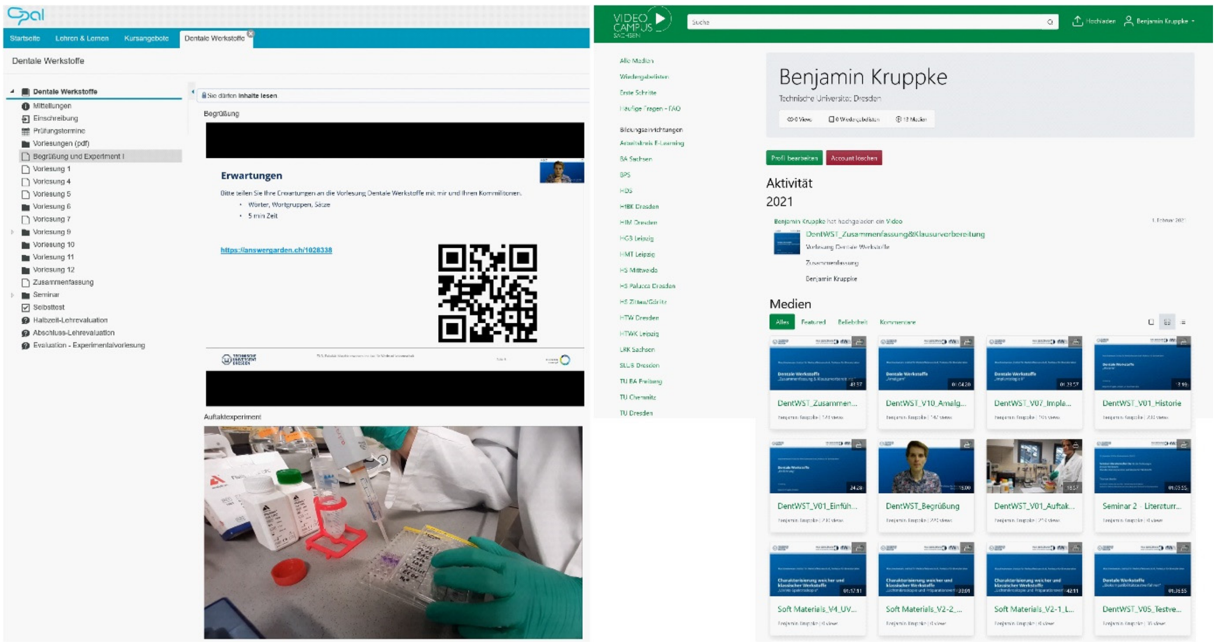

Fig. 2: Web pages: OPAL course Dental Materials with a single page and two videos embedded in it (left); the videos are hosted via Videocampus Sachsen (right) and can be accessed there after uploading and conversion in the media library.

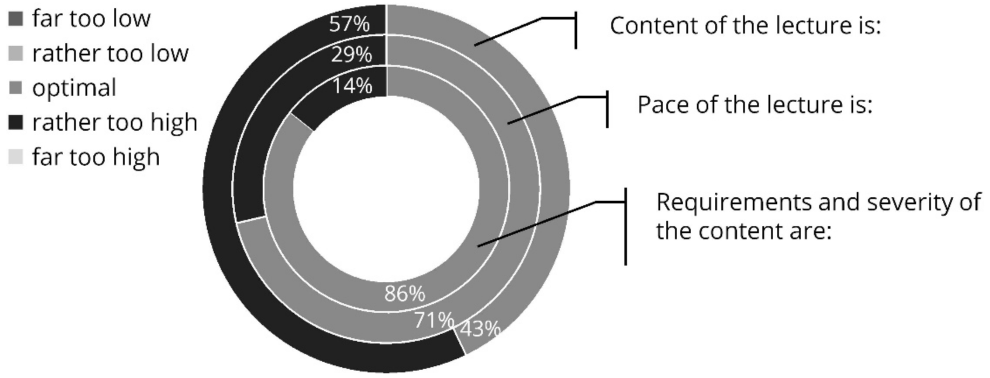

Fig. 3: Evaluation result for the predominantly asynchronous lecture in the "Applied Biomechanics" module

Nevertheless, the advantages of asynchronous lectures thus include the possibility of repeated playback, a low technical effort and a sustainability of the prepared presentations, as individual slides can easily be exchanged, re-annotated or updated. This advantage is somewhat diminished by the creation of videos, as updating is a somewhat greater effort. Nevertheless, the asynchronous events enable very flexible preparation of the individual lectures and their provision via OPAL.

The disadvantages of asynchronous teaching undoubtedly include the tendency to teach too much content, at too high pace without varied explanations. The increased degree of precision, that is required for the recording of such a permanently available lecture, increases the workload for the lecutrer. From the students' point of view, the asynchronous lecture also makes it easy to postpone it, which may lead to lesser preparation and follow-up, as the lectures are/appear to be permanently available - i.e. also directly in the context of exam preparation.

3.2 Synchronous lectures ("classical")

In order to motivate students to engage with the module throughout the semester and actively avoid procrastination, synchronous lectures were held.

Initially, a few synchronous consultations (via Zoom) were offered, which took place at the time of the regular lecture in addition to the upload of an annotated PowerPoint presentation. Concerns about possible poor connection quality, students' willingness to participate, time commitment, owing to a synchronous web meeting with students, or similar were not confirmed. On the contrary, there was great participation and even demand for consultations and synchronous lectures. This led to the frequent use of synchronous lectures in the winter semester 2020/21 in the Dental Materials module according to Table 1.

The assessment from the students' point of view was basically positive: "I found it very helpful that we had the opportunity to ask questions directly in live discussions. ". However, it was also self-critically noted that the anonymity of the asynchronous but also the synchronous events (when sound and image are switched off by students) removes the pressure to prepare for the event. This led to the idea of involving students more in the preparation for the course (see 3.3 Inverted Classroom).

During the synchronous online lectures, PowerPoint presentations were explained live and occasional comprehension questions were addressed to the auditorium. Initially, Zoom was used as a web meeting platform. Due to data protection concerns of the students, BigBlueButton was used furtheron in the course of the Dental Materials module. Since the latter does not have the option of recording the event, the classic lecture character became somewhat more prominent. However, the resulting "transience" of the course was not criticised by the students. Furthermore, the slides were made available as a pdf file.

One advantage of *BigBlueButton* is the multi-user mode, which can be used as a shared "*whiteboard*" with a blank slide of an uploaded presentation. This was used to activate the students. The joint filling of tables, the parallel note-taking of reaction sequences, etc. noticeably lowered the hurdle for students to participate. Thus, information noted in the group were explained without great delays via microphone of individual students. It is advisable to prepare and upload a pdf file for the multi-user mode, so that headings of blanked pages or similar are already present. A short note on the current task is also helpful for the students.

3.3 Synchronous Lectures as *Inverted Classroom*

As a result of the positive feedback on the synchronous lectures and the explicit request to offer more consultations, the method of an inverted classroom seemed to make sense for the synchronous lectures in the digital space.

The added value of inverted or flipped classrooms has often been explained in the literature, as they combine the self-learning phase through prepared teaching impulses in the form of videos, annotated lectures, manuscripts or preparatory questions followed by a lecture as a consultation and consolidation element [1,2]. In this way, the sometimes challenging and frustrating follow-up of classical lectures can be replaced by a consultation led by a lecturer. Here, all students benefit from the questions of individual fellow students. This process is characterised by the creation of an inclusive learning environment that actively aims to reduce barriers to learning [3]. A positive, albeit not lasting, effect on critical thinking and group work has already been demonstrated for the inverted classroom, which could be perpetuated through increased use of the method [4].

For the inverted classroom in the dental materials module, a preparation task was issued, which the students worked on in self-study between two courses. For this purpose, pdf files were made available via OPAL, which contained up to three topic complexes for preparation. It seems to be particularly important to have very precisely formulated and thematically well-defined tasks, if necessary with suitable literature references. Priority should be given to low learning levels (knowledge, understanding) according to Bloom's taxonomy of learning objectives [5,6]. Higher levels of learning (application, analysis, synthesis, evaluation) should be part of the synchronous courses.

Within the framework of the synchronous lectures, questions that arose from preparing the tasks were addressed first. In order to bring all students to the "same level of knowledge", a preparatory task was first presented by a student and the researched contents were presented. Additional information was added by other students. Subsequently, in-depth contexts were explained and visualised by the lecturer with selected PowerPoint slides. The deviation from the rather rigid order of a classical lecture can be counteracted by taking up and discussing the other preparatory tasks according to the same scheme.

A forum set up in the OPAL course, in which students were supposed to help each other with questions and solutions, was hardly used, despite several calls for participation. This circumstance did not even change after formulating work assignments to comment on each other's contributions in the forum.

As a result of the different types of lectures in the module, an evaluation was carried out which asked for the students' assessment of the amount of content, the pace and the standard of the content (Fig. 4). The majority of the students' assessments were optimal in all points.

The question about the structure of the course (Is there a recognisable thread?) was also answered with 71.4% "completely agree" and 28.6% "mostly agree". Thus, the multiple change of the lecture method as well as the switch to a different web meeting platform do not seem to have had a negative influence on the comprehensibility and structuring.

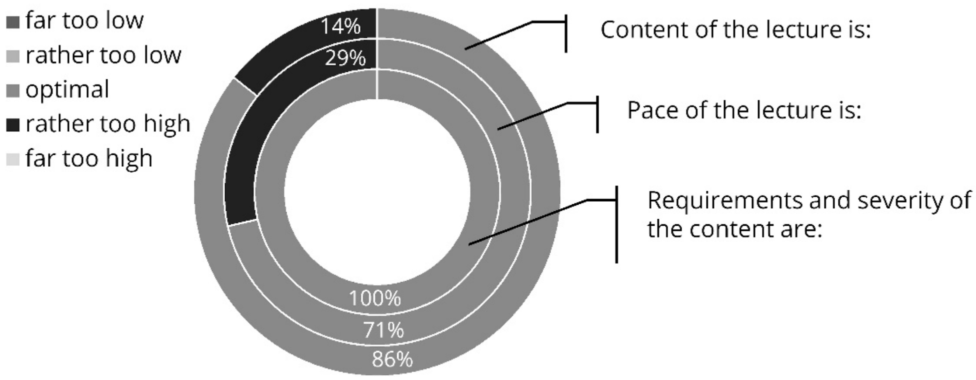

Fig. 4: Evaluation result after combination of different lecture methods in the module "Dental Materials"

4. Experimental lecture

In order to offer students a practical aspect in the digital semester, the opening experiment usually conducted with the students in the lecture hall was extended and an experimental lecture was held halfway through the semester [7].

An earlier study within the framework of the professorship for biomaterials dealt with the activation of study applicants through an internet-based blended learning module, whereby it was shown that it is possible to inspire particularly qualified and motivated students for a biomedical degree programme at a university [8]. In contrast to this, the question now arose, as to whether and how the activation of students who are already familiar with the university learning situation can take place in the digital space, since in contrast to the classic and rather one-sided lecture, active participation of students within the lecture (as feedback for the lecturer) was now desired.

As an impulse and to motivate the students, a collection of ideas was initiated in the 1st lecture of the Dental Materials module by means of a digital pin board (www.padlet.com), in which experimental parameters and methods of analysis for the examination of tooth hard substance were suggested by the students (Fig. 5).

The web-based pinboards were created in advance of the experimental lecture to give students the opportunity to give direct feedback or suggestions on the experiments and their subsequent evaluation. The structure of the pinboards was adapted to the corresponding experiments (free notes, columns, timeline). For example, one pinboard was filled by the students as an expectation query of an experiment, while the preparation of another experiment took place [7].

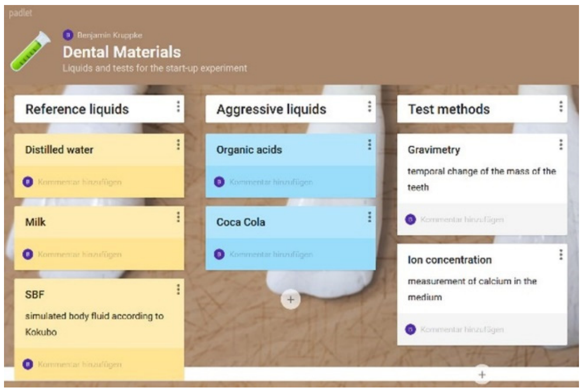

Fig. 5: Exemplary collection of notes on a digital pinboard - web-based asynchronous possibility to collect suggestions via padlet.com (according to [7])

Another pinboard was created for an expectation query as a timeline to visualise along the given axis the sequence of the electrochemical potential of different metals under investigation. Students could access the padlets via a QR code (on PowerPoint slides) or a hyperlink (posted in Zoom Chat) at the appropriate time.

The advantages of such audience response systems (e.g. Padlet) have already been described extensively in the literature, whereby the group character of the chosen web tool can fundamentally help to reduce the fear of a wrong answer [9]. In addition, the immediate mutual feedback (peer feedback), which is not directly addressed to the lecturer, has been shown to be a particularly beneficial element of digital courses [10]. Digital pinboards are also a popular and positively evaluated tool with regard to inclusion and lowering learning barriers for people with disabilities [11,12].

The suggestions submitted via the asynchronously filled pinboard (Fig. 5; supplemented by established methods from the previous year) were included in the experiment. The start of the experiment was documented by video and made accessible to the students via OPAL. This asynchronous start of the experiment was followed (after a 7-week incubation phase) by its evaluation in the context of a synchronous experimental lecture. The course and evaluation was published earlier with a detailed description of the material scientific experiments [7].

As a brief summary, the process and student perception of the experimental lecture can be described as follows. In addition to selected other experiments, the evaluation of the kick-off experiment took place during the synchronous digital experimental lecture. This was transmitted from the laboratory of the Chair of Biomaterials via Zoom and transmitted by means of the Logitech Group conference system (movable and programmable HD camera with 10× optical magnification; microphone & loudspeaker as well as 2 extension microphones).

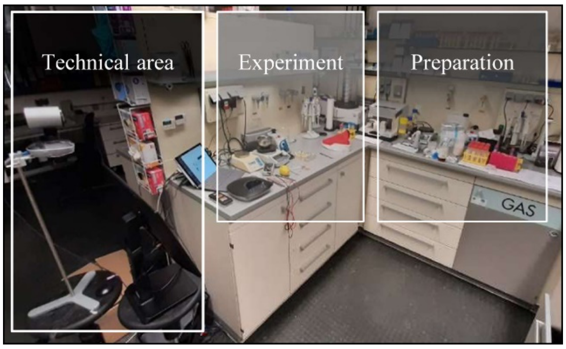

Fig. 6: Photograph of the laboratory with division of the three work areas (according to [7]).

In the laboratory, the separation of the areas (technical area, experiment, preparation; Fig. 6) was suitable for filming a clean work area for the students. Saving up to five camera positions and magnifications contributed to a continuous transmission with smooth changes between detailed shots of experiments, long shots for greetings and explanations and half shots for the working area, etc.

The use of an external monitor to control the web meeting and the main monitor e.g. for explanatory PowerPoint slides or live surveys is highly recommended.

During the experimental lecture, expectation polls were conducted for the individual experiments and the students were able to explain their hypotheses directly via microphone or by means of the digital pinboards. This resulted in a lively exchange and the students voted for an extension of the event in order to be able to experience all the experiments live.

5. Teaching evaluation and reflection

Of particular interest was the evaluation of the inverted classroom in comparison to both established methods in form of asynchronous lectures (recorded/annotated presentations) and the synchronous lectures (live explanation of slides in a web meeting). This comparison was filled as a free text within the evaluation by 7 students (out of a total of 18 students who took part in the final examination) as follows:

"With the inverted classroom, it was easier to understand the subject matter because you had to think for yourself, but the effort up front was not insignificant."

"The online lecture is much more pleasant in my opinion and I was able to internalise the content better in this one."

"I find synchronous online lectures the best. For me, it's like the classic lecture but at a cosy desk and not on the hard wooden benches. But the inverted classroom also has definite advantages. Maybe the implementation still needs a bit of tweaking so that the preparation effort [is] balanced out."

"I [find] the concept of the inverted classroom very good. The subject content can be internalised better compared to the normal lecture. If I were to choose a mixed concept [...] I would place the majority of the inverted classrooms [at] the beginning or in the middle of the semester [...]."

"I am not a fan of the inverted classroom. As soon as face-to-face lectures are possible again, online events should be waived. Small preparatory tasks for the lecture are nevertheless useful."

"For me, it is easier to internalise subject content with the Inverted Classroom because: a) I am forced to really deal with the subject and not just a week before the exam. b) I cannot digress as easily as in a normal lecture. In addition, the Inverted Classroom offers a better opportunity to clarify questions that arise."

"The concept of the inverted classroom makes total sense to me. Students should be able to acquire very basic knowledge á la "name" or "draw" themselves in order to later use the time with the lecturer effectively for more complex contexts".

The positive feedback on the concept and implementation of the inverted classroom (despite its first-time implementation) should encourage greater use. This should be seen above all against the background of the effort that has to be planned anyway for the transformation of courses from the lecture hall to the digital space.

The second didactic challenge in the transfer of classical teaching formats into the digital space concerned the practical element, which was transferred into an experimental lecture with activating (audience response) methods. Here, the question arose as to what the students particularly liked about the experimental lecture:

"Definitely that it existed at all. The practical reference was really fun, even if it was online. A lecture like this should be done in many more modules."

"The will to make experiments possible despite the online situation. The setting in the laboratory. The illustration of lecture content by practical example."

"The experiments were very well structured and the learning content was conveyed in a sympathetic manner. The ratio of experiments to explanations was optimal. It was easy to follow and will be remembered for a long time. [...] These various pre-programmed camera settings actually make an assistant superfluous, but also shows how well the entire procedure was thought through in advance."

The question of what the students did not like about the experimental lecture was answered as follows:

"I thought they were really good, no criticisms."

"I can't say anything negative about the lecture."

"The time pressure, which left too little time for understanding and comprehension. Perhaps it would be better to do 1-2 experiments less."

The predominantly positive assessment of the students justifies the significantly higher time for preparation and the rescheduling of the experiments for implementation in the digital space. The experiments (despite being carried out by a lecturer) represent added value in the perception of the students and can also be linked to many important learning objectives from the perspective of the teacher.

Of course, the learning of hand movements and behaviour in the laboratory remains underrepresented, but with the help of the audience response systems, an indirect as well as direct influence can be taken on the live experiments. As a result, the students came to the conclusion, among others, that "one had the feeling of being "live" on site".

In this context, it should be taken into account that many practical courses in engineering studies are carried out in groups anyway, which means that only some of the students are actively involved in carrying out the experiments, while others observe the process. Maintaining the attention of the students during the video broadcast was also successful through the varied implementation of the experimental lecture with segments of interaction, experiment execution and evaluation.

This can be concluded from the evaluation of the ratio of experimental sequences to scientific background sequences. Thus, the selection of experiments and the ratio of experiments to explanations was rated as very good by 50% of the students, as good but with too many explanations by 33.3%, and as good but with too many experiments by 16.7% of the students. The evaluation of student participation via padlet, chat, surveys and feedback via microphone was rated as very good by 50% of the students and as good by 50%.

As an evaluation of audience response systems from a lecturer's point of view, it is necessary to keep the pedagogical goal in mind, which in this case means that students should perceive themselves as part of the experimental process. Thus, the systems should not be used in the sense of a fun and anonymous tool, which has been shown as a result of other research [13,14]. To avoid this, a close relation of the queries to the experimental procedure was used, whereby open questions that encourage comments or discussions were formulated as far as possible. In this way, a purely voting-oriented use of the audience response systems was avoided. As a result, a high level of participation was present, which had not been observed in previous face-to-face events. This confirms the high attractiveness of synchronous lectures in the digital space, on the one hand, in contrast to face-to-face events and, on the other hand. This is especially true in comparison to recorded lectures, which has also been shown in other studies [15-17]. It should be noted that students like to access recorded lectures to prepare for exams or to catch up on missed lectures, but that in most studies they prefer access to synchronous online lectures [16].

6. *Lessons Learned*

In conclusion, the lessons learned from the transfer of conventional face-to-face lectures into the digital space can be summarised as follows with respect to the three aspects of technology, teaching methodology and students:

Technology

- External high-quality microphone for clear voice recording without clipping or noise (e.g. auna CM600 USB - condenser microphone)
- Flexible and controllable camera system and multiple microphones (e.g. Logitech Group) or lavalier microphone for experimental lectures offer freedom of movement and variety for spectators
- Speech pauses when changing slides in PowerPoint so that all comments are played back completely
- Videos uploaded to Videocampus Sachsen and integrated into the OPAL course offer students the highest platform compatibility (better than (password-protected) annotated PowerPoint presentations).
- Limiting the online tools to one asynchronous communication channel (e.g. common digital pinboard) and one synchronous communication channel (e.g. chat or voting) serves to provide an overview and focus on didactically appropriate use.
- Less is more ... Concentrating on methods, formats and techniques that you yourself enjoy. This spark jumps over to students even in the digital space.

Teaching methodology

- Avoid postponing to listen lectures provided asynchronously by tasks (e.g. with learning success questions or timely and regular consultations with comprehension questions)
- Synchronous events promote continuous engagement with teaching content
- Confront students during consultations with tasks that require responses - No: "Are there any comprehension questions?"
- Forum for mutual help among students is not suitable for small groups (here: 20 students)
- Formulate tasks/self-learning assignments very precisely in the Inverted Classroom
- Check/reduce amount of content
- Showing instead of telling (in lecture and with experiments, also in the digital space) or even better:
- Let them work it out themselves and explain it together instead of presenting it.

Students

- *Inverted Classroom* means noticeably more effort for students - this must be taken into account and appreciated (self-learning tasks as a starting point in courses).
- Digital experimental lectures, despite being purely demonstrative, can provide an immediate view of what is happening, which can be perceived as "*being closer to the scene*".
- Cooperation increases if groups are activated (shared pinboard or shared "whiteboard")
- Very good examination results confirm intensive engagement with asynchronously provided materials
- Commitment and open-mindness are rewarded, which means that concepts that can still be optimised are tolerated.

- Students recommend when dealing with first-year students in digital-only semesters: "INFORMATION is the most important thing", "for digital delivery I recommend (...) weekly live conferences" and "support the exchange of phone numbers and email addresses".

7. Conclusion

In summary, the combination of a teaching concept that is adapted to the digital space and the corresponding technical framework conditions can be evaluated as the fundament for successful online teaching. Activating methods help to overcome the distance between lecturers and students as well as the distance between students and to increase the willingness to communicate. The use of *audience response systems* should follow the respective learning objective, which can be implemented with precise but open questions or tasks.

Activating students within the framework of the inverted classroom requires a conceptual revision of the courses, but can promote willingness to learn over the whole semester. This stimulates the questioning of the course content through independently acquired knowledge.

As a result, it seems that instead of a complete transfer of face-to-face teaching into a rigid online concept, a combination of different lecture concepts in the digital space is particularly recommendable. In this way, many types of learners can be addressed or event preferences taken into account, and the flexibility allows the event to be adapted to the complexity, topicality and accessibility of the content to be taught.

In the future, the combination of different course concepts and forms of communication certainly seems to be preferred by a large part of the students, whereby finally, reference should be made to the high significance of face-to-face teaching (Fig. 7).

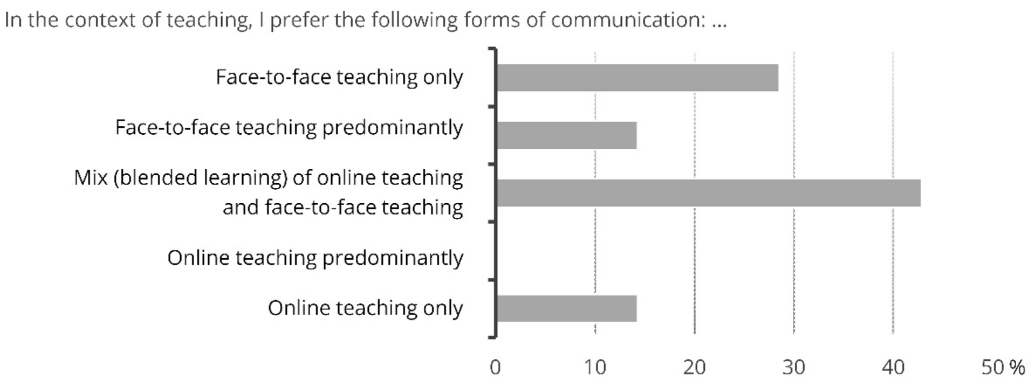

Fig. 7 : Evaluation result for online teaching versus face-to-face teaching in the dental materials module after implementation of the three-part lecture concept

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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).

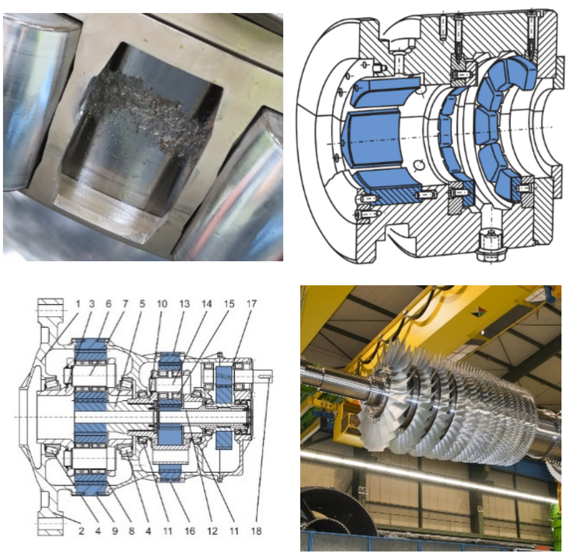

Fig. 1: Machine elements - examples of use

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.

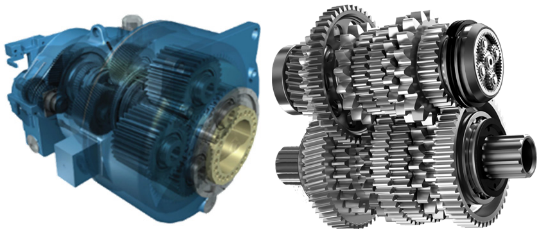

Fig. 4: Spur and planetary gearboxes

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.

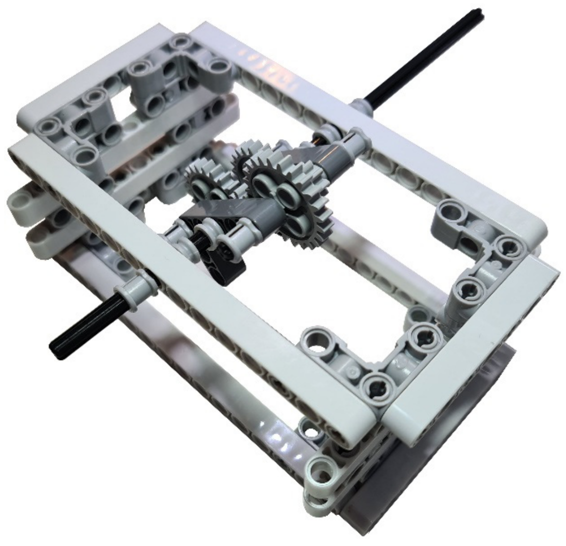

Fig. 8: Model explaining the self-locking effect

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.

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Design options for online teaching in the assembly of flexible materials

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Abstract

In diesem Beitrag wird ein Erfahrungsbericht über die Umsetzung der Online-Lehre und eine konkrete Aufgabenstellung während des COVID-Semesters in den Jahren 2020 und 2021 vorgestellt. Die Montage von flexiblen Materialien beinhaltet viele manuelle Tätigkeiten, die bisher von den Studierenden während der Praktika selbst durchgeführt werden konnten. Gezeigt werden zwei Aufgaben zur Online-Unterstützung der Lehre durch die Programmierung einer 3D-Visualisierung der Stichtypen und der Dokumentation der Montagevorgänge durch Video oder Bild- und Textreihen. Die Erfahrungen zeigten, dass diese Visualisierungsvarianten den Personalaufwand etwas reduzieren können, aber das Mitführen eines Abspielgerätes (Tablet) von jedem Studenten während des Praktikums erfordern. Die Erfahrungen aus den beiden Aufgaben sollen auch für die Zukunft genutzt werden, um den Studenten mehr eigenständige Aufgaben anzubieten.

This paper presents an experience report on the implementation of online teaching and a concrete task during the COVID semester in 2020 and 2021. The assembly of flexible materials involves many manual operations, which until now could be performed by the students themselves during the practical courses. Shown are two tasks for online support of teaching by programming 3D visualisation of stitch types and documentation of assembly operations by video or series of images and texts. The experience showed that these visualisation variants can reduce the staff input a little, but require carrying a playback device (tablet) from each student during the practical. The experiences from the two tasks will also be used for the future to offer the students more independent tasks.

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1. Introduction

In the course "Machines and processes of ready-made clothing technology" the students learn the functioning and construction of the machines for joining flexible materials. While the non-initiated of ready-made clothing technology only understand sewing cheap T-shirts, the experts know that the scientific preparation of this subject requires a multidisciplinary deeper knowledge from several subjects. The optimisation of a sewing process for joining components made of high-performance fibres, as well as the automatic sewing of human skin, starts with the kinematic analysis of gears with complex spatial movements. The laws of motion are then only the first step for the analysis of the interaction between the machine elements and the moving viscoelastic one-dimensional material - the sewing thread that is pulled 100 times a second, then bent, kinked, heated by friction and relaxed again at the end.

The design of the textile assembly is also complex - the flexible fabrics must be folded in the right places for individual processes, then brought together as several layers on the machine and then folded over, untwisted, heat-set, etc. Before an engineer begins to robotise or at least partially automate such a process, these steps must first be fully understood. In the pre-Covid days in the presence factory, these skills were taught as practical exercises directly on the sewing and welding machines and the ironing machines. As Aristotle already knew [2] and the pedagogues confirm - the probability of retention in do-it-yourself is 90% because several channels - sight, hearing, touch - are addressed at the same time.

This paper presents some problems encountered in the preparation of individual contents for distance self-learning, which was necessary to keep the attendance times and the number of people in the laboratories within the permissible limits.

2. Typical tasks

One of the tasks of assembly is to learn the thread interlacements (stitch types). Besides the mostly known lockstitch, which runs on household sewing machines and is also predominantly used for joining seams in industry, there are numerous more complex stitch types, divided into several classes. Fig. 1, for example, shows a cover chain stitch, represented in the usual in the books drawing.

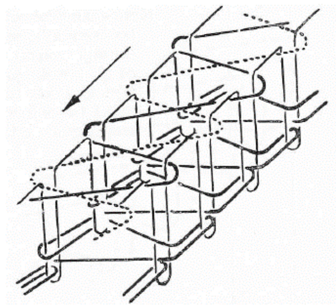

Fig. 1: Cover stitch [1]

If you sit on the sewing machine and create this type of stitch yourself, the movements of the individual organs are clear and the end product is also visible from above and below. The same effect is difficult to achieve with a drawing.

The main task of the practical training is to learn how to sew together a whole product such as a shirt, laptop bag, seat cover or similar. This task requires a longer sequence of spatial movements of both hands with at least 3 fingers each and their interaction with fabrics and machines. This is realised in the presence mode by "show" and "let repeat".

3. Basis for implementation Dokuwiki - the "learning studio"

OPAL is a powerful tool for regulating access to a repository of material and data. At the beginning of the COVID period, the built-in wikis and learning modules were not suitable for serial processing of large quantities of images and materials. In order to still be well prepared in terms of time for the semester of "teaching without a lecture hall", after several weeks of struggle with Opal, the author spontaneously decided to install a second wiki on the professorship's webspace, which runs as a DokuWiki [3], and to design the content there. Thus the "Learning Studio of the Professorship Development and Assembly of Textile Products" was born.

Why Dokuwiki as Wiki? The decision was made internally years ago, based on the Wikimatrix [4] and tests with MediaWiki, TWiki, PhP Wiki, WordPress and Joomla. Reasons for this:

- it is freely accessible and open source
- it is small and fine (3.6 MB installation)
- it only needs PHP and no SQL database, so it runs on the TUD webspace
- it uses plain text files for the contributions, which can still be directly accessed and used in the event of a theoretical crash
- it provides a simple backup of all data
- a simple restore by unpacking the backup from the folder is possible
- it has namespaces (folders) with the possibility of regulating access rights
- it allows the embedding of YouTube videos
- it has a syntax that is easy to learn
- several plug-ins are available
- HTML, Latex also PowerPoint (through VBA script) can be converted into Dokuwiki format by pandoc [5].
- The author already maintains several such wikis and has experience with them. Thus, the creation of teaching materials can be realised quickly.

4. Virtual representation of stitch types

In order to enable the active understanding of the learning material: Crossing of sewing threads, according to the principle "do it yourself", the following task was designed: Each student is given an individual stitch type, and in addition a parametric 3D model is to be created in Python. For the 3D data set visualisation, a freely accessible viewer is provided by the author. At the end of the assignment, the thread lengths are to be calculated. With about 15 students, there were no problems in distributing the individualised tasks, but after the first ZOOM lesson on this topic, it became apparent:

Lesson Learned 1: The students in the 8th semester have "already" programmed (and passed the computer science exam in C#), but they cannot demonstrate proper algorithmic thinking.

Lesson Learned 2: Not much knowledge has been retained from the programming units, in the first semester, as hardly any of the honoured colleagues seem to ask for it or maintain it.

As a result, the following content was prepared as "Step by Step Introduction - Python for Beginners" (Fig.2), "Seam image as 3D projection, the coordinates are described parametrically and coded in Python" in the Learning Studio. An easy-to-install and "low-maintenance" environment "Thonny" [6] was found.

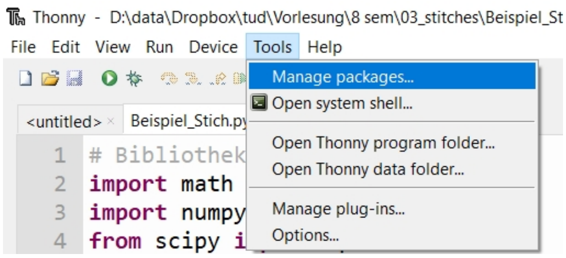

Fig. 2: Picture from the step by step instructions for Thonny

After two sessions of 90 minutes each and an additional demonstration of the step-by-step instructions, the "aha effect" came to the students with the first colourful images as a result, as in Fig. 3.

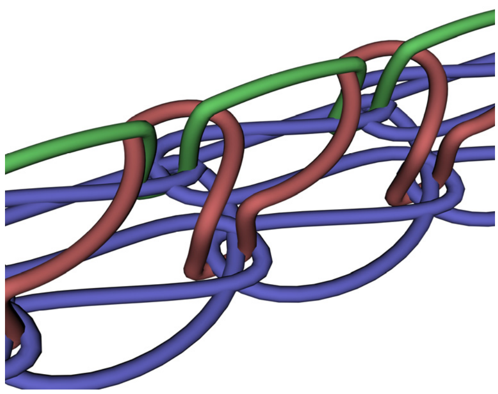

Fig. 3: Generated 3D image based on a parametric model of the student K.H.

The attempt to have the students determine the length of the thread alone failed. Here the hints about numerical integration or Pythagoras in space and "loop" did not really help.

In further Zoom meetings, the algorithms were dealt with, how to go through the coordinates with a loop and how distances are added.

Lesson Learned 3: The generation born with "mobile phones in their pockets" still cannot practically apply what they have learned in mathematics, numerical methods and computer science.

Most students found the wiki content with pictures and detailed explanations (it is an electronic manual) more enjoyable to use than recorded videos because they could go through the content at their own pace.

Lesson Learned 4: Text with explanations is easier to follow, the small amount of data is about 2-3 MB per lesson.

Lesson Learned 5: Resumption of the lecture is nevertheless desired.

Nevertheless, some students have asked to make the recorded content with explanations additionally available via ZOOM. (Amount of data x00 MB per teaching unit)

5. Assembly technology

The technology of assembling individual products in industry is supplied for 4 learned "operators of sewing machines" as a table with machine types and short descriptions of operations, naturally supplemented with pictorial material, as shown in Fig. 4. There, the cross-sections at the joints and the associated seams are shown.

The picture in Fig. 4 shows the "**finished state**" **of** the joints, but not the sequence of hand or machine movements used to bend, guide and sew the soft textiles. To explain more by ZOOM on the basis of this picture is pointless.

An alternative, which excites many people, are the videos on YouTube (Fig. 5). To put it into practice, it means getting or borrowing a sewing machine at home, putting the computer next to it and watching each step, pausing the video and then practically repeating it yourself.

In principle, this proves to be a good solution if one wants to overcome the annoying advertising in YouTube. By using the newly designed Video Campus Saxony [7], this problem is solved and, in addition, the author rights and access are very professionally regulated.

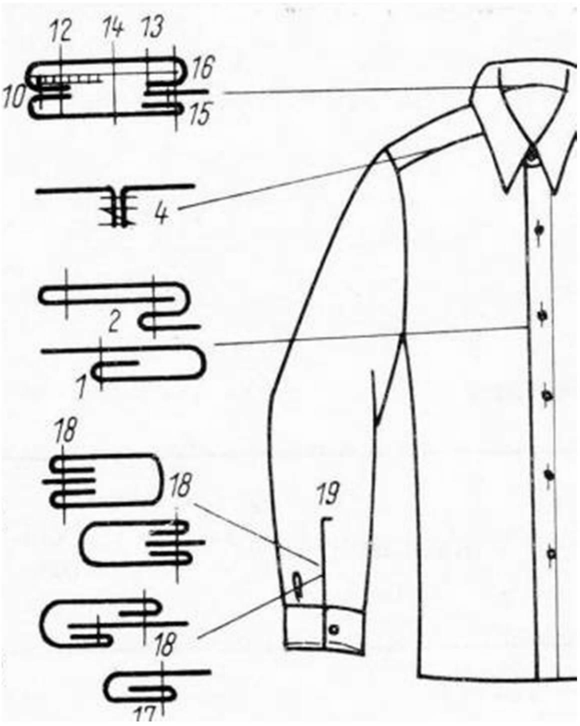

Fig. 4: Excerpt from the sequence for assembling a shirt [1].

Fig 5. YouTube video on how to create a bag [*https://www.youtube.com/watch?v=Zx4yKzfRrus*](https://www.youtube.com/watch?v=Zx4yKzfRrus)

Nevertheless, the videos have some disadvantages as a medium - you can't watch the whole thing clearly in a quick pass and then concentrate on specific passages, and they still require a lot of data volume, a good internet connection and a lot of preparation work in recording and video editing.

For this reason, alternative variants were sought, such as pictorial representation of the individual operations, with some text, as befits a classic book (Fig. 6).

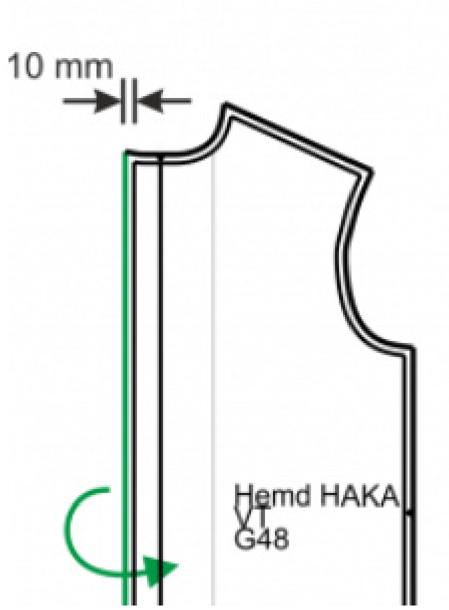

Fig 6. Illustration of an operation during manufacturing

This variant required significantly less storage space, is somewhat clearer than individual cross-section images and allows quick perusal and deepening at individual points. In terms of effort, this variant is not faster than the production of a video - in this case, a member of staff also had to work on the diagrams for a few days with CorelDraw.

The test phase with about 15 students in the first run found this presentation not really helpful. When questioned about the reasons, it was explained that the problem was not with the presentation but with the application - here the students were asked to look at the sequence and practise "dryly" at home (which of course did not happen) in order to move forward with less explanation afterwards during the practical. Like leading Augmented Reality users, one would have to place an AR Glass or at least a tablet or laptop next to the sewing machines here - whether YouTube video or pictures as a series of images - for it to have an effect.

This possibility was also thought of, but the problem turned out to be that:

a) no laptop fits straight next to the machine for reasons of space

b) it makes technological sense for the student to carry their tablet/screen/laptop and look at the next steps.

This last option is being planned and will be tested in the near future, because it allows for a more dynamic design of the practicals even in normal times, where each student can work on the assignments at his or her own pace.

6. Summary

The introduction of 3D seam programming has only partially replaced the practical exercise, but has also resulted in students learning methods for representing seams and later being able to use these representations directly for FEM calculation. This unit will also be continued in post-Covid times.

The presentation of the production technology as a video or series of images with explanations is possible, but its application requires that this content is taken along on a portable tablet right next to the machine. This implementation will also be tested and further developed in the future to optimise the supervision effort and to create more individualisation in the practical units.

Mails like this " I learned a lot and found the tasks super, I enjoyed it. :)" (A.G., 13.08.2020) have confirmed my more than 20 years of teaching experience that the way to design a semester accompanied by individual assignments and to honour them in a way that is relevant to the exam - has been right.

Acknowledgement

Many thanks to Ms Claudia Neumann SG 7.5 and the web support team for the competent advice and quick regulation of the professorship's web space, where the Learning Studio was implemented.

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The practical in the virtual - digital teaching at the ILK

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Abstract

Die Umstellung der Lehre am Institut für Leichtbau und Kunststofftechnik von Präsenz- zum Digitalangebot stellte Lehrende wie Studierende gleichermaßen vor enorme Herausforderungen. Um ein hohes Niveau der studentischen Ausbildung zu erreichen, wurde ein umfassendes Lehr-Lern-Konzept entwickelt. Dieses Konzept umfasst vier Aspekte der digitalen Lehre: neben Lernen und Lehren sind auch die Bereiche Beraten und Begleiten, Prüfen und Bewerten sowie Evaluieren und Feedback für eine erfolgreiche Durchführung der Lehre von wesentlicher Bedeutung. Mit diesem umfassenden Ansatz wurde die Entwicklung der jeweiligen digitalen Lehr-Lern-Formate für sehr unterschiedliche Lehrveranstaltungen ermöglicht. So wird die konkrete Umsetzung mit den angewandten Methoden sowohl für eine eher theoretisch-analytische als auch für eine eher technologieorientierte Lehrveranstaltung vorgestellt.

Converting teaching at the Institute of Lightweight Engineering and Polymer Technology from face-to-face into a digital concept posed enormous challenges for lecturers and students alike. In order to achieve a high level of student education, a comprehensive teaching-learning concept was developed. This concept comprises four aspects of digital teaching: in addition to learning and teaching, the areas of advising and accompanying, examining and assessing, as well as evaluating and providing feedback are also essential for a successful implementation strategy. This comprehensive approach enabled the development of the respective digital teaching-learning formats for very different courses. Thus, implementation results with the applied methods are presented for both, a theoretical-analytical and a technology-oriented course.

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This article was originally submitted in German.

1. Adjustment of teaching at the ILK

Like most institutes of the TU Dresden (TUD), the Institute of Lightweight Engineering and Polymer Technology (ILK) was forced to move its entire (face-to-face) teaching programme with more than 15 courses into the digital space. In addition to the challenge of preparing content appropriately, it also had to be made accessible to students. There has been experience in using the OPAL learning platform since 2014, although it was mostly used for providing scripts and organisational information.

In addition to the need of digital rooms, which were only available to a greater extent and capacity in the course of the first weeks of the semester, there was also the requirement to make the lectures available in video formats. The intention was giving students the opportunity to avoid highly frequented time slots with sometimes high server utilisation and to download or stream course material for self-study according their own time planing. A central video platform is available for making video files accessible, which on the one hand can be very large and also have different formats. Before the introduction of the *Video Campus Saxony* (VCS, starting in winter semester 2020/21), the streaming service MAGMA was used at the TUD. For the majority of lecturers, using MAGMA was new and unfamiliar. Video files will be uploaded by the lecturer, but must then be optimised by the plattform so that they can be played smoothly and barrier-free on any computer system. Due to the sudden large upload volume at the beginning of the semester and the necessary transcoding processes, there were sometimes waiting times of several days before the lecture videos were available. Some lecturers helped themselves with provisional solutions, for example by making the files available via their official cloud store or by exhausting the storage capacity of OPAL (1 GB). The introduction of the new video platform (VCS) has shortened waiting times and simplified handling. The disadvantage, however, is that it is no longer possible to file in a structured manner in folders. The ILK refrained from using private services such as *Youtube* or *Vimeo*.

It was also necessary fundamentally changing communication with students. Whereas before "digitalisation" announcements for changes of dates, SHK applications, etc. were essentially made verbally during the courses. After cancellation of all live lectures only the digital way was usable. Obviously, the faculty decided to use OPAL for this purpose and advertised it prominently on the homepage as well as via e-mail distribution lists - especially directed at students. For this purpose, a catalogue of all courses with the corresponding internet addresses of the OPAL courses was provided. Older semesters may be used accessing OPAL, but first-year students lack experience in using it. Providing the virtual addresses and the announcement that all communication for the courses would take place solely via OPAL, the way in which teaching material and longer-term information is made permanently available could be standardised at the faculty and thus also at the ILK.

With OPAL, a central, albeit only virtual, point of contact has been established through which important news can be quickly and widely distributed to students and teachers.

2. Dimensions of digital teaching

The summer semester 2020 presented students of lightweight engineering and the staff of the ILK with enormous challenges, especially in practical lectures. In contrast to normal lectures, which could be transferred into cyberspace after an acclimatization phase but with increased effort, the preparation, implementation and follow-up of digital exercises and practical courses require entirely new didactic-methodical learning-teaching concepts. The experience gained in the process was mostly used on a weekly basis iteratively improving the teaching-learning concepts. Four aspects of digital teaching were focused on in particular:

- 1. learn and teach,
- 2. advise and guide,
- 3. check and assess, and
- 4. evaluate and feedback.

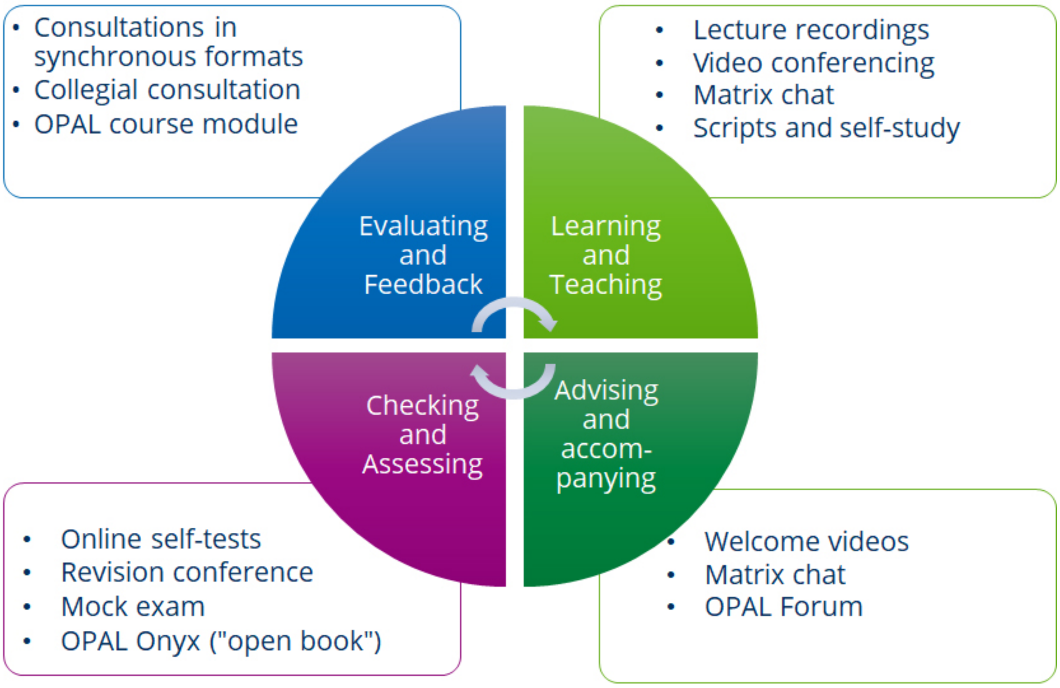

Fig. 1: Dimensions of the digital teaching-learning formats tested at the ILK with exemplary fields of application

Figure 1 provides an overview of the dimensions of the teaching-learning formats tested at the ILK, each with exemplary applications.

At the beginning of the semester, activities were concentrated in the area of teaching and learning. Here, the activities focused on the digitisation of documents for lecture, exercise and laboratory work as well as the establishment of digital communication channels.

Exchange among students and between students and teachers is essential for successful teaching. The semester-long counselling and support took place through different channels, which had to be established in the course of the semester. In retrospect, this dimension of digital teaching still needs to be greatly expanded.

The conversion of the examinations to a partially digital OPAL-ONYX format was supported by semester-long self-tests and a mock examination, so that content-related and technical challenges could be addressed by students and lecturers alike.

An important building block for the continuous improvement of teaching, whether digital or analogue, is qualified feedback from students. This was obtained whenever possible through direct teacher-learner discussions.

In addition, the OPAL evaluation modules of the Faculty of Mechanical Engineering were used. It can be seen that relatively few students take the opportunity to provide feedback on the teaching-learning concepts that have been implemented. The activation of students needs to be increased in the coming semesters.

In the following, the collected findings on the teaching-learning concepts in the digital summer semester 2020 are presented and compared on the basis of two courses (LV) in the eighth semester: The applied methods are considered both for a more theoretical-analytical course such as "Calculation of Composite Structures 1" (BerFVS1) with 79 students and for a more technology-oriented course such as "Plastics Processing" (KV) with 103 enrolled students.

3. Teaching and learning

In both courses, the lecture slides were discussed using the audio recording function and made available to the students weekly as a video and PDF script. Additionally, in the summer semester 2020, interactive PowerPoint formats were investigated in which various areas of the slides were discussed only after the push of a button, where individual explanations could thus also be repeated. The feedback was generally positive. However, a high level of programming was required for an intuitive and error-free process, which is why this format could only be used selectively. The use of videos and pen input during lectures was also evaluated very positively. While the lectures were initially provided as PowerPoint slideshows, they were later switched to a video format. Feedback from the students was decisive for this. On the one hand Microsoft PowerPoint is not available for every student and on the other hand it is easier to navigate in videos. Initially, the scripts provided had a password-protected editing lock, which was later relaxed at the request of the students so that comments and markings were also possible in the electronic PDF document.

In order to encourage students to communicate more actively, a consultation will be added to the lecture videos in the summer semester 2021. It will take place at the beginning of each lesson and should give students the opportunity to ask questions about the content covered of previous weeks. Students can then actively prepare for this consultation. Self-tests will be made available in OPAL after each lecture, with approx. 5-6 questions following the format of the examination at the end of the semester, which deal with the contents of the lecture. This procedure meets with lively interest, especially among the active students, and enables the lecturers to assess the current state of knowledge. It helps the students to formulate concrete questions. There has been very positive feedback on the first consultations in the summer semester of 2021, although only around 10-15% of the enrolled students take part.

The exercise outputs in the subject *BerFVS1* were provided in a similar way using the OPAL education portal. At the time of the planned exercise lesson, the students could ask questions via the subject-specific Matrix-chat in order to solve the tasks independently. Afterwards, the sample solutions were published to give students the opportunity to revise their results if necessary. Formulating and answering the questions was cumbersome and therefore only used sporadically. In order to improve the activation of students, synchronous video conferences using *Zoom* were offered from the fourth exercise unit onwards. Technically, the sessions ran smoothly, but passive and active participation was still rather low, at around 20 and 5 people respectively. Possibly the time of the event (Fri. 1.DS) was also unattractive for many students. In the further course of the exercise units, a small programming task needed to be completed. Here, the sample solution and the test of the software were provided as a video.

Although lecture videos and scripts as well as exercises and solutions were made available on a weekly basis, accessing or viewing the documents was rather discontinuous. Figure 2 shows the number of accesses to the Opal module "Teaching materials", in which all teaching materials are summarised, as a progression over the semester. It is noticeable that from week 4 onwards, the number of accesses drops to well below 1 access per student and week. There are several possible explanations for this. It is possible that some students did not use the teaching materials. Perhaps because the learning phase was postponed shortly before the examination. Also, it is possible that some students watched several videos in one week. In any case, the goal of continuous learning was not achieved. Only in the weeks shortly before the exam the access numbers increase to about 1 access per student and week It can be assumed that almost all students had prepared for the exam.

In the subject *KV,* the weekly access numbers to the teaching materials exceeded the number of course participants, so that it can be assumed here that the documents were studied continuously. This is also supported by the access peak observed at the respective lecture date. In addition to the lecture slides discussed, the course also included practical sessions involving work on actual devices and systems. These virtual and interactive sessions usually included an explanation of the equipment with its functions, process videos and exemplary process data sets. Each also contained one or more tasks.

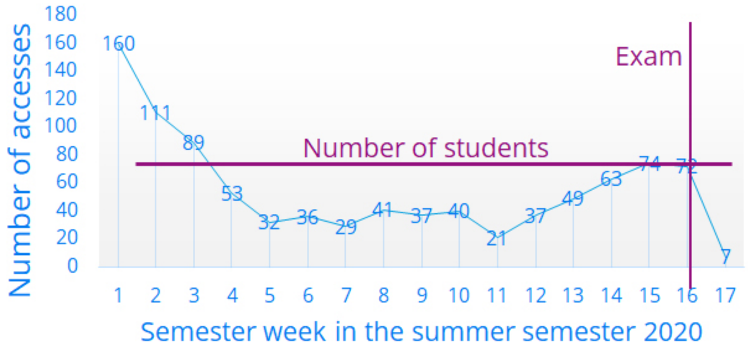

Fig. 2: Number of accesses to the Opal module "Teaching materials" in the subject BerFVS1

The virtual sessions were created in PowerPoint kiosk mode, with learners able to move freely around the slide set using buttons (see Figure 3). Each slide has an audio commentary, making it potentially accessible. In the summer semester 2021, these interactive documents will be reused and extended to include online consultation.

4. Advising and Guiding

In both courses, different formats were used to guide students during the course of the semester. Essentially, the message function in Opal and e-mail through Opal were used to inform the students about content-related and organisational matters. These information seem to have been received by the students and no information deficits occurred. In the course *BerFVS1*, a matrix chat room was used to enable a professional exchange. Despite several requests from the supervisors to discuss questions among the students first, there was hardly any exchange among the students. Most of the time, they waited for the supervisor to answer the questions. This may be due to the rather analytical nature of the course.

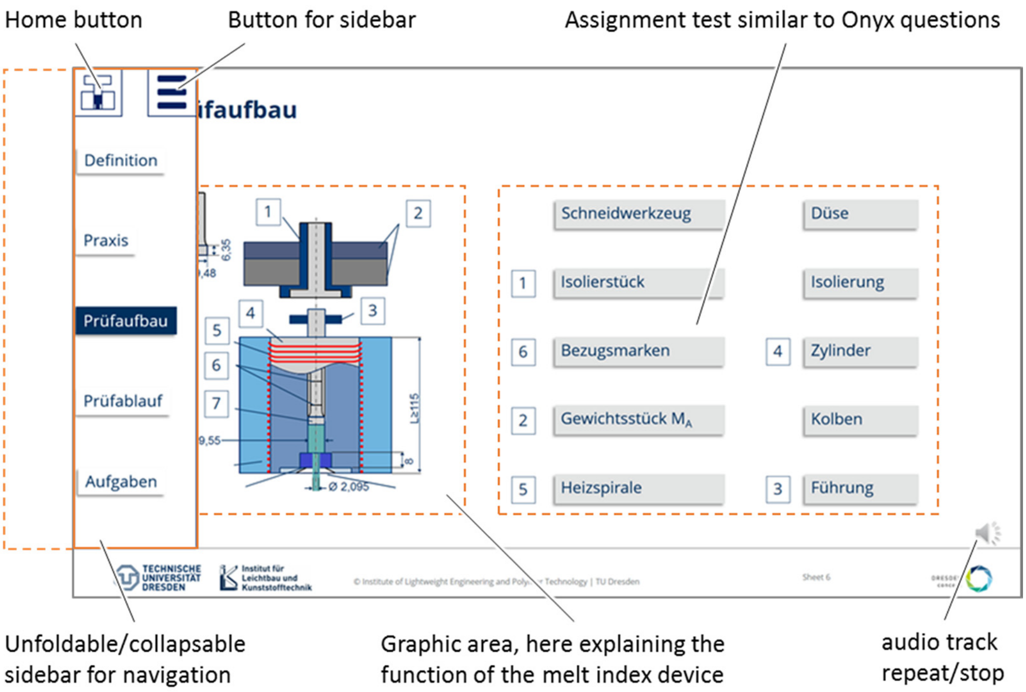

Fig. 3: Screenshot from the virtual practical "Melt index test". An intermediate test is shown in which the components are to be assigned. On the left - here folded out - is the menu area.

In contrast, the Opal forum was initially evaluated in the LV *KV*, although the figures and postings indicated only sporadic use. As in the face-to-face mode, only a few students communicated openly in front of the group. Some chose the personal email route. The questions asked were then posted anonymously in the forum by the course instructor to transfer the information to all students. There is therefore a great demand to lower existing barriers for personal but also for group communication. Experience has shown that this inhibition threshold is quickly lowered in the course of a presentation, so consultations take place in the *KV in the* summer semester.

The use of digital teaching-learning formats offers both opportunities and risks for non-native speaker students. On the one hand, teaching materials can be edited individually, and the use of digital translation tools facilitates both reading comprehension and the writing of academic texts. On the other hand, digital communication makes listening comprehension in synchronous formats more difficult and, as a result, students are little challenged to engage in discussions with teachers and among students.

5. Checking and evaluating

To enable learning during the semester, two self-tests were offered in Opal-Onyx in *BerFVS1*, in which the majority of students participated. However, the evaluation of access rates also shows that students used these tests more for exam preparation than for continuous learning.

To prepare the content of the examination, a revision course was conducted as a synchronous video conference without recording. In addition to summarising and focusing on the learning material, the students were able to ask questions about the content. This was used to a similar extent and depth as in previous semesters.

For the technical and organisational preparation of the two digital examinations *BerFVS1* and *KV*, a digital mock examination was offered, which was used by almost all students. At the same time, the students could participate in a matrix chat. Here, questions regarding connectivity problems or of general organisational nature were answered in a moderated manner and the individual digital infrastructure was tested. This also included entering or uploading external content created during the examination as, for example in handwritten notes and sketches in the form of scanned documents.

The exams were conducted as digital OPAL exams. Due to the changed framework conditions, the exam questions for *BerFVS1* were conceptually newly created. Since it was not possible to check usage of additional sources, the questions were modified in such a way that this kind of additional material can be used ("open book"). Here, one of the great opportunities of the digital examination becomes apparent, as it was increasingly possible to examine in a competence-oriented manner.

Designing the exam questions proved to be exceedingly time-consuming. The time to answer the examination questions is limited. In addition, open questions that require a free-text-based answer are to be avoided in order to be able to assess the subject knowledge independently of the students' language skills. Also, the pure reproduction of learned knowledge in accordance with the "open book" approach already mentioned above is not sensible. Therefore, the following question formats provided by Opal-Onyx were mainly used:

- Choice (Single / Multiple Choice): Demonstrate basic understanding based on definitional knowledge and transfer to higher-level contexts.
- Hotspot: Verification of classification and identification skills based on illustrations, e.g. regarding material structure and failure behaviour by means of interactive image areas.
- Cloze / Numerical input: for checking the results of calculation tasks.
- Upload: Possibility to assess individualised results and the ability to abstract, for example in the form of sketches and construction tasks.

On the one hand, there was a lot of uncertainty during the creation of the examination regarding the OPAL. On the other hand, sometimes several versions of a question were created in order to make it difficult for students to exchange questions during the examination. Variable-controlled question types could also be used for this purpose. In order to avoid an increased need to look up questions in the teaching materials, the scope of the questions was increased. At the request of the students, the navigation area was activated in the examination. The sorting of the questions was randomised to prevent synchronous joint working. During the examination period, a matrix chat was available for organisational questions only. The students were instructed that no content-related questions may be asked. This chat was heavily used at the beginning and after the end of the examination. It would be desirable to have a permanent information area for the examiners in the chat area in order to ensure that important information is received by all students. In the course of the examination, however, the chat area is hardly frequented, so that it is not suitable as a medium of communication from the examiner to the students in this time.

Exam evaluation proved to be advantageous for the automatically evaluable part. The manual evaluation of the rest of the questions was similar to the correction of the presence examination. Of course, the readability of the answers is significantly improved.

The distribution of exam results is similar to that of the previous semester. The biggest difference was in the number of grade 5s. A total of eight students did not pass the *BerFVS1 exam.* This is significantly more than in previous exams. It can be assumed here that some students took advantage of the free attempt regulation.

In the subject *KV,* an OPAL-ONYX examination was conducted in the summer semester. In preparation, the students received a question catalogue with 100 questions that lead through all the topics covered in the lecture. Those who work through this catalogue are thus well prepared for the exam. The exam consisted of two parts: an overview part, which essentially asked for knowledge from the subject area, and a calculation part, in which knowledge was to be applied and simple calculations performed. In contrast to *BerFVS1,* the question part was oriented towards the tasks of the previous years. The questions were randomised and asked in linear order, so that the students had to adhere strictly to the order assigned to them. In order to take the changed situation into account (all aids available, possibility of communication among the examinees), there was a stronger focus on quickly testing existing knowledge. The number of tasks was therefore significantly higher than in previous years.

Exam evaluation can be completed much more quickly than in the classic examination format. However, some tasks had to be corrected manually because students interpreted questions or answer options differently than intended, which led to incorrect evaluations in the automatic analysis. In addition, it was found that the high number of questions led to some of the questions in the calculation section not being processed. For some of the questions, blocks of text from the corresponding lecture chapter were copied or transcribed into the answer fields, some of which did not match the question asked.

After the examination, research on relevant platforms revealed that ready-made solutions were shared for the 100 questions from the preparation catalogue, which, however, were not always correct. However, some of these incorrect solutions were used.

It has therefore to be assumed that examination questions which are set in online examinations will also be shared in corresponding collections afterwards. As a consequence, it can be assumed that the question pool must become both more diverse and more complex in order to avoid simple copy-paste algorithms during examinations.

6. Evaluating and feedback

An essential method of giving students opportunities to comment on the implementation of the course was to have the supervisors interview them during the videoconferences. Few students took advantage of this opportunity.

However, they tended to be positive about the design of the course in the digital framework.

In both courses, the Opal course module provided by the faculty was used. Here, too, the participation of 14% (*BerFVS1*) and 1% (*KV*) was insufficient for a reliable representative evaluation. The reason for this is possibly that, in contrast to the face-to-face event, where extra time is planned for the evaluation, fewer people take part in the evaluation. Perhaps some students shy away from the additional effort or do not believe in the "effectiveness" of the evaluation.

Nevertheless, some interesting results for the subject *BerFVS1 will be discussed* below:

1. All students stated that the teacher is available to answer questions: According to this statement, there is no need to establish further communication channels.

Only about one sixth of the participants found the work materials provided and the e-learning options unhelpful: Certainly, there is always room for improvement in the design of the work materials, but overall this value is no worse than for a face-to-face course.

3. Almost all students stated that the time for answering the examination questions was too short: the examination concept was geared towards a certain time pressure due to the prevention of arrangements during the examination time.

4. 80 % of the participants stated that they regularly prepared and followed up the course: However, this contradicts the evaluation of the access figures. This could be explained by the fact that it was mainly those students who really did prepare regularly who also took part in the evaluation.

5 In the free text answers, completeness and punctuality of the documents were highlighted positively, as were the motivation and accessibility of the lecturers. The scope of the examination was mentioned negatively.

In the *KV* subject, some feedback was received via chat after the exam and in the lectures that followed in the following semesters. The focus here was on the desire for more intensive personal communication. However, these intentions usually come from the group of people who also actively use the consultations. The silent majority cannot be activated by offers to talk. For this, targeted approaches would have to be made, which is hardly feasible with more than 100 students and is always a challenge, even in face-to-face studies.

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Remote Concurrent Engineering from the customer's perspective

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Abstract

Concurrent Engineering ist ein Ansatz zur Entwicklung komplexer Systeme, der durch eine direkte Kommunikation zwischen den beteiligten Disziplinen gekennzeichnet ist. Diese Interaktion zu erlernen und zu verstehen, welche Informationen zwischen den Disziplinen kommuniziert werden müssen, gehören zu den zentralen Lernzielen der Lehrveranstaltung „Entwurf von Raumfahrzeugen“. Die Studierenden vertreten darin unterschiedliche Disziplinen und arbeiten eine Missionsstudie aus, die von den Lehrenden in Auftrag gegeben wird. Die Lehrenden nehmen somit in der Rolle der Kunden am Entwicklungsprozess teil. Aufgrund der mit der COVID-19-Pandemie einhergehenden Einschränkungen musste die Lehrveranstaltung in ein virtuelles Format übertragen werden. Daraus ergab sich die zentrale didaktische Herausforderung, die Struktur und gewählten Methoden so anzupassen, dass die Missionsstudie, die auf ein Zusammenarbeiten aller Beteiligten angewiesen ist, dennoch durchgeführt werden konnte. Dieser Beitrag erörtert, wie dies durch eine Mischung aus synchroner und asynchroner Lehre erreicht wurde, wie das Lernerlebnis der Studierenden dabei ausfiel und welche Schlussfolgerungen sich für die Weiterentwicklung der Lehrveranstaltung für postpandemische Zeiten ergeben haben.

Concurrent engineering is an approach to the development of complex systems that is characterized by direct communication between the disciplines involved. Learning this interaction and understanding what information needs to be communicated between disciplines are among the central learning objectives of the course "Spacecraft Design". In this course, the students represent different disciplines and work out a mission study that is commissioned by the instructors. The instructors thus participate in the development process in the role of customers. Due to the constraints associated with the COVID-19 pandemic, the course had to be transferred to a virtual format. This resulted in the key didactic challenge of adapting the structure and chosen methods so that the mission study, which relies on all participants working together, could still be conducted. This paper discusses how this was achieved through a mixture of synchronous and asynchronous teaching, how the students' learning experience turned out, and what conclusions emerged for the further development of the course for post-pandemic times.

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1. Introduction

The design of space missions and their systems is a complex task, even in the preliminary design and concept phase. All technical disciplines and sub-disciplines are interconnected to some degree, and none of them can be neglected in the development of the entire mission. Classical, i.e. sequential or centralised, development approaches require a large number of iterations and have a low resistance to errors. Concurrent engineering (CE) was developed to avoid these very disadvantages and to shorten development times for highly complex systems while maximising the probabilities of success. [1]

This development approach, which has meanwhile assumed a central role in the space domain and is just as relevant for similar systems in other industries, is taught to the students of the Aerospace Engineering specialisation of the Mechanical Engineering degree programme in the course "Spacecraft Design". The central element of this course is a CE workshop, in which the teachers take on the role of customers and give the student teams a design study assignment.

This paper discusses the virtualisation of teaching this course as a result of the restrictions associated with the COVID-19 pandemic and the experiences gained thereby. First, section 2 discusses the context and framework. Section 3 presents an overview of the CE approach and Section 4 presents the CE software Valispace used in the course. Section 5 describes the learning objectives of the course. Section 6 discusses the didactic challenges, whose solutions are presented in Section 7. Section 8 reflects on the course of the semester, while the conduct of the examination is discussed separately in Section 9. Section 10 provides a comprehensive insight into the conducted teaching evaluation and draws a conclusion. The following section 11 presents possibilities for improvement. This contribution is summarised in section 12, which also contains an outlook on the further development of the course.

2. Context and framework conditions

The course "Spacecraft Design" is embedded in the specialisation module Space Systems Engineering of the diploma programme Mechanical Engineering, specialisation Aerospace Engineering, and regularly takes place in the 9th semester. This course is one of two courses of the aforementioned module and is usually completed by a written examination of 90 minutes as specified by the module description.

The students have already acquired detailed knowledge of the design of space systems in courses such as "Energy Systems for Spacecraft" or "Space Propulsion". The course chronologically and thematically forms the conclusion of their courses before the diploma thesis. However, some students exchange the 9th semester with the 7th semester, which is reserved for internships. These students lack all the knowledge from the 8th semester. In addition, there are a few students from other disciplines (e.g. from business administration and management or exchange programmes such as ERASMUS+) who do not necessarily pursue this specialisation. Occasionally, students from lower and higher semesters also participate, as can be seen in Figure 1. This results in a heterogeneous group of participants.

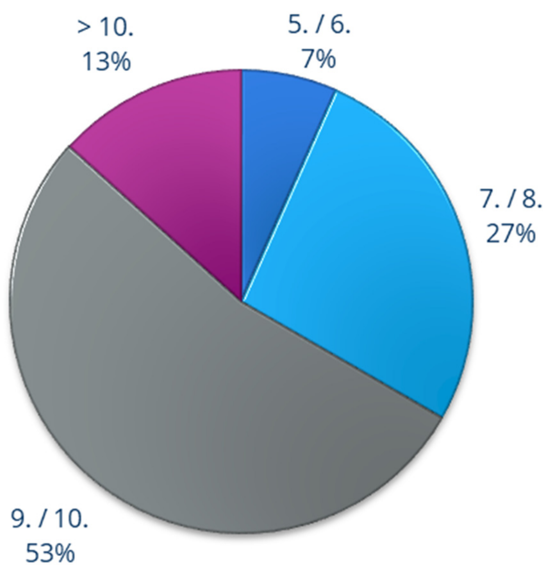

Fig. 1: Distribution of participants by study semester

The number of students is usually between 30 and 40, in the present semester there were 32. As can be seen in Figure 2, based on an evaluation carried out in the present semester (see Section 10), the large majority of participants are male students. According to their own statements, all participants were pursuing a degree. However, the reasons for participating in the course differed. For most participants, the selection was based on interest in the content (see Figure 3).

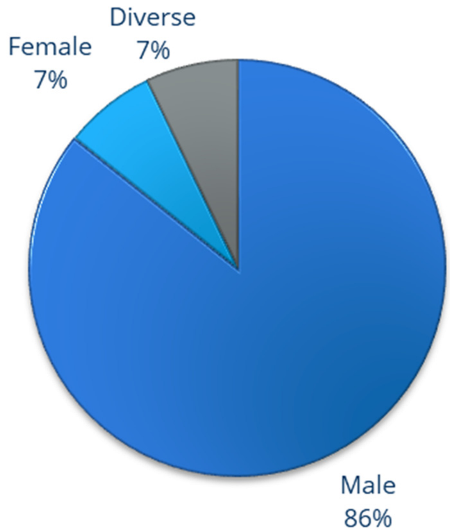

Fig. 2: Distribution of participants by gender

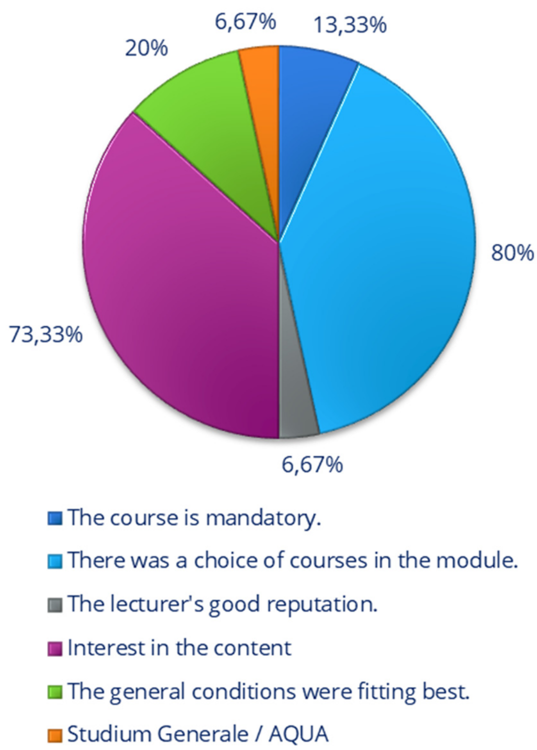

Fig. 3: Motivation of participants in the course (multiple answers were possible)

3. Concurrent engineering (CE)

Space missions and their technological components are extraordinarily complex systems, characterised by the close interaction of various disciplines. The development of such missions is characterised by high effort, often extreme requirements and low fault tolerance.

As a counter-design to classical development approaches, which for example are sequential (i.e. all disciplines work on the design one after the other) or centralised (i.e. all disciplines work in parallel, but all communication is directed through a central interface, usually the system engineer), Concurrent Engineering (CE) has been developed in order to meet the needs of the different stakeholders. It is characterised by a collaborative, cooperative, collective and simultaneous development environment. This means that all disciplines work in parallel and together on the mission and exchange information with each other. This includes, in particular, the customers / clients, as a central goal of CE is to increase customer satisfaction. [2]

To enable CE, several elements are needed. Besides the central multidisciplinary team, these include a hardware and software infrastructure (see section 4) that enables the integration of a design model, as well as a defined process. The latter is divided into installation, preparation, study and follow-up phases. In the study phase, the actual elaboration takes place, which in turn is subdivided into alternating design sessions and individual work. [3]

The present course covers all phases, with the main part falling on the study phase. While the course was previously structured mainly as a closed design session (i.e. all students were on site at the institution), a restructuring is taking place in the present semester. In this process, the individual work is moved to the self-study phase and only the design sessions are conducted synchronously with the teachers, who represent the clients (see section 7).

4. Valispace software

During the course, the web-based software Valispace of the German-Portuguese start-up with the same name was used. Valispace is a software support for the joint and simultaneous development of a design or system by a multidisciplinary team.

The central idea of Valispace is the development of the design in a central database (Single Source of Truth). Users access the database and are able to read, store and link information. Every change that any user makes in the database is passed on to all other users in real time. The great advantage of such a system is that all users have access to the current data at all times. This eliminates the need to exchange documents that only reflect a temporary design status.

The design itself is built up in Valispace in a directory tree (product tree) via the hierarchical linking of individual components. In addition to the directory tree, which is the heart of the design, there are a number of other functions. Particularly noteworthy is the implementation of a requirement manager. This allows the automatic checking of the current design against defined boundary conditions. In addition, test procedures can be stored. Moreover, Valispace supports numerous extensions that can significantly simplify development in an interdisciplinary team. Examples include a complete unit calculation and the temporal development of the individual parameters over the course of the design. Above that, there are functions for time management (Gantt chart) of the project, the possibility of implementing simulations (or complex calculations) by means of an Octave GUI as well as the creation of documentation with automatically derived tables and diagrams. Furthermore, Valispace also allows direct communication with other participants in the study via various commentary and discussion functions.

Although the full range of functions is by no means used in the course, Valispace is an important support in the efficient implementation of the CE process with students. For example, the browser-based implementation allows participants to access the current design from anywhere and expand it with their corresponding work. Working with a "single source of truth" also supports the fundamental aspects of CE. The clear structure of the software enables students to use it effectively during the course, even without prior knowledge.

5. Learning objectives

The overall learning objectives of the course can be summarised as follows:

1. By establishing criteria, weighting them and performing a trade-off, students can comparatively evaluate concepts for space missions to find the solution approach with the highest probability of success.
2. By practically applying and combining the knowledge gained in the previous courses, students will be able to conceptualise space missions to develop an overall system to solve a specific engineering problem.
3. By getting to know their characteristics as well as advantages and disadvantages, the students know different strategies and models for the development of technical systems and are able to classify and assess them in order to apply them in a targeted and justified manner.

The essential expansion of these learning objectives in the winter semester 2020 / 2021 results from the shift of the class into the digital space:

- By learning about and applying different collaboration tools, students can use digital collaboration opportunities to solve a development task that they cannot do alone.
- By exploiting different tools of virtual collaboration, students will be able to contrast and develop concepts of interplanetary space missions using the concurrent engineering model to circumvent the limitations of direct interaction.

The students must first learn about and experience possibilities of virtual cooperation in order to then be able to apply them in a targeted manner. Although this is aimed at pragmatically circumventing contact restrictions in the present semester, it is intended to show them more generally, how they can efficiently achieve their goals even under adverse conditions.

6. Didactic challenges

Up to now, the course was held as a block course on three complete days shortly before the end of the lecture period. The three days were spread over a period of eight days - Friday, as well as Friday and Saturday in the following week. At the beginning of the course, the characteristics as well as advantages and disadvantages of design processes were taught. Special focus was put on concurrent engineering (see section 3). In addition, the most important basic knowledge was briefly refreshed and an introduction to the software Valispace (see section 4) was given.

The remaining time is used to carry out a concurrent engineering process for the conceptual design of a space system (e.g. a Mars probe or a Moon rover). For this purpose, a mission objective is issued by the teachers and the role of the customer / client is assumed. The mission is first discussed by the students and initial solution concepts are postulated, which are then evaluated. We / the students divide themselves into different roles / disciplines. Each discipline develops the corresponding subsystem (e.g. for energy supply or communication) or carries out the tasks belonging to the corresponding role (e.g. cost or risk analysis).

The concurrent engineering process is characterised by the fact that all subsystems are developed in parallel. Since all subsystems and roles are interdependent, the process is characterised by an extremely high need for communication. This is precisely the main learning objective: the students should have understood how the individual subsystems, which they already know from other courses, are connected to each other, i.e. which interfaces there are and which inputs and outputs have to be transmitted. The students have a large PC pool at their disposal for this purpose and can constantly exchange information while detailing their subsystems.

However, due to the restrictions resulting from the COVID-19 pandemic, the course could not be conducted in attendance in the present semester. Nevertheless, all students had to be reached and motivated throughout the course, as all students depend on each other. The particular didactic challenge is therefore to transfer the previous format to the virtual space in such a way that the learning objectives can be achieved. This is particularly difficult, because the core of the course lies in the interaction between the students (and teachers).

7. Didactic approach

Only the introduction (approx. 15% of the course) could be digitised relatively easily. For this, screencasts were already made available at the beginning of the semester and a live consultation was held to conclude the introductory part.

The rest of the course had to be restructured completely. Our approach was to stretch the course over the entire semester. The actual task processing was then to be carried out in self-study, if possible in small groups. Students and teachers met virtually at regular intervals (every 2 to 3 weeks) to present progress and exchange.

In order to keep the organisation manageable and to offer each person the opportunity to contribute, the course was divided into 2 groups, which worked on the design task in parallel to and independently of each other. The group division and role assignment required special attention and was realised via an enrolment tool in the course on the OPAL learning platform. This was intended to give all participants equal opportunities to secure the discipline they preferred. Final inhomogeneities in the distribution of roles within and between the teams were balanced out in the subsequent live consultation (e.g. the occupation of one central role instead of the double occupation of another). In previous years, we experimented with the distribution of roles. In some cases it was predetermined, which partly forces students out of their comfort zone, but can also lead to some demotivation. In some cases, students were able to choose the roles, although compromises had to be found for roles that were particularly in demand. Enrolment via an online tool largely circumvents these difficulties and is the fairest variant of role assignment to date.

The size of the teams was 16 participants each. This is considered a very good group size, as on the one hand, all essential roles can be covered and on the other hand, the communication effort within the team remains manageable.

It should be noted that not all 15 existing roles were filled, as some roles are considered essential (e.g. Team Leader), while others can be replaced in case of doubt or carried by the other participants (e.g. "Integration, Assembly and Verification"). As in previous years, it was important to double up on particularly critical roles (e.g. energy supply) in order to create a certain redundancy. In principle, this would be desirable for all roles, but larger teams would make implementation much more difficult.

While the sizes of the two teams were identical, the distribution of roles in the two teams showed slight variations. This was again due to the fact that roles, which were not considered essential, could be assigned according to the inclinations of the participants (e.g. only team A had a simulation engineer). On the one hand, this of course makes a direct comparison of the results achieved by the two teams difficult, but on the other hand, it allows the effects of different role assignments to be examined. The latter has the advantage that the significance of the (non-)participation of individual roles can be visualised to the students.

The video conferencing tool GoToMeeting was used for communication with the course tutors. Between the appointments, an exchange platform also had to be provided for the students. This was possible via the Valispace software, which was used anyway to centralise all the data. In addition, the OPAL course was provided with various elements (e.g. a forum).

The development task was subdivided by several milestones in order to be able to motivate the students to work continuously throughout the semester. These milestones corresponded to the iteration stages of the design or its detailing and were represented by the live consultations, in which the current status was presented to the clients / teachers. This enabled us to uncover communication or other problems in the self-learning phases and to ensure the active participation of all involved. In addition, this process not only gave us insight into the progress of both teams, but also ensured that any lack of consistency in the work became visible to us as well as the students.

The live consultations with the individual teams were conducted independently of each other. The main reasons for this were, on the one hand, to limit the time required of the participants and, on the other hand, not to give an advantage to the team presenting last. This means that the teams were not informed about each other's progress. However, it is possible that the students also exchanged information with each other across teams. This cannot be prevented and can even be beneficial if, for example, a role of one team is stuck and asks the corresponding role representatives of the other team for advice. This was supported by the provision of an overview of the team compositions by those responsible for the course.

8. Reflection on the process

It should be noted that, as expected, the preparation of the course in this semester required far more effort than was otherwise necessary. However, this effort was worthwhile because the careful planning could be fully implemented. In addition, the actual implementation during the semester took place with a reasonable amount of effort.

Particularly noteworthy is the consistently high level of student engagement. This led to a scope and level of detail of the results that is significantly higher than those of the previous years. This is not entirely surprising, since the students also had a much longer period of time to work on the design task and this was also used effectively, for example through weekly team meetings.

However, it remains unclear to what extent this is due to external circumstances. While the course offers an opportunity for active involvement that is clearly above the usual level, it stands to reason that limited social interaction opportunities have further increased the students' motivation to work in teams.

An interesting aspect resulted from the division of the participants into two parts. This made it possible to respond to the individual wishes of the teams and to slightly adapt the approach. This illustrated that relatively small differences in implementation can have an impact. For example, Team A's bi-weekly consultations with teachers / clients were purely for status presentation and discussion via GoToMeeting. Team B, on the other hand, asked for the customer meetings every fortnight to be combined with the weekly team meetings via Discord. From the teachers' point of view, the originally planned approach as carried out with Team A worked better, as the team was forced to coordinate precisely in advance and to come to a coherent state. This allowed more time to discuss the design and the development process.

9. Conduct of the examination

According to the module description of the examination regulations, the assessment for the course consists of a written exam of 90 minutes in length. However, due to the restrictions associated with the pandemic in this semester, it was requested that the examinations either be conducted digitally or that alternative forms of examination be sought. Since the students were supposed to present their approach and obtained results at the end anyway, it was obvious to include this in the examination performance. However, only 180 minutes were available for the final presentations including discussion for 32 students, so that no reliable assessment of individual performance could be made on the basis of the presentations alone. For this reason, the students were required to submit a final report, the main text of which was to be between 1500 and 3000 words.

The main focus of this final report was on the process. Thus, not only information on the data exchange and the final state of the design study was required, but also self-reflective elements on the individual progress and problems encountered in the development / learning process.

The examination performance was very well received and mastered by almost all students. For Team B alone, a total of 271 pages of reports were submitted. The quality of the presentations and reports was very good. With one exception, the grades were in the range of 1.0 to 1.3. In both teams, the average was 1.2.

Figure 4 shows a small section of the final result, a rendering of the lunar lander developed by Team A.

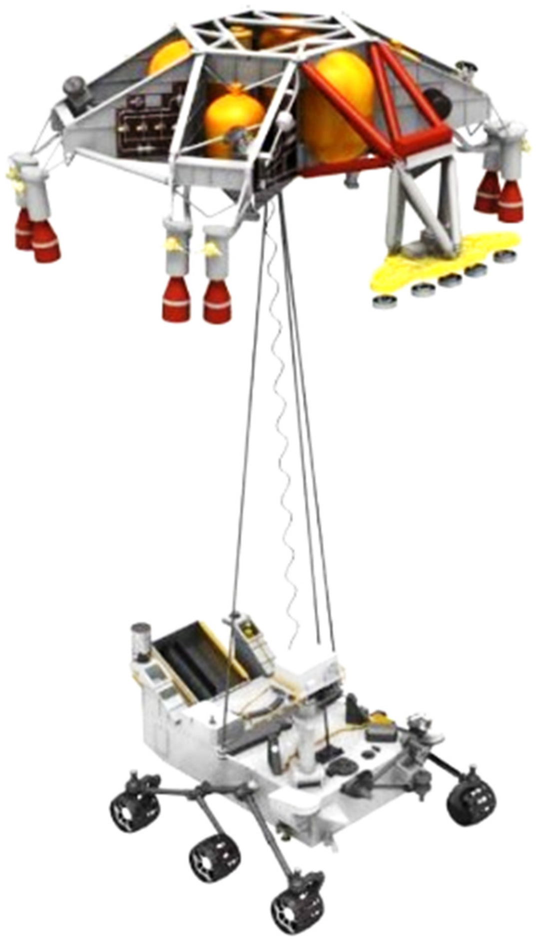

Fig. 4: CAD rendering of the lunar lander developed by one of the two teams.

10. Teaching evaluation

In order to obtain feedback from students on their learning experiences, they were encouraged to openly communicate feedback already at the beginning of the semester and at regular intervals thereafter. However, this request was almost not complied with. In addition, a teaching evaluation provided by the Faculty of Mechanical Engineering was implemented in the OPAL course towards the end of the semester. Although this also does not provide an anonymous opportunity for feedback due to the direct user assignment, 15 of the 32 students participated in the evaluation. This section summarises the main results of the evaluation.

On a positive note, the vast majority of students (93%) were able to understand the objectives of the course (see Figure 5), all participants were able to recognise a common thread in the structure of the course (see Figure 6) as well as the direct practical relevance (see Figure 7), and 80% of the students found the pace of the course to be optimal (see Figure 8).

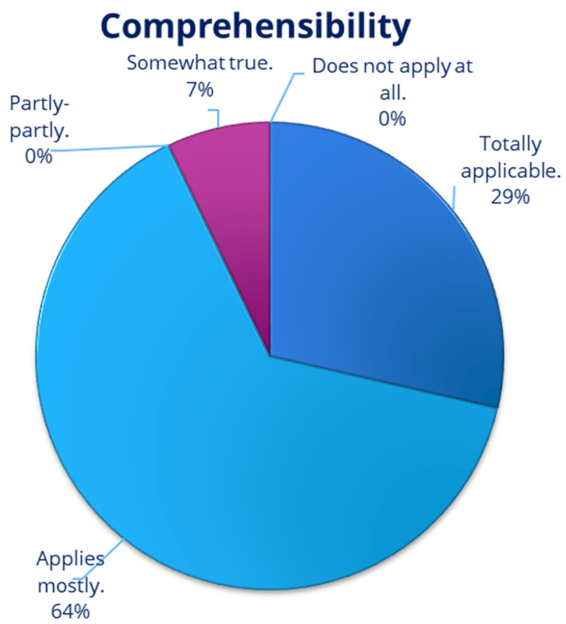

Fig. 5: Answers to the statement "The teacher presents the objectives of the course in a comprehensible way".

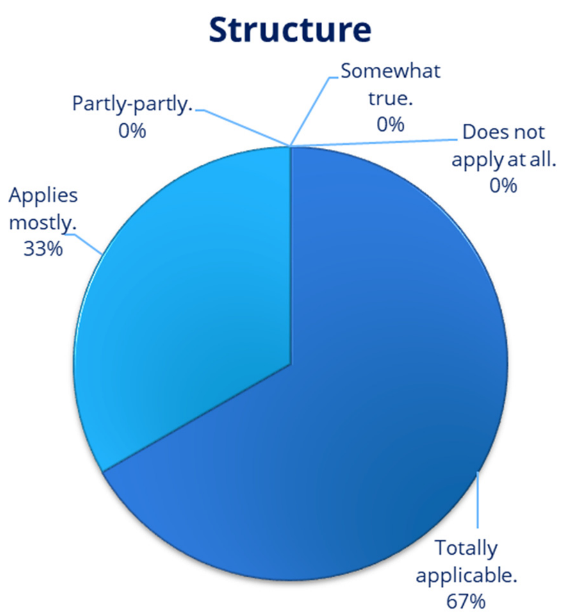

Fig. 6: Answers to the statement "The teacher structures the event. There is a recognisable thread."

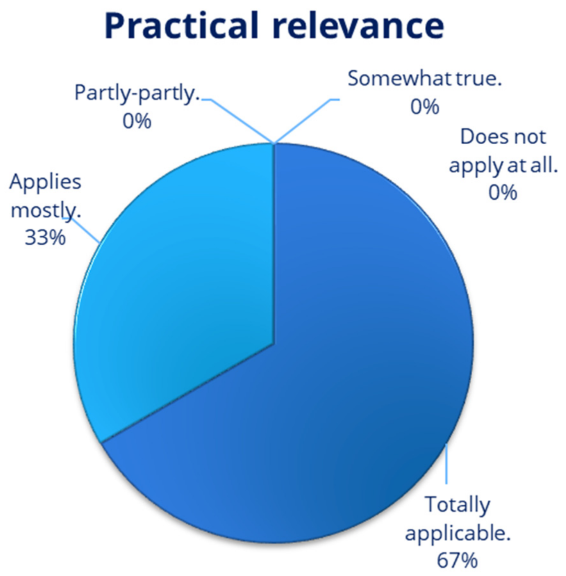

Fig. 7: Answers to the statement "The teacher establishes a link between theory and practice / applications".

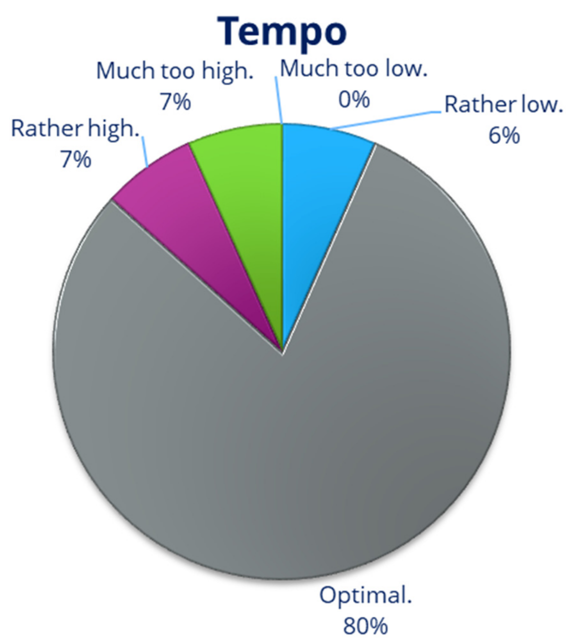

Fig. 8: Answers to the statement "The pace of the event is:. "

In addition, all participants found that the teachers were available for questions (see Figure 9) and 79% of the students stated that the teachers were able to make complicated issues understandable. This shows that the didactic concept of the redesigned course worked.

A similarly convincing picture emerges with regard to the media used to conduct the course. Two thirds of the participants stated that the work materials provided were helpful (see Figure 11). It should be noted here, that the 13% of participants who stated that there were no working materials, although e.g. information on individual roles and literature recommendations were communicated, distort the result somewhat. The presentation media used, i.e. in this case the screencasts and associated slides provided, were also rated as helpful by a 79% majority (see Figure 12).

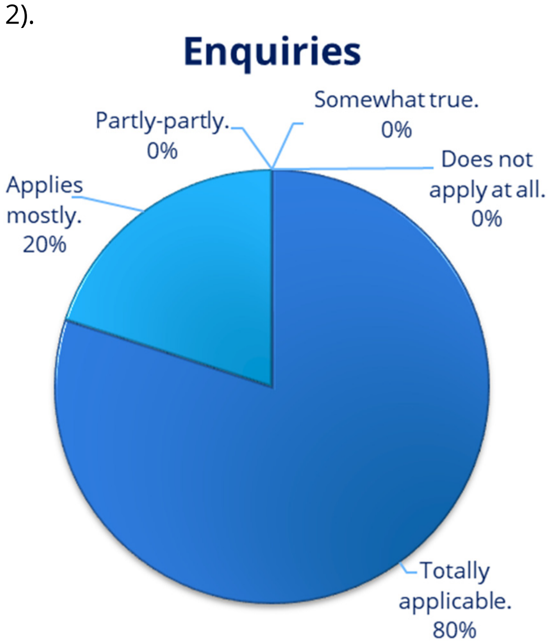

Fig. 9: Answers to the statement "The teacher is available for questions".

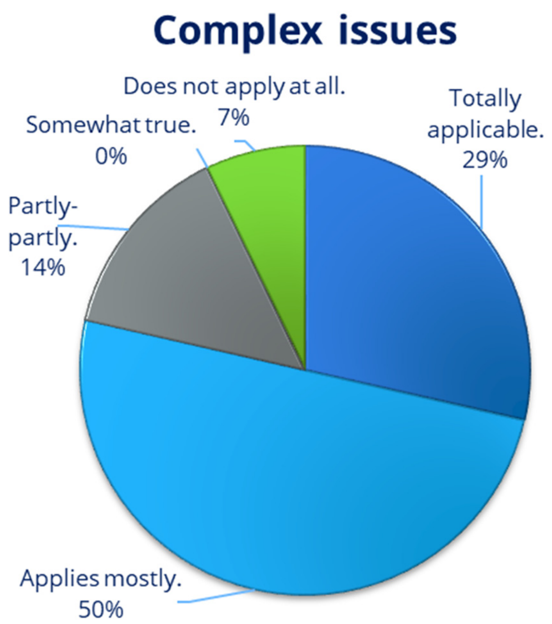

Fig. 10: Answers to the statement "The teacher can make complicated issues understandable".

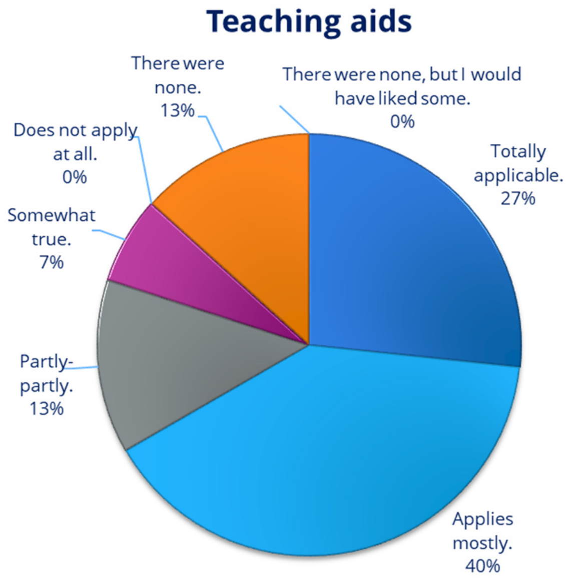

Fig. 11: Answers to the statement "I find the work materials provided helpful (e.g. handouts, scripts, references). “

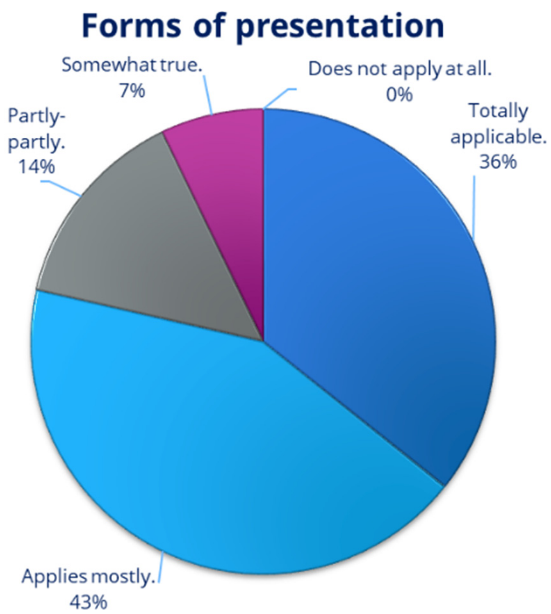

Fig. 12: Answers to the statement "I find the presentation media used helpful (e.g. presentation, slides, visual objects). “

Furthermore, all participants rated Discord positively for the course (see Figure 13). This platform was not specified, but chosen by the students themselves for their exchange. It is therefore worth considering to deliberately integrate this platform into the course or at least recommending it to future participants, but ultimately leaving the decision up to them.

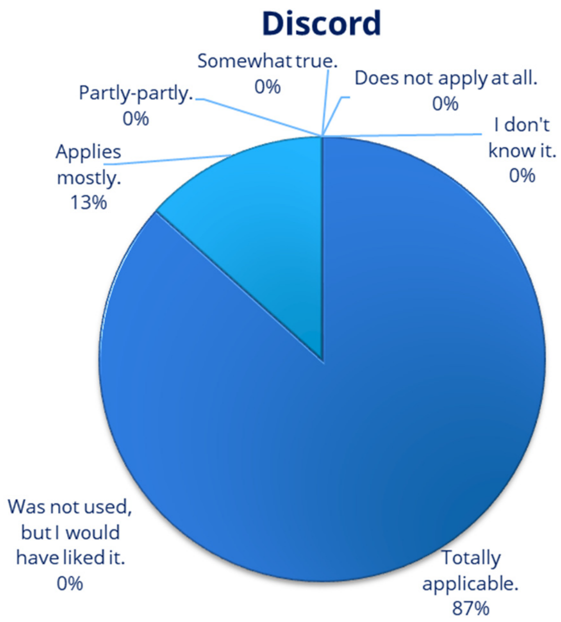

Fig. 13: Answers to the statement "I find the Discord communication tool helpful in teaching".

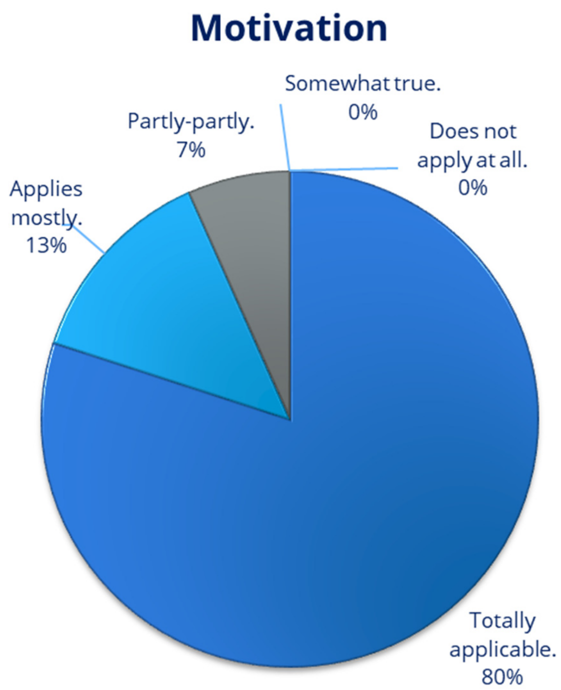

Fig. 14: Answers to the statement "The event motivates to deal with the contents on ones own".

The evaluation also paints a positive picture of the transformed course in the areas of motivation, learning experience and transferability into practice. Thus, 93% of the participants stated that they were motivated by the course to deal with the contents themselves (see Figure 14). An equally high percentage stated that they had learned a lot from the course (see Figure 15) and felt able to apply the knowledge they had learned in practice (see Figure 16). The latter point in particular is crucial, as the course places special emphasis on better preparing students who are about to complete their studies for everyday working life. It is therefore hardly surprising that 87% of the students stated that they were satisfied with the course overall (see Figure 17).

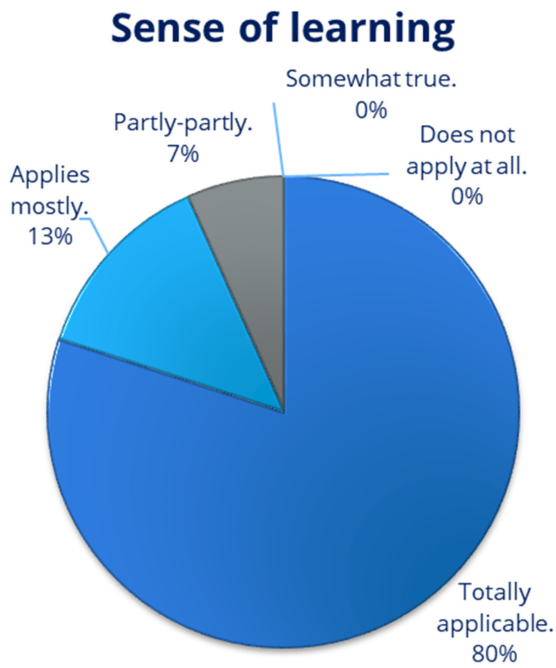

Fig. 15: Answers to the statement "I learned a lot from the event".

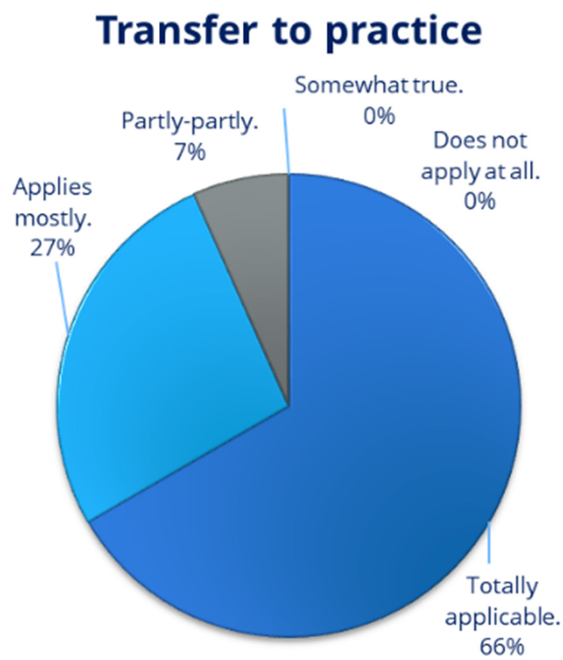

Fig. 16: Answers to the statement "I feel able to apply the knowledge learned in the course in practice."

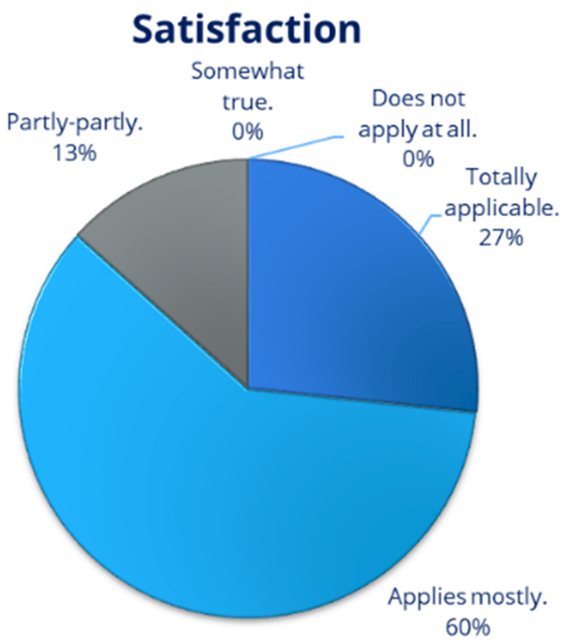

Fig. 17: Answers to the statement "Overall, I am satisfied with the course".

A somewhat more differentiated picture emerges with regard to the amount of material (see Figure 18). Although two thirds of the participants stated that the amount of material in the course was optimal, the remaining third felt that the amount of material was too high. Accordingly, no one felt that the amount of material was too low.

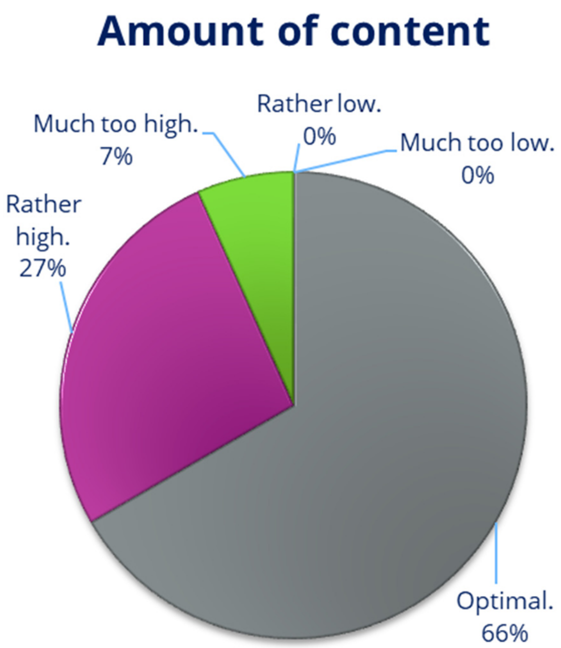

Fig. 18: Answers to the statement "The amount of material in the course is:“

This corresponds with the feedback on the amount of preparation and follow-up work (see Figure 19). Here, 87% of the students stated that they regularly prepared for and followed up on the course. This is clearly the intention due to the chosen structure with fixed milestones. However, this is accompanied by the fact that the workload was perceived as above average, at least subjectively. Thus, 93% of the students confirmed that the workload was higher than in other courses (see Fig. 20).

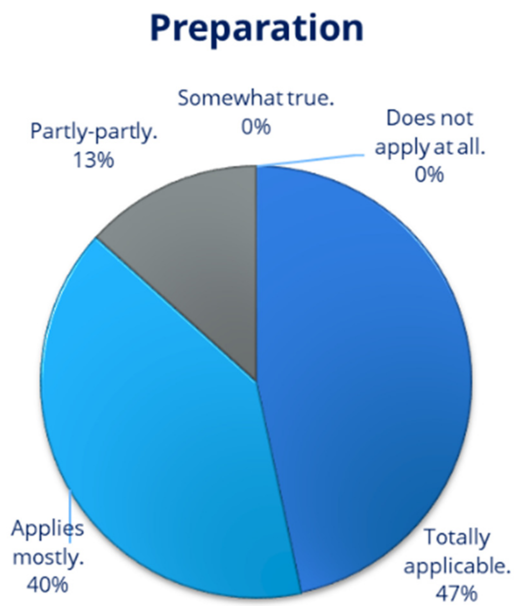

Fig. 19: Answers to the statement "I regularly prepare the event before and after".

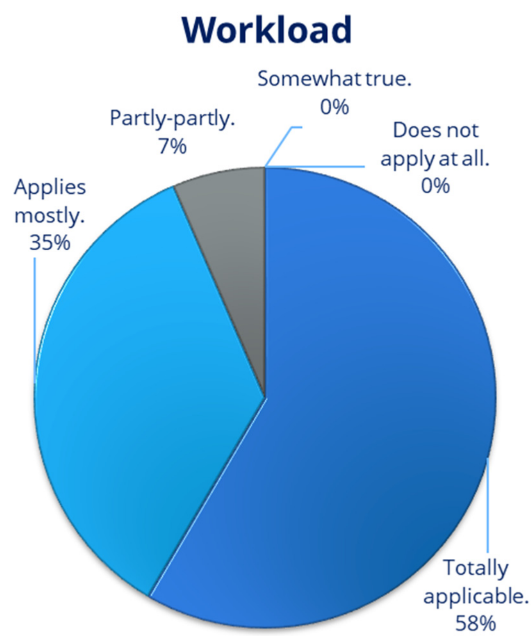

Fig. 20: Answers to the statement "My workload is high compared to other courses".

Figure 21 shows that this refers more to the amount of work than to the difficulty of the material, as 93% of the participants stated that the difficulty of the material was optimal. A further 7% tended to find it too low. Thus, the perceived high effort could be reduced by dropping one of the three iteration cycles. This would also eliminate a live consultation, which the students would not have to prepare and follow up accordingly. In this case, the effects on learning outcomes would have to be evaluated as precisely as possible.

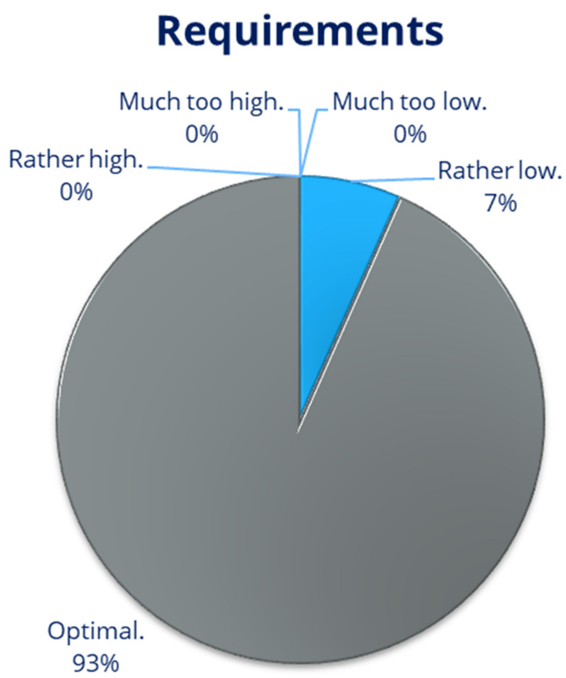

Fig. 21: Answers to the statement "The requirements are / the severity of the substance is:"

Overall, it can be said that the conversion of the course to a virtual format was a complete success. In fact, we were even more satisfied with the teaching-learning outcome than after the face-to-face events of the previous years. This includes the examination performance, which in the alternative format of final presentation and report is much closer to the professional reality of an engineer than a written exam.

11. Opportunities for improvement

However, the students' feedback also shows that there is still room for improvement. It turned out that the schedule of the course, which is very different from other courses in the aerospace engineering specialisation, did not become clear to everyone. In addition, not everyone was able to cope well with his or her role from the beginning. These points could be remedied relatively easily, for example, by explaining the tasks of the individual roles more clearly during the introductory session.

Another point is the utilised software, Valispace, which was rated positively throughout, but could not be fully utilised due to its limited performance (especially with regard to long times for synchronisation and calculation of data). A separate evaluation was carried out on this, which will be the subject of a future publication.

A disadvantage inherent in the applied approach is the limited insight into student learning during the semester. It is true that the consultations every two to three weeks, in which all students are expected to point out problems as well as their progress, provide a basis. Nevertheless, the perception of learning difficulties is more direct in face-to-face events and feedback loops can be kept shorter.

13 Summary and outlook

In the context of the course "Design of Space Systems" of the specialisation aerospace engineering of the diploma course mechanical engineering of the TU Dresden, a concurrent engineering workshop on the conception of a space mission was successfully transferred into a virtual format. The core of the restructuring, which became necessary due to the restrictions associated with the COVID-19 pandemic, was the stretching of the course, which had previously been held as a block course over three days, to cover the entire semester. The portfolio of utilised methods included screencasts to teach the basics at the beginning of the course, shifting the actual elaboration to self-study, and regular live consultations with short presentations by the students. This mixture of synchronous and asynchronous elements, together with the change of the assessment from a written exam to a combination of final presentation and report, led to the success of the course in this semester, which was underlined by the conducted teaching evaluation.

At the same time, this first iteration revealed concrete approaches for further improvements. For example, the students noticed the high amount of work compared to other courses. This could be reduced in the future by omitting an iteration stage in the detailing of the mission design or shortening it. In addition, the introduction to the course can be expanded, e.g. through dedicated short presentations with concrete example scenarios for the introduction to the different roles. This is important in order not to lose students at the beginning. After all, the main challenge of reaching all students and enabling them to actively participate, so that the mission study carried out can be led to success in the sense of concurrent engineering, arises anew each time.

Since the virtual format has led to a very positive teaching-learning result overall, the approach suggests itself to develop a hybrid format in the future, which is based on the structure of the virtual approach, and thus partly asynchronous knowledge transfer, and links this with face-to-face events. However, it will probably not be possible to please all students, as the opinion on face-to-face and online teaching in Figure 22 shows.

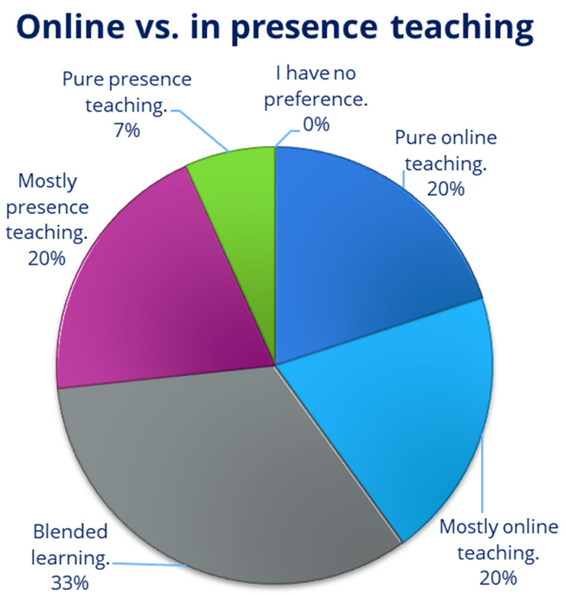

Fig. 22: Answers to the statement "In the context of teaching, I prefer the following forms of communication:"

Acknowledgement

We would like to thank all participating students for their adaptability, commitment, understanding and feedback.

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Self-discipline - The key

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Abstract

Die COVID19-Pandemie zeigt in allen Ebenen nur allzu deutlich die Stärken aber auch die jeweiligen Schwächen des Bildungssystems auf. Von geschlossenen Kindertageseinrichtungen, Grundschulen, weiterführenden Schulen, Fachhochschulen bis hin zur universitären Ausbildung sind die bildungstechnischen, persönlichen und sozialen Folgen des ausgesetzten Unterrichts bzw. der digitalen Varianten nicht absehbar. In allen Bildungsbereichen schien man nahezu unvorbereitet mit dem digitalen Zeitalter konfrontiert worden zu sein. Das Online-Format als solches schien bisher nicht in das (deutsche) Bildungssystem zu passen. Die Frage nach dem warum stellt sich hier nur allzu offensichtlich, da sowohl Schüler nahezu jeden Alters als auch Studierende täglich privat online sind. Das vorliegende Paper stellt kritische Fragen, wie online-Lehre sinnvoll für Lehrkräfte und Schüler/ Studierende umgesetzt werden kann, wo der Grundstock eines zielführenden online-Unterrichts gelegt werden muss und bei wem welche Zuständigkeiten für eine produktive Ausbildung liegen. Das umfangreiche Angebot an vertonten und visualisierten Kursen ist nur eine Seite der Medaille. Auf der anderen Seite stehen Themen wie Selbstdisziplin und -organisation. Sowohl die kindliche Ausbildung (Grundschule) als auch die Ausbildung an der Universität werden im Rahmen dieser Veröffentlichung aus Sicht der Autoren diskutiert und Kommentare sowie entsprechende Vorschläge zur Optimierung der Ausbildung auf Seiten der Lehrenden und Lernenden unterbreitet.

The COVID19 pandemic clearly showed the strengths and weaknesses of education systems at all levels. From closed kindergartens, gradeschools and highschools to universities, the educational, personal and social impacts of the suspended education system are inconceivable. In all areas of education, it was shown that the digital age was nearly fully unprepared to confront these challenges. To date the online format has proven not to fit to the (German) education system. The question that arises is why is this the case, since schoolchildren of almost every age are online privately every day. The following paper states critical questions such as how online education can be applied in a way that is reasonable for both students and teachers, where the foundation of a purposeful online lecture must be laid and by who do which portions of responsibility for a productive education lay? The extensive offer of recorded and visualized courses is only one side of the coin. On the other side lay topics such as self-discipline and organization. Both the gradeschool and university education are discussed by the authors in this publication, as are associated suggestions for optimization of the education from the sides of the teachers and students.

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1. Introduction

As part of the preparation for the Lessons Learned events in autumn 2020 and spring 2021, a variety of discussions took place between the authors of this publication as to why active participation in the teaching-learning process changes so abruptly when there is a shift from face-to-face to online teaching, whether there are similar phenomena in the educational systems of the USA and Germany, and what conclusions should be drawn for the future.

The primary questions are: How do we learn? How did learning and teaching take place in the past and today, and how should the learning process be accommodated in the future?

The private challenges associated with the COVID19 pandemic naturally play an immense role on the side of the teachers and lecturers, as well as on the side of the pupils and students, in the design of teaching and learning, as well as in scheduling. However, this area will not be dealt with in greater depth in the following work, as the picture is too diverse and thus does not necessarily lead to general statements for future teaching.

The purpose of this publication is to evaluate the possibilities offered by the digitisation of teaching, the tasks that result from it for the entire education system, being for both teachers and learners. Additionally, the problems we teachers have faced and still face and the approaches to solutions that have emerged will be evaluated. The focus of the observations should not be the detailed listing of and experiences with individual web meeting portals or the use of specific software and hardware. Rather, the authors wanted to take a step back and look at the entire education system.

When analysing the preparation, implementation and follow-up of their own courses, one central point crystallised among the authors: self-discipline. This may sound surprising at first, however the choice of this term was made because both the conversion of one's own teaching to digital formats and the associated effort in terms of time and costs on the part of the lecturer, as well as the constant *active* participation of the students on the other side of the screen, depend on one's own self-discipline.

The following article addresses the question of how self-discipline can be triggered in the context of education and how it must be taught or supported in the future.

2. How do we learn?

In order to pursue a complex question of "how do we learn?", the search for the training of self-discipline and self-organisation in our educational system is a central core issue.

During the years of school-based training, children were trained by a teacher in face-to-face lessons. For the children, direct contact, the opportunity to ask questions directly, learning non-verbal communication and also receiving comparison with their peers is possible here.

Fig. 1: Teacher-pupil communication in person [1]

This concept is based on the approach that as much external guidance as possible is needed at a young age to teach children "right" and "wrong". However, if one continues to follow the school education path, it quickly becomes clear that despite the increasing age, little changes in the leadership style of the education system. The focus is often on the content to be learned and tested (examinable) and less on the "how" and "why". In regular face-to-face teaching, there is compulsory attendance, which is not questioned in principle, as well as clearly defined tasks that have to be completed in class and as homework. Of course, the need for self-discipline increases with age. For example, students have to plan for themselves when they will start learning a poem or designing a poster. However, up to the final years, a teacher or the parents are often there to remind the students of their tasks during the school year. In an emergency, there are still various possibilities to "iron out" the grade if something goes wrong.

In the context of the COVID9 pandemic, however, it has now become increasingly clear that this approach should be fundamentally reconsidered. Not only are the students and parents often overtaxed with education in the digital format, but a similar picture emerged among the students, especially in the first few months. The "hand holding" was missing. The day was long, the tasks *actually seemed* manageable on the page... so why start *now* and not a little later?

Our education system must therefore start to teach "learners" their own responsibility in a timely manner. The "why" and the "how" play an important role here in order to put the understanding, the necessity and the benefits of this turnaround into a concievable context for all concerned.

However, "guided learning" does not end at the school door. A similar trend can be seen in the university education system. Especially in STEM subjects, there fixed timetables for courses in Germany that students are encouraged to take and that are required to both pass the corresponding examination as well as to obtain the final degree. However, the term "compulsory" is apparently rather loosely translated and understood in some cases from the time of entering "adulthood". With end-of-semester exams in many cases accounting for nearly 100% of the final grade, one can well imagine that this examination strategy alone must lead to the development of self-discipline. The logical consequence should therefore be that students *continuously and actively* participate in the courses and - just like the lecturers - prepare and follow up on them. In reality, however, the procrastination path is often chosen. Terms such as "bulimic learning" make the rounds here, since during the semester active learning and self-study are in some cases nearly nonexistent, but shortly before the exam almost all stops are pulled out to compensate for the lack of expertise.

With that being said, an education system must include more than lectures and the transmission of technical knowledge. It is not only about how to find the correct solution, but which path one has been taken to find a solution and for what reason. Therefore, a deeper understanding of the cause of motivation is needed. The central approach must address how motivation can be developed and supported by our educational systems in order to find a strategy for teaching and learning, with special consideration of digital teaching during pandemic times.

Fig. 2: Lecturer-student communication in attendance [2]

After discussion of all the pros and cons and the approach of whether the problems of digital courses could stem from the fundamental educational policy approach of the authors' countries of origin, it became obvious that self-discipline or disciplinary measures seem to be a possible key to a "successful" course. This term does not refer to a particularly good average grade in the final examination, but to both the regular and interested participation by the trainees as well as internalisation of the subject matter and the *ability to apply* what has been learned. But it is not only on the side of the learners that the issue of self-discipline must be illuminated: a motivated lecturer with fresh ideas, a didactically valuable preparation of the teaching content as well as a fruitful interaction between the lecturer and the students are also necessary for a satisfactory outcome of the training. However, fulfilling the wishes and needs of the lecturer and the students are even more difficult to achieve in the context of a digital course than in face-to-face teaching. Therefore, the focus in "early education" must be on self-initiated and active learning, and this must be supported by the "teaching staff". As this transition will be a long process, the need for self-discipline, self-study and questioning of facts and approaches must be taught, refreshed and supported at all levels of the education system.

3. Link between self-discipline and courses during the COVID19 pandemic.

If we now look at the above questions and theses from the point of view of the lecturers, the following picture emerges: The majority of lecturers who see teaching not only as a profession but as a vocation take advantage of available further training before and during pandemic times, and implement new tools, programmes, approaches, hardware and software. The COVID19 crisis thus represented a cause and opportunity - albeit a very hard and forced one - for the further development of teaching. Pragmatic solutions had to be found for the start of the 2020 summer semester. The first week of lectures was approaching and the country was in lockdown. Accordingly, the teachers and lecturers first used all the familiar tools and modified them - always with a view to the fact that this would hopefully be a short period in which distance teaching would have to take place. After a few days and weeks in this operation, however, it became foreseeable that the effort and quality of teaching in this approach would have serious consequences for education: In some cases, for example, slides were simply put online in pdf format. Other approaches such as "presentations set to music with PowerPoint" drove the teachers (including the authors) to the brink of madness, as the quality of the soundtrack was not satisfactory and if there was a small slip of the tongue or a short stumble, they preferred to record the slide again from the beginning. Now, even as an outsider, one can well imagine that the third, fourth or fifth attempt at a slide leads to a rapid decline in motivation. Self-discipline on the part of the teachers was also absolutely necessary here! The time investment for preparation increased rapidly and solutions had to be sought to improve the quality of teaching again and to reduce one's own weekly time commitment again, at least partially. This in turn meant: self-discipline, self-initiative and self-study on the part of the teachers: New tools, new didactic approaches, and new hardware were required! After more than a year of the pandemic, various tools are now known that are specifically suitable for digital teaching and some of which will most likely also be used in hybrid concepts or the face-to-face teaching that most lecturers long for in the future.

Many such ideas are being implemented worldwide and also at TU Dresden. The lessons learned events in autumn 2020 and spring 2021 showed the great commitment of the lecturers: The experiences with new programmes such as the lecture-specific Paella Player [3] were shared in this context. The aim of this tool is to improve the lecture experience for the lecturer as well as the students by simplifying navigation between the slides and the video, and to have simple ways to customise the screen. Other approaches such as the use of green screen technology [4] provided important insights into the advantages and disadvantages of the technology. With the help of this technology, the lecturer can integrate themselves into the lecture and thus interact better with his teaching content. Such ideas drove the further development of education despite difficult boundary conditions and are a model for the process of "invention through need".

Since the authors of this article only worked in the area of lectures in the previous "Corona semesters", their experiences are also limited to this. After a multitude of considerations, tested tools and new approaches, the authors decided to use the web meeting platform Zoom, among other things, because of the stability of the platform and the possibility of recording the course. This was a decisive advantage compared to BigBlueButton, for example, as it meant that students who were unable to attend a synchronous event due to lockdown, childcare, etc. also had access to the content. The integration of videos for a better explanation of the processes in the considered systems as well as the possibility of using survey tools such as Invote, Kahoot! etc. are additionally usable for the "synchronous" participants and are both easier and more stable to integrate than with other platforms.

However, since lectures are only one part of the courses offered at the TU Dresden, new ideas for conducting practicals without presence were and are in demand, also. Laboratory practicals in physical chemistry, for example, were carried out using ideas such as Lab@Home [5], so that students could gain a deeper understanding of complex issues. The tasks previously carried out together in the PC pool have now been transferred to work at home (Lab@Home), with direct supervision from the department set up online. Another excellent example at the TU Dresden is a lab in the context of a physics practical course [6], where machines were displayed virtually and the students were able to view them independently on their home screens from different angles, which contributed to a better understanding of how they functioned. Of course, this procedure is not comparable to actually touching and trying out components and machines, but it represents a logical intermediate step between the desired haptic experience and an image as a pdf.

The examples given show only a fraction of the tools and approaches used at the TU Dresden. Basically, the following must be noted on the side of the lecturers:

The will is there, the possibilities are almost inexhaustible, but the time is quite limited.

After discussions with lecturers and practical instructors during the first two "Corona semesters", it became clear that, in most cases, the live audience had decreased rapidly. Compared to the participants registered in the OPAL education portal, some internally congratulated themselves on as little as 10% of this crowd attending the weekly events. With all the effort put into preparing for digital teaching, coupled with the fact that the cameras and microphones on the other side of the screens are mostly dark and silent during the lecture, the level of frustration is also progressive on the part of the teachers. Regarding the reduced participation in the synchronous event, one important point seems to be in the foreground: Is the live lecture made available digitally afterwards (including sound and images) or not?

The questions that arise for the authors are the following: Is it enough for students to listen to and watch lectures set to music? Do students actually like this offline teaching better than face-to-face teaching?

After consultation with individual students, the free allocation of time for "listening" to the teaching content emerged as the main reason. Is it therefore possible that only (or mainly) the lecturers would like to have teaching in the lecture hall back? Additionally: How can the active participation of students in online teaching be increased in order to evoke an *active* teaching experience among students and reduce "bulimic learning"?

Apparently, a variety of digital teaching methods are offered at the TU Dresden. However, these cannot replace the active and joint learning of the students and the support of the lecturer within the framework of the courses and beyond. Regular work on the part of the students must be strived for. Knowledge cannot be acquired in a meaningful and long-term way within a few days. This means that ways must be found to encourage and also challenge the process of learning throughout the semester.

If one now looks again at one's own educational path and school years, there were in principle two possibilities why a task was carried out: Either there was an awareness that it was necessary to understand and be able to apply one or the other teaching content, which implies that the causal connection up to one's own benefit of what has been learned is known, or there was a clear demand, including a directly related consequence/sanction, if the task was not fulfilled.

In the first, naturally intended case, it is the task of the teaching staff to explain why an assignment should be carried out and what the aim of the course and the final examination is. However, it must be emphasised here that the participants in a university course are young adults who have chosen their course themselves and should be anxious, or rather intrinsically motivated, not only to attend the events but to *actively* participate in them. Here, the causal connection between learning, one's own commitment of time and resources and one's own (professional) goal should be established at a much earlier stage, preferably in childhood.

If this way is not successful, the second way is also a possibility: drawing consequences in the form of "intermediate examinations". These can be that participation in a course that is defined as compulsory and entails examinations. In this way, students who need more structure and guidance are offered appropriate assistance and all participants can regularly discuss the content of the courses. A further step towards regular learning is, following the school mode, homework or quizzes during the course, which form part of the module grade. These approaches are rarely practised in the university system in Germany. In other countries, for example in the home country of one of the authors of this article, the USA, these ideas are regularly implemented.

Of course, there are always advantages and disadvantages to the named approaches, which need to be considered carefully. However, a situation like we are facing during the COVID19 pandemic needs as many ideas, suggestions and alternative approaches as possible.

Especially with regard to the issue of self-discipline, the second approach mentioned in this section is, in the authors' view, the "wrong" one in the long run. It is true that this binds students to their own subject, but it must be made clear again in the education system that education is a privilege that is not made possible for everyone, and that one's own drive for further education and professional success is supported by the lecturers and that it is not a punishment to attend courses.

4. Suggestions and discussion: what is useful and meaningful?

In conversations with individual students as well as written feedback, it became clear that "*simple pdfs without comments are not very helpful*" and are considered by students to be "*unmotivated*" on the part of the teacher. Recorded versions or recorded lectures, on the other hand, are highly valued. The quality of the recording, the number of built-in gimmicks that we teachers are so proud of (due to the amount of time spent and the beautiful didactic approach), seems to be rather less important here. The main thing is that there is "*something there to explain*".

When asked why the cameras are turned off on the part of the students, a response came that was perplexing to the authors, but nevertheless quite logical. "After *all, we see you and have contact with you. We would not have thought that this would be funny for you*". Individual participants comply with the wish to switch on the cameras in order to interact better, but here, too, this has to be reminded again every lesson. The goal for digital teaching should, however, rather be the *joint* teaching event, in terms of content, both visually and acoustically (see Fig. 3).

Fig. 3: Participants in the International Refrigeration and Compressor Course, TU Dresden, 2020

In a self-test of how to "process" PowerPoint lectures set to music that are not attended live, the authors came to the conclusion that 90 minutes of concentrated listening is not possible - thoughts drift away if no questions are asked that require an answer and no urgently needed change of media takes place. This is because the medium - despite the lovingly prepared videos, animations, tablets used, etc. - is and remains the mp4/ppsx format. When asked by the students, it is mentioned that the courses are "*played back faster*" and that the speed is adjusted again for "*interesting things*". Comprehensible? Quite. Does it lead to a deeper understanding of the subject matter? Hardly.

An alternative to 90-minute block lectures are shorter recordings. On the one hand, 60-minute lectures with subsequent discussion and question opportunities were tried. The result was that few to no questions were asked and the event ended a few minutes later. Teaching blocks of 15 minutes are quite possible in order to follow the events in a concentrated manner. However, there is the question of reducing the teaching content. Even with three 15-minute teaching blocks, 45 minutes of the previous teaching content remain. A simple option: self-study! This brings us back to the point of self-discipline. If "homework" is given during pandemic times, which we affectionately call "self-study" in adult education, how is it completed? Sobering results are probably pre-programmed in some cases. The question is, why was this possible in school but yet so difficult today? An unmolested semester and a final exam seem to be the problem here. Short tests, preferably unannounced, seem to offer a possible solution. The problem here seems to be the structure: one exam, no required active participation in the course, the end. The students are left alone with their (existing or non-existent) self-discipline. Is that helpful? For one side, both sides or in the end for none at all?

Perhaps approaches such as those listed in Fig. 4 are useful for a start to the lecture.

Fig. 4: Adaptation of meeting objectives for lectures [7].

Let's think of the multitude of online meetings that take place every day and how quickly one writes an email "on the side". Self-discipline needs to be brought to the fore again here. A new approach, which will be at the top of the "trial and error" list in the coming summer semester, is the suggestion to choose two goals to be fulfilled for the respective course, such as "camera on" and "at least one question asked in the chat". The objectives in Fig. 4 should of course be seen as illustrative and should be adapted accordingly.

For us, the aim of teaching has always been concomitant teaching and learning. Communication is nonexistent with black screens in a zoom course. Disciplinary measures, even if it's just a small quiz, are officially not possible (at least in the authors' modules), unless you go down the route of changing the examination regulations. The inclusion of small tricks, such as multiple choice questions in the lecture, is appreciated and completed by the participants (those who participate synchronously). However, relatively few then want to discuss the answers provided. Perhaps an improvement in digital teaching is possible with jointly set goals (camera on, question asked,...) and even greater openness on the part of the teacher towards the students with regard to the (non-content-related) course of the event. Practice shows, however, that the requests of some participants are fulfilled, but then the familiar image of "black screens" reappears over the semester.

In the internal discussions on teaching between the authors on the subject of self-discipline, the connection to one's own "time management" was always made. Each of us has our strengths and weaknesses here. We all have an internal laziness. The question is, how can we better teach students (and ourselves) to deal with it?

Fig. 5: Self-discipline [8].

The authors' proposal may be too strict for some here, but that is precisely why it should be put up for discussion:

A compulsory course on self-discipline, a "how-to" (online) collaboration and time management for all students at the beginning of their studies or next semester with subsequent testing on case studies. To go one step further: the integration of these "trainings" into the school routine, so that the causes and ways can be clarified at an early stage.

The added value of such an event is considered very high by the authors - not only for studies, but also for later professional and private life.

5. Summary

This article was written after a year of gaining knowledge regarding new software and hardware and the resulting experiences. New tricks, video editing programmes, tablets, online meeting tools, lighting, dubbing, advantageous video settings, and dos and don'ts were learned and tested - alongside everyday tasks. All this was only possible with a fair amount of enthusiasm and self-discipline, which a large number of lecturers and students also possess. Both "sides" need a push now and then for a good and satisfying course. From the authors' point of view, this is only possible if the lecturer does not speak into the great "darkness", but rather when the regular operation and *active participation is* made possible and transferred into the digital format.

We hope that the tone of this statement is not too negative. The difference between desire and reality had to be questioned several times last year. Not every tool that excites the lecturers evokes this enthusiasm in the students, and it is questionable whether the effort and the benefits become visible to the participants and achieve greater success. This article thus likely shares more the authors' own "lessons learned": from getting to know one's own frustration thresholds, unbelievable and not expected "aha" experiences, to using completely new approaches, to seeing the "light at the end of the tunnel".

As a final word and link to the thesis and the call for more self-discipline and self-organisation, all participants in a course - lecturer or student - should again be reminded of the meaning of the word "study". Both teachers and learners, from the authors' point of view, should always be considered as students (studens - Latin), because they should "strive" for knowledge and further education according to the definition of the word and "strive" for their own progress and that of others.

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Concepts for beneficial teaching under pandemic conditions

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Abstract

In diesem Report wollen wir aufzeigen, wie Lehre unter Pandemiebedingungen nicht nur bewältigt wurde, sondern tatsächlich zu einem Mehrwert für die Studierenden geführt hat. Dazu analysieren und vergleichen wir unsere Erfahrungen aus drei Lehrveranstaltungen. Alle Veranstaltungen wurden vollständig virtuell und live gehalten und abschließend von den Studierenden evaluiert. Das positive Feedback wird Einfluss in die zukünftige Gestaltung dieser Veranstaltungen auch nach Bewältigung der Pandemie haben.

In this report, we want to show how teaching under pandemic conditions was not only managed, but actually led to added value for the students. To this end, we analyse and compare our experiences from three courses. All courses were held completely virtually and live and were finally evaluated by the students. The positive feedback will have an influence on the future design of these events, even after the pandemic has been overcome.

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1. Introduction

In the summer semester 2020 and winter semester 2020/21, the lectures "Solid-Fluid-Substance Exchange Processes" (FF-SAP) and "Product and Production Integrated Environmental Protection" (PIUS) were held by our chair as part of the optional module VNT-36 (K. Eckert). In addition, the optional lecture "Bubbles, Foam and Froth" (BFF, S. Heitkam) was offered for the first time.

In FF-SAP we lay the physical-technical foundations for relevant processes in resource extraction (including electro- and hydrometallurgical processes, nitrification in activated sludge tanks, fixed-bed adsorption or particle separation) and recycling (e.g. de-inking flotation for waste paper). The PIUS lecture, which was held by Dr Brummack until last year, has been completely relaunched to better link it to FF-SAP. PIUS is dedicated to environmental protection strategies as well as important aspects of the circular economy such as resource conservation and sustainability; eco-balancing is also included. The main goal of our PIUS lecture is to enable students to critically and ideology-free analyse problems at the interface of environmental protection and society/economy.

The BFF lecture was purely optional. It was created in connection with the Emmy Noether Junior Research Group on the topic of "Fluid Dynamics of Foams and Froth", which has been anchored at the Institute since May 2020. The lecture is intended to arouse interest in foams, convey the basics and introduce the methods and results used in the project into teaching.

2. Implementation

All lectures were held at the time announced in the lecture schedule via GoToMeeting or Zoom using PowerPoint. In addition, there was a calculation exercise every two weeks, primarily connected to FF-SAP. The recorded lectures were then placed on the ZIH cloud and the lecture PDFs were placed on OPAL before the lecture. The module exams, both of which had to be taken orally according to the current PO, were taken as presence exams.

As "pen people" who develop lectures live via tablet PC, the digital semesters initially presented us with considerable problems, as we had the feeling that the students would "fall asleep" in front of the PC if we kept this concept. Therefore, a lot of time has gone into digitising the lectures throughout the semester, as we are sure everyone has. In principle, however, the revision and specification of the FF-SAP lecture required for this has done us good. However, we were shocked to discover that we are now much faster than with the previous face-to-face lectures. We have counteracted this with four measures: (i) explain facts longer and (ii) usually offer 15-20 min repetition of the previous lecture. (iii) Provide additional computational tasks that can be worked on when time is available, thus creating a flexible buffer. (iv) We have made a special effort to link lecture content with current research topics of our chair or department at the HZDR. This has met with approval and has currently brought us an enormous number of student workers.

The BFF lecture pursues various goals and addresses different audiences: the lecture is intended to familiarise students of process engineering and natural materials technology with the very special but highly relevant topic of "foams". Furthermore, students of all disciplines should be enthused about foam and thus be won as future assistants or employees. In addition to students of process engineering, doctoral students in the engineering sciences should also be addressed here. Many international doctoral students feel that there is a lack of English-language courses at TU Dresden, especially in the field of fluid mechanics. Since doctoral students need appropriate courses to take their viva, an English-language alternative should be created with the optional BFF lecture.

Since the lecture had to take place virtually in the 2020/21 winter semester anyway due to the pandemic, the idea arose to make the lecture accessible to students and doctoral candidates at other universities. Therefore, the lecture announcement was published via subject-specific email distribution lists and in corresponding subject forums. Since no comparable lecture is currently offered throughout Europe, the offer met with good interest, especially among doctoral students in foam-related subjects. In at least three cases, doctoral researchers were explicitly invited by their PI to attend. A total of about 30 listeners initially took part. According to a Mentimeter survey [1], about 20% of them were TU Dresden students at the beginning, 30% were doctoral students from the TU Dresden and other Dresden research institutes, and 50% were external scientists. In the course of the semester, the number of participants fell to around 20, with students from the TU Dresden in particular losing out. This could possibly be counteracted through laboratory practicals in presence.

The problem with a public announcement was access control. Without access control, there was a risk of misuse or disruption of the event. Therefore, the link to the Zoom meeting was only distributed individually upon email request. This procedure proved successful, as there were no disruptions.

The organisation of the course via OPAL was also problematic. Although external persons could download the lecture slides here using a password, they could not enrol in the course or be active in the forums.

The content of the BFF lecture was essentially based on three pillars. Firstly, scientific facts were taught. Secondly, calculation exercises were discussed in order to internalise the interrelationships learned. And thirdly, examples of the application of what was learned in academic and industrial practice were explained.

These columns have been adapted for the virtual format.

Pillar 1: Foams are generally a very interdisciplinary field of research. They combine physical, chemical, mathematical and engineering approaches. Since 50% of the listeners were external scientists and scholars, there was also a certain dispersion of training here. A Mentimeter survey at the beginning showed 70% from engineering, 20% from physics and 10% from chemistry. Because of this distribution, little prior knowledge was assumed. Instead, subject-specific basics were extensively introduced or repeated. In a face-to-face course, more basics would probably have been assumed here and then further explanations added based on the direct feedback from the students. Based on the students' feedback (Figure 1), all listeners were able to follow the content well.

Pillar 2: The scientific basics were underpinned with 1-2 calculation exercises in each session. These were done in the middle part of the session to create a break and activate the listeners.

Compared to calculational exercises in presence, there were very few questions or discussions. Presumably, the students were uncomfortable presenting mistakes or ignorance for all to see. Instead, there was only a competition to see who could write the correct result in the chat first. A possibility for anonymous questions should be created here in future events, e.g. via Mentimeter.

Pillar 3: Since the lecture was originally designed for students of process engineering, there was a focus on the practical application of the scientific fundamentals. To this end, topic-related current measurement techniques or simulation methods were discussed in each lecture. At appropriate points, gaps in knowledge and the connection to our own research were also pointed out. Due to the participation of external scientists, Pillar 3 in particular led to very interesting discussions after the events. These discussions were very enriching as they demonstrated to all listeners how complex and diverse foam research is. If external guests cannot participate in future events, guest speakers should be invited or virtually integrated to demonstrate different points of view.

As just outlined with the BBF lecture, it was also necessary to break new ground with PIUS. The entire PIUS lecture was an intellectual adventure that kept me (KE) spinning the whole semester. I have rarely read so many books on current topics in one semester, in addition to textbooks, and incorporated them into a lecture. One really recommendable book that I take the liberty of quoting is Christian Berg's [2].

Since, unlike FF-SAP, PIUS did not have a prefabricated framework to which one could adhere, the following concept was applied.

(i) It was important to activate the students in the "corona isolation". This was attempted by including current, also political topics and occasionally provocative theses. Great importance was attached to actively inciting the students to form an opinion. After the lecture, there was always a 10-15 minute post-session in GoToMeeting, where problems were discussed together with interested students.

(ii) According to the motto "why should only we struggle with the troubles of digitalisation", there was a podcast project in the first third of the lecture series. Here, the students were encouraged to critically approach important, lecture-relevant problems, e.g. economic growth vs. sustainability, from several sides and to come to an opinion. This was actively accepted by 2/3 of the students and very nice contributions were produced in groups of 2, 3 and 4 using Audacity. These were uploaded to the OPAL course upload folder and were thus accessible to the others. In a relaxed evening session, which was suggested by the students themselves, we went through the podcasts again. Overall, the podcasts were seen as a profitable venture by all: The students found the exploration of the topics exciting and had fun in the production with Audacity and we were able to do something about the Corona isolation. We had the chance to see what makes our students tick and were very taken with the depth of engagement.

(iii) The PIUS lecture also included discussions on sustainability concepts (such as efficiency/sufficiency/consistency etc.), which also included an examination of individual lifestyles. Optionally, there was an offer to go through everything in order to calculate the individual CO2 footprint. Almost everyone participated voluntarily and uploaded their results to OPAL.

(iv) Life cycle assessment now plays a role in many projects. It was therefore important to us to offer an introduction to the topic coupled with a practical software exercise using free software (OpenLCA). This project had a scope of 4 lectures: Introduction, installation instructions, three exercise blocks. In the exercise blocks, there were questions formulated by us, which the students were to investigate independently. The starting point was the official OpenLCA tutorial on mineral water bottle evaluation (advantage: well documented, accessible to all). We gradually expanded this to include more complex questions (e.g. different transport routes, multiple fillings, etc.). These 3 blocks, which included a free-style variant (i.e. a question that the students had to come up with themselves), were to be worked on in the time window of the last 3 lectures (June/July). During this time, the GoToMeeting channel was open and the students could discuss problems with us. The solutions found were to be uploaded to OPAL.

In the end, we did not use the option originally approved by the examination board to include 30% of the OpenLCA solutions in the examination. The technical and social precondition of the students were too uneven. However, almost all of them took part in the project. 90% completed at least one block; 70% uploaded solutions to all three blocks.

3. Our conclusion

Despite the high time commitment, we considered the semesters to be profitable. We were very positively surprised by the oral exam results. In FF-SAP, there were no differences to previous years. We were particularly enthusiastic about the PIUS examinations. It was a pleasure to experience the high number of smart and critically arguing students.

We see the following things as needing improvement in VNT-36: (i) Exercises in GoToMeeting are a difficult undertaking. In face-to-face exercises students always dare to ask more; in GoToMeeting rather less. Then you speak into the mic without seeing students, which was not much fun. That's why we mostly held the exercises as pre-calculus exercises with some questions live from the auditorium or via chat. Here we are very interested in an exchange for optimisation. (ii) Due to time constraints, the PDFs always had to be uploaded without further editing, i.e. without deliberately placed gaps. An efficient solution is still missing here. (iii) In some lectures, Mentimeter was used to activate and test knowledge for concrete questions. This should have been done more often here. But on the one hand, there was not enough time for preparation; on the other hand, the scope of services of the free version was clearly less convenient than before. An alternative is, for example, umfrageonline.com.

4. Feedback from the students

An anonymous evaluation of the BFF lecture was carried out after the conclusion of the last event. Figure 1 shows the results.

It can be seen that all participants found the content of the lecture interesting. Most participants found the scope appropriate and were also able to follow the lecture well digitally. All participants found the online exercises helpful. These points speak for a successful implementation of the virtual event with the chosen format. However, 50% of the participants spent less than 10 minutes per week, in some cases even no time at all, on preparing and following up the course. This could be due to the optional nature of the event, but possibly also to a feeling of anonymity in the virtual space. Poor preparation on the part of the students is not noticeable.

The FF-SAP lecture was in the official course evaluation and was given an overall grade of 1.27, which made us very happy. We are trying to implement the remaining criticisms (better structuring now and then, incorporating more exam questions directly into the chapters, quizzes at the beginning).

Equally motivating was the spontaneous feedback from several students after the oral PIUS exam. They had rarely had so many exciting discussions among themselves about topics in a lecture as they had this semester.

This encourages us to offer academic content linked to current and, in part, political issues from time to time in order to stimulate students to take an active stance and form opinions.

5. Outlook on a hybrid teaching offer

We can imagine shortening some of the lectures to 30 min online video on a specific topic. We would use the freed-up time, on the one hand, for the students to have to think about the problem and find solutions for it. On the other hand, for a consultation and discussion

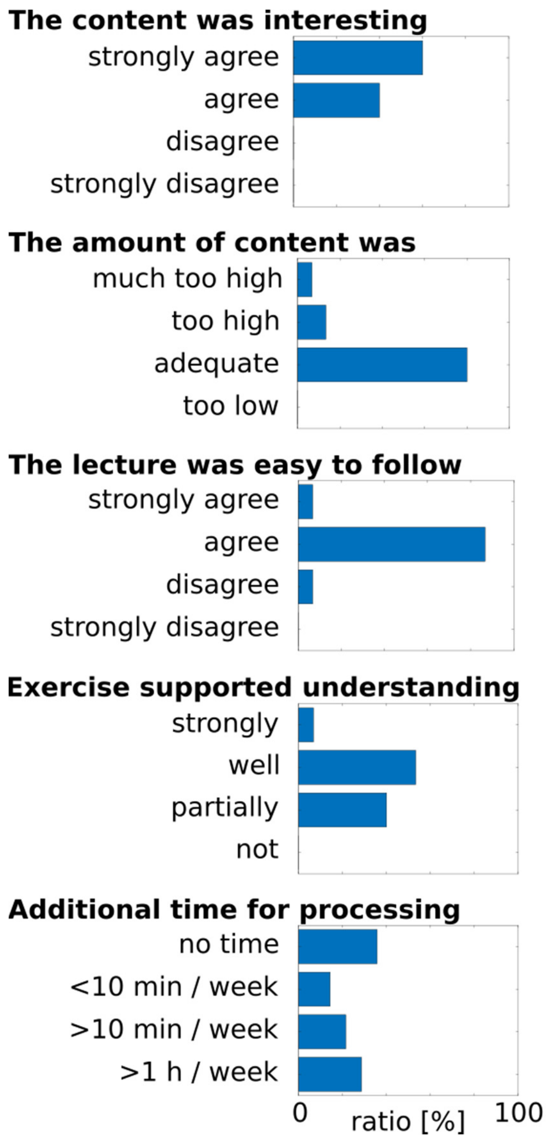

Fig. 1: Anonymous evaluation of the BFF lecture in the winter semester 20/21

session to discuss the questions that have arisen and the solutions that have been found.

Apparently there is no dedicated lecture in the field of foams in Europe. Due to the very positive feedback from international students and doctoral candidates on the BFF lecture, the lecture could also be held virtually and openly in the future. Alternatively, a live stream from the lecture hall would also be conceivable. In addition to the pure teaching task, this would also strongly serve international networking and student exchange. However, a laboratory practical should be added in the future for students in attendance.

Acknowledgement

Sincere thanks go on the one hand to Dr. K. Schwarzenberger for the OPAL support of the lecture and for taking over the lecture block on desulphurisation, as well as to our tutor, Robin Wolf, for the effective support of the exercises on life cycle assessment. On the other hand, we would like to thank all the students in the 2020 recycling module for their enormous interest and commitment, which also made the lectures an inspiring experience for me.

Literature

[1] https://www.mentimeter.com
[2] Christian Berg, Ist Nachhaltigkeit utopisch? Der neue Bericht an den Club of Rome, oe-kom-Verlag (2020)

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Presentation and student evaluation of digital learning formats in two methodological basic subjects of mechanics

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Die pandemiebedingte Umstellung der Präsenzlehre auf digitale Lernformate brachte vor allem für die Studierenden große Herausforderungen mit sich. Die beiden vorgestellten, methodischen Grundlagenfächer der Mechanik wurden vollständig digital angeboten. Zur Stoffvermittlung wurden aufgezeichnete Lehrvideos und zur Fragenbeantwortung vor allem Übungsforen eingesetzt. Mithilfe von Umfragen unter allen Prüfungsteilnehmenden wurden die eingesetzten Lernformate evaluiert. Es zeigt sich dabei, dass aufgezeichnete Vorlesungsvideos gegenüber Präsenzvorlesungen von den Studierenden als hilfreicher wahrgenommen werden. Als Vorteil wird dabei die Möglichkeit zum Anhalten und Wiederholen der Vorlesungsvideos genannt. Das Übungsforum wird zwar als eher hilfreich bewertet, jedoch nicht als adäquater Ersatz zur Präsenzübung eingeschätzt. Laut den studentischen Kommentaren spielt die direkte und unmittelbare Kommunikation in der Präsenzübung eine wichtige Rolle, die in einem Forum nicht erreicht werden kann. Die beste Bewertung unter den Lernformen erzielten kurze Einführungsvideos in die Thematik und Aufgaben der Übungen.

The pandemic-induced migration of classroom teaching to digital learning formats brought great challenges, especially for the students. The two presented methodical subjects in basic mechanics were offered completely digitally. Recorded teaching videos were used to convey the course content and mainly exercise forums were used to answer questions. The learning formats used were evaluated with the help of surveys among all examination participants. The results show that the students prefer recorded lecture videos over classroom lectures. The possibility of pausing and repeating the lecture videos was named as an advantage. The exercise forum is rated as helpful, but not as an adequate substitute for the classroom exercise. According to the student comments, direct and immediate communication plays an important role in the classroom exercise, which cannot be achieved in a forum. The best rating among the teaching formats was achieved by short introduction videos on the topic and tasks of the exercises.

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1. Introduction

The shift in university teaching from the classroom to the digital space over several semesters due to the Corona pandemic has brought great challenges, especially for students. Especially in calculation-intensive subjects such as technical mechanics, teaching basic methods in classroom exercises is an essential part of the usual course programme. This article deals with the realization of digital teaching in two subjects of the Chair of Dynamics and Mechanism Design at TU Dresden in the summer semester 2020 and the evaluation of the implemented learning formats by all students who participated in the corresponding written examination.

2. Presentation of the courses

The course *Technical Mechanics Kinematics and Kinetics* (TMKK) is a compulsory course with 3 credit hours per week (CHW) lecture and 2 CHW exercise in the diploma and bachelor degree programme Mechanical Engineering in the 4th semester. In attendance semesters, the exercises take place in groups of 20 to 60 students. The audience of the English-language course *Kinematics and Kinetics of Multibody Systems* (MBS) consists mainly of students of the degree programmes Mechanical Engineering in the specialisation Simulation Methods in Mechanical Engineering (MB-SIM), Mechatronics (MT) and Computational Modelling and Simulation (CMS). The students regularly attend 2 CHW lecture and 2 CHW exercise. In addition, students of the mechanical engineering specialisation in Processing and Textile Mechanical Engineering (MB-VTMB) regularly attend half the course content with 1 CHW lecture and exercise each. For the diploma degree programmes (MB-SIM, MB-VTMB, MT), this is a elective course in the main study period.

3. Digital learning formats in TMKK

In the course TMKK, lecture recordings were available that were recorded by the AG Fernstudium (correspondence course team) of the Faculty of Mechanical Engineering at the TU Dresden in 2015 during the regular lecture. The respective lecture videos were released in the corresponding semester week on the saxon learning platform OPAL using the video server MAGMA. The lecture content is mainly taught using hand written notes on a tablet computer (see Figure 1).

For the respective exercises, detailed introduction slides, instructions for solving the single tasks and detailed sample solutions were provided. In addition, the first two exercise introductions were recorded on video. This video production was not continued for the further exercise introductions due to capacity reasons of the teaching staff. Questions about the exercises and for exam preparation could be asked in an OPAL forum. A separate forum was set up for each exercise. Online consultations were offered approximately every fortnight, although this offer was only used by an average of 5 students.

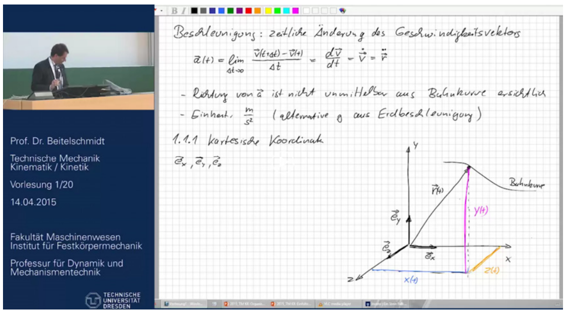

Fig. 1: Lecture TMKK, recording of the AG Fernstudium of the Faculty of Mechanical Engineering at TU Dresden.

4. Digital learning formats in MBS

The lectures of the MBS course are designed as a combination of slide presentation and handwritten tablet lecture. The lecture videos (see Figure 2) were recorded during the semester. The actual video duration is shorter than the usual lecture time of 90 minutes due to a lack of questions and spontaneous additional explanations.

While changing the course language from German to English one year before, slide-based introduction videos (intro videos) of approx. ten minutes were produced for all exercises (see Figure 3). As in TMKK, the OPAL forum was used to answer questions about the exercises and sample exams.

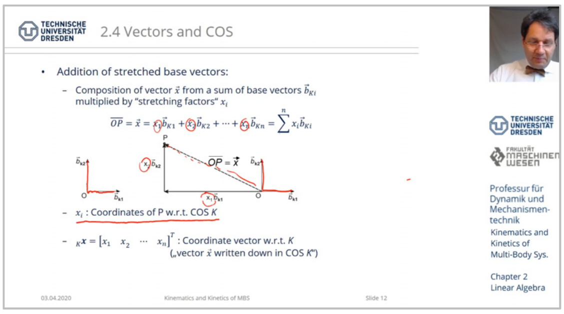

Fig. 2: Lecture MBS, slide with handwritten comments, recorded using OBS Studio.

The final course element is a complex exercise. In the digital semester, it took place partly in presence, but with low participation. The aim of the complex exercise is to program a multibody simulation in the commercial software MATLAB. For examination preparation, one online and one classroom consultation took place.

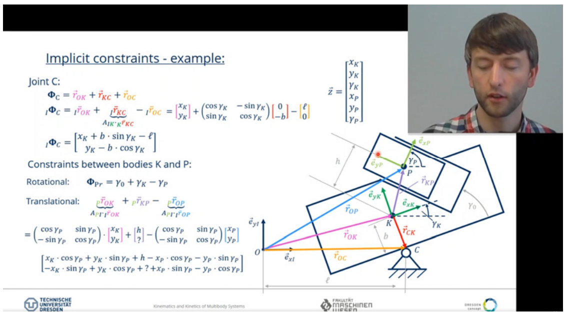

Fig. 3: Exercise introduction MBS, example calculation on PowerPoint slide, recorded using OBS Studio

5. Evaluation of the courses

In order to allow a comprehensive teaching evaluation, an anonymous survey with approx. 20 questions and comment fields was conducted among all examination participants at the end of the respective written classroom examination. Thus, 338 filled surveys are available for the TMKK course and 70 for MBS. Further 52 completed surveys with partly identical questions are available for the MBS course of the previous year. This allows a comparison between the digital and the classroom semester.

In the diagrams for the TMKK course, the proportion of students who have repeated the examination and have thus already attended the course for the first time in a regular classroom semester is marked in orange. This applies to 16% of the students who took the examination. In the course MBS, a distinction is made between the student groups Mechanical Engineering-SIM/Mechatronics (blue), CMS (orange) and Mechanical Engineering-VTMB (yellow). Due to negligible failure rates, the proportion of students repeating the exam plays a subordinate role here.

Prüfungsversuch: O Erstversuch O Zweit- oder Drittversuch

Muttersprache: O Deutsch O Andere

Aussage (Bitte bewerten Sie nur Aussagen, zu denen Sie aussagefähig sind)	Trifft voll zu	Trifft zu	Teils/ Teils	Trifft kaum zu	Trifft nicht zu	Keine Aussage möglich
Ich konnte der Vorlesung inhaltlich sehr gut folgen.	O	O	O	O	O	O
Ich konnte den Video-Vorlesungen besser folgen, als „normalen" Vorlesungen in Präsenz.	O	O	O	O	O	O
Ich habe die Videos zur Vorlesung in der jeweils vorgesehenen Woche angeschaut.	O	O	O	O	O	O
Ich hatte technische Probleme, die Videos anzuschauen.	O	O	O	O	O	O
Die Einführungen und Lösungen zu den Übungen waren sehr hilfreich für mich.	O	O	O	O	O	O
Ich habe die Übungsaufgaben in der jeweils vorgesehenen Woche bearbeitet.	O	O	O	O	O	O
Ich habe mich regelmäßig mit Kommilitonen über Vorlesung bzw. Übung ausgetauscht.	O	O	O	O	O	O
Das Übungsforum war für mich sehr hilfreich zur Bearbeitung der Übungsaufgaben.	O	O	O	O	O	O
Ich hatte technische Probleme bei der Teilnahme an den Online-Konsultationen.	O	O	O	O	O	O
Das Prüfungsforum hat mir in der Prüfungsvorbereitung sehr geholfen.	O	O	O	O	O	O
Vor der Prüfung habe ich mich sehr gut vorbereitet gefühlt.	O	O	O	O	O	O
Bei der Prüfung habe ich gemerkt, dass ich sehr gut vorbereitet war.	O	O	O	O	O	O
Die Möglichkeit, das Prüfungsergebnis im Nachgang zu annullieren, beeinflusste meine Prüfungsvorbereitung.	O	O	O	O	O	O
Es fiel mir in diesem Semester schwer, mich für die Bearbeitung der Kursinhalte zu motivieren.	O	O	O	O	O	O

Fig. 4: Front page of the survey in the TMKK course

As shown in Figure 4, most of the survey questions offered 5 response options ranging from "1: Fully true" (left) to "3: Partly true" (middle) to "5: Not true" (right). Deviating answer options are marked in the respective diagrams.

6. Comparison of face-to-face and online semesters

The comparison between classroom and online semester reveals a differentiated picture. Figure 5 shows the TMKK students' rating of the statement whether they were able to follow the online lecture better than normal classroom lectures. With an average rating of 2.55, the students stated that they were able to follow an online lecture better. The statement whether they were able to follow the online lecture very well was rated with 2.41 on average.

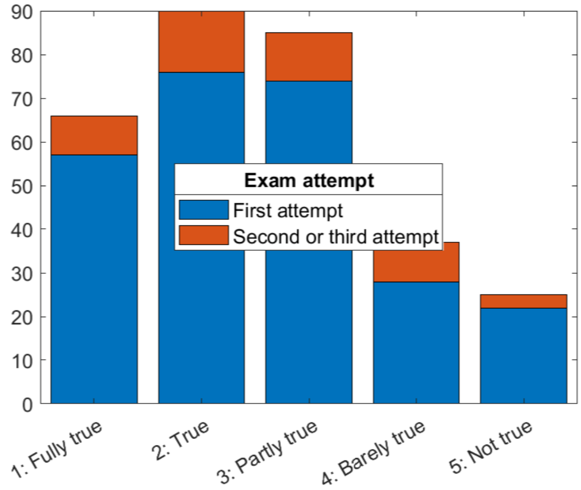

Fig. 5: "I was able to follow the video lectures better than normal classroom lectures". (TMKK)

This is also supported by the direct comparison of the MBS lecture between the summer semesters 2019 and 2020 in Figure 6. The question about the benefit of the respective lecture was answered with an average rating of 2.44 for the video lecture and 2.74 for the classroom lecture of the previous year.

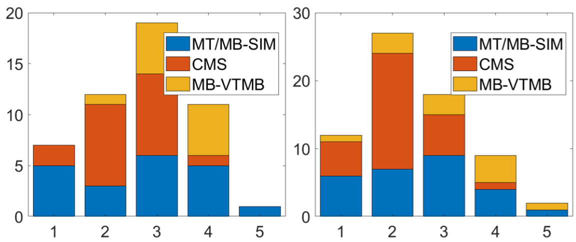

Fig. 6: "The lecture was very helpful for me" (FMD). Left: Presence 2019; Right: Digital 2020

One possible reason for the better rating of the online lecture can be found in the handwritten comments in the survey. Here, the possibility of pausing and repeating the video lecture was named positive several times. One student concretized it saying that listening and writing can be done separately by using the pause function. Another named the repeatability of "difficult parts" in the video lecture.

It should be pointed out that the regarding lectures content contains many complex derivations and calculation methods. The individual learning speed of each student can only be addressed very limited in the classroom lecture.

The fact that approximately half of the students in TMKK watched more than 75% of the lectures (see Figure 7) is consistent with the lecture attendance in classroom semesters of the course.

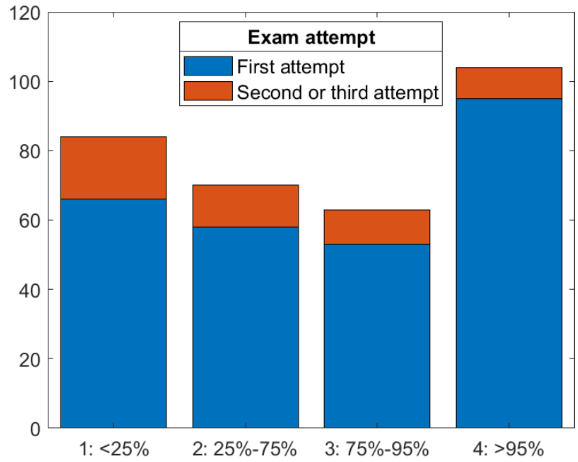

Fig. 7: Viewed lecture videos. (TMKK)

However, the entire MBS course consisting of lecture and tutorial performs worse in the online semester than in the classroom semester, as shown in Figure 8. The statement whether the course content is much harder to understand in the online semester than in the regular semester is rated with an average of 2.77 in MBS.

The positive evaluation of the digital lecture in contrast to the entire course indicates that the quality of exercises in presence is not reached by the online substitute.

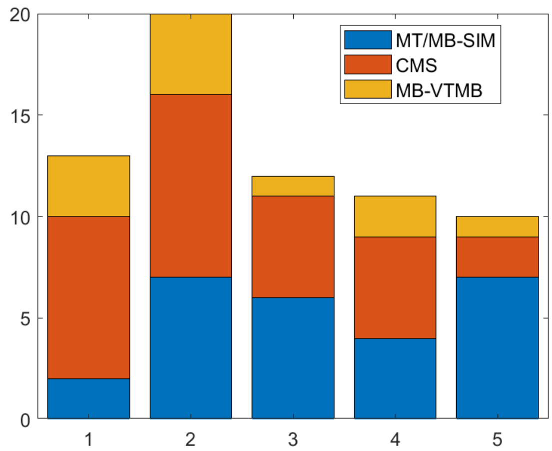

Fig. 8: "The course content is much harder to understand in an online semester than in a regular one". (FMD)

A large proportion of the students states that they had at least partial motivation problems to study the course content (see Figure 9). The statement whether it was difficult for the students to motivate themselves to work on the course content is rated with an average of 2.61 in TMKK.

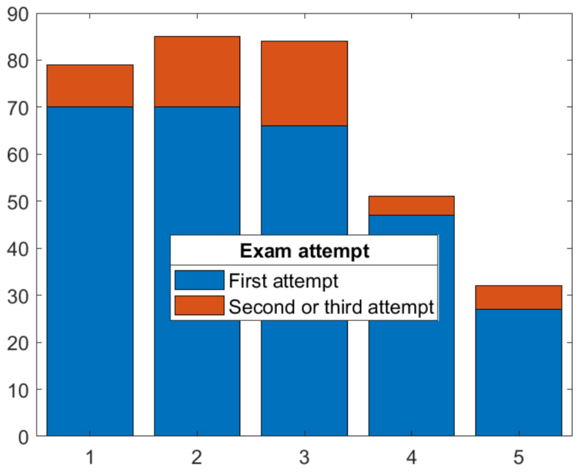

Fig. 9: "It was difficult to motivate myself to work on the course content this semester." (TMKK)

As shown in Figure 10, this is supported in the fact that the larger proportion of TMKK students spent less than the weekly planned attendance time on the course during the semester. A similar result is obtained from the survey in MBS.

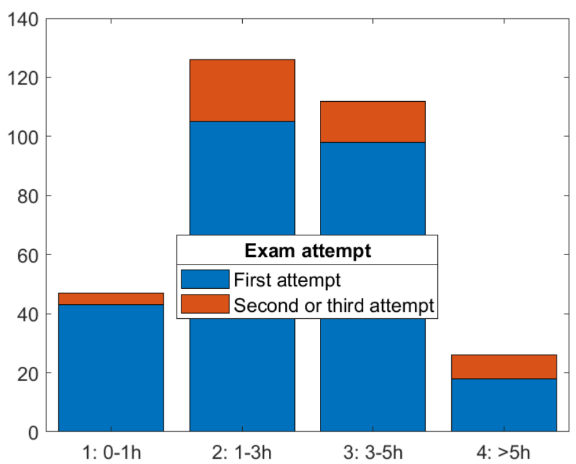

Fig. 10: Weekly time spent on the course. (TMKK, weekly presence time would have been 3.75 h)

In MBS, the statement whether the students had problems keeping up with the course content is rated with an average of 3.10. TMKK students rated the statement with an average of 3.28 whether the exercises were completed within the scheduled semester week. In other words, the majority of the students had at least partial problems following the given schedule in the online semester. Since no comparative data is available from a classroom semester, no solid comparison can be made here between online and classroom semesters.

The low number of participants in the complex exercise in MBS in the online semester is a further indication of delay in the course schedule by the students. To successfully participate in the complex exercise, it is necessary to complete all the exercises beforehand.

In TMKK, a comment field was used to ask for reasons for lagging behind in course content. “Motivation, stress, understanding problems" were given as example answers. The lack of motivation, understanding problems and the lack of separation between studies and free time were frequently named by the students. The sample answers presumably play a role in the frequency of the first two answers.

It can be concluded from Figure 11 that the smaller proportion of students had regular, content-related communication with fellow students. The statement whether the students regularly communicated with fellow students about the course content was rated with an average of 3.36 in TMKK. The majority of students acquired the course content in self-study, which is in clear contrast to the classroom exercises.

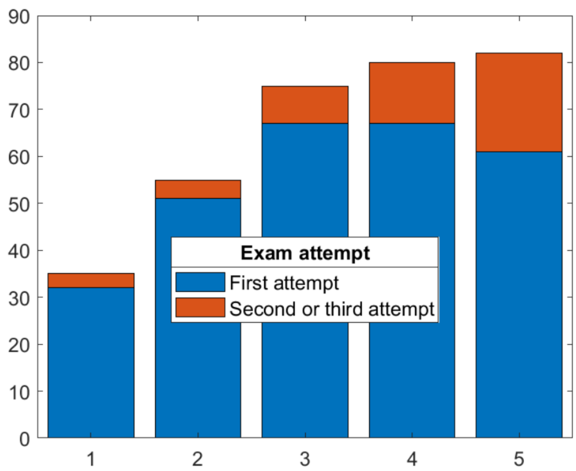

Fig. 11: "I regularly communicated with fellow students about the lecture or exercise". (TMKK)

7. Assessment of the individual forms of learning in the exercise

As already mentioned, largely asynchronous learning formats have been used for the exercises in the courses presented.

Figure 12 shows that the written practice material provided, consisting of introductions and sample solutions, was perceived as helpful in TMKK. The statement whether the corresponding material was very helpful was rated with an average of 2.41.

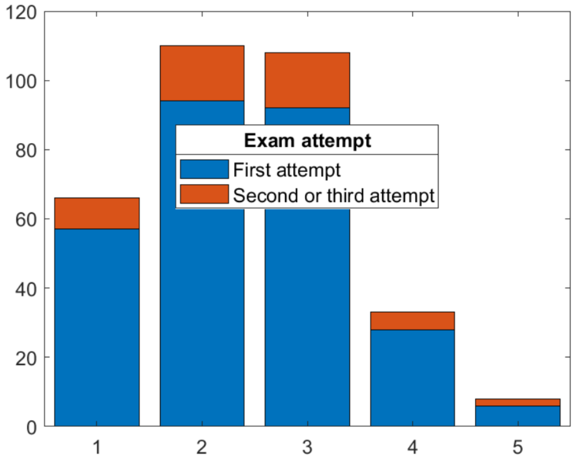

Fig. 12: "The introductions and solutions to the exercises were very helpful". (TMKK)

The exercise forum was rated rather lower, as shown in Figure 13. The statement whether the exercise forum was very helpful was rated with an average of 3.00 in TMKK and with an average of 2.55 in MBS.

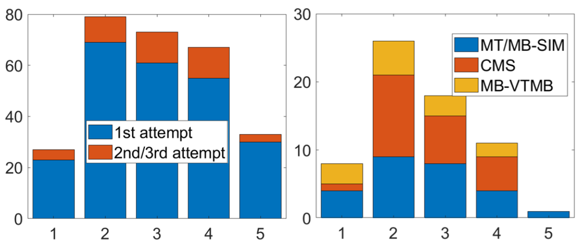

Fig. 13: "The exercise forum was very helpful for me". Left: TMKK; Right: MBS

Accordingly, the comments on the forum in TMKK give a mixed picture. On the one hand, the low clarity and the long waiting time for an answer were criticised several times. On the other hand, it was stated several times that students had only read the forum contributions and had benefited from them without asking questions themselves. A student noted positively that through the forum he came across problems that he had not recognised on his own. It was also noted that the possibility to ask anonymous questions reduced the inhibition to actively use the forum. Very often, the desire for classroom exercises was stated in the comment fields, since answering questions in the forum could not replace direct communication in a classroom exercise.

As shown in Figure 14, the short intro videos that were used in MBS for exercise introductions achieved by far the best rating. The question whether the intro videos were very helpful for the students was rated with an average of 1.58 in MBS in the 2019 classroom semester and an average rating of 1.64 in the 2020 online semester.

As shown in Figure 15, the short intro videos were watched multiple times by a large proportion of students. The longer lecture videos were watched once by the majority of students.

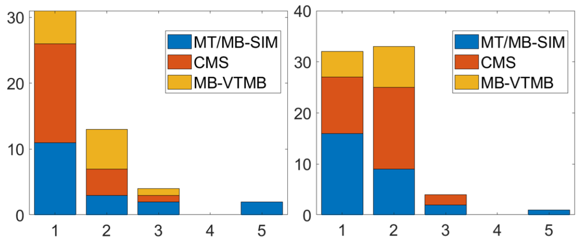

Fig. 14: "The intro videos were very helpful for me." (FMD) Left: 2019; Right: 2020

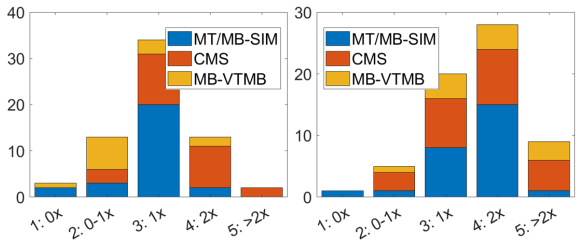

Fig. 15: "How many times did you watch each video on average?" Left: Lecture video; Right: Intro video

The statement whether the students were able to solve the exercises in self-study using the intro videos and the forum was rated with an average of 2.16 in MBS in the online semester 2020. The similar statement whether the students were able to do this (only) using the intro videos was rated with an average of 2.12 in MBS in the 2019 classroom semester.

8. Exam preparation

As shown in Figure 16, the students' felt level of exam preparation in the digital semester is slightly worse than in the classroom semester.

The statement whether the students felt very well prepared for the examination is rated on average with 2.62 in MBS in the 2019 classroom semester and with 2.91 in the 2020 online semester.

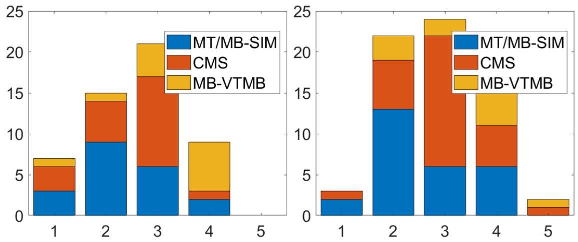

Fig. 16: "Before the examination, I felt very well prepared ". (MBS) Left: 2019; Right: 2020

In the summer semester 2020, students at Dresden University of Technology had the option of cancelling examinations without justification. As shown in Figure 17, the majority of students see this option as having little influence on their exam preparation. The statement whether the opportunity to cancel the exam result afterwards influenced their exam preparation was rated by the students in MKS with an average of 3.78 and in TMKK with an average of 3.89.

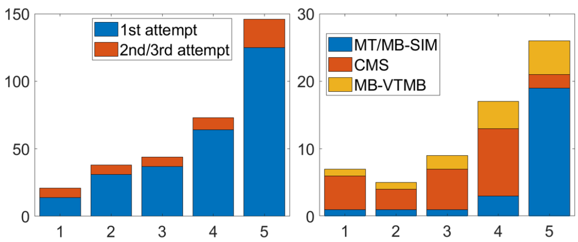

Fig. 17: "The opportunity to cancel the exam result afterwards influenced my exam preparation." Left: TMKK; Right: MKS

9. Summary

A differentiated picture results from the evaluation of the two courses surveyed. For many students, an online lecture seems to have advantages over a classroom lecture. In contrast, no adequate substitute for classroom exercises was used in the digital semester. The offer of online consultations on the exercise was hardly taken up and the exercise forum does not offer an equivalent substitute for direct communication due to the time-delayed communication. Short video exercise introductions are rated as the most helpful course format.

Acknowledgement

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Lessons Learned at the DIU

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Abstract

Es ist notwendig, ein Umdenken im Bereich der Bildung zu erreichen - nicht zuletzt aufgrund der permanenten und schnellen Veränderungen, die durch Technologie möglich geworden sind. Die Digitalisierung ist dabei nur ein Teilstück, welches die Anpassungen zum einen begünstigt, zum anderen aber auch erfordert. Wissen ist jederzeit abrufbar. Zu jedem Thema findet man Informationen im Internet. Deshalb ist es zum einen wichtig, Kompetenzen zu entwickeln im Umgang mit der Vielfalt der Daten, aber auch zu erkennen, dass das reine Lehren von Wissen nicht mehr zeitgemäß ist und unsere Kinder und Jugendlichen nicht auf das vorbereitet, womit sie in ihrem Arbeitsleben konfrontiert sein werden. Die Erlangung von Kompetenzen wie Kommunikation, Kreativität, kritisches Denken und Kollaboration (4 K) rückt in den Vordergrund und löst reinen Wissenserwerb ab. Wie können wir nun mit Hilfe von Tools und Methoden ein neues Zeitalter der Bildung zumindest einmal einläuten? Wie können wir erreichen, dass Digitalität als Unterstützung und nicht als in der Pandemie notwendiges aber vorübergehendes Übel betrachtet wird? Welche Ideen haben wir für hybride Lernsettings entwickelt? Wir haben seit März 2020 sehr viel lernen dürfen und einiges ausprobiert und möchten unsere Learnings im folgenden Bericht teilen.

It is essential to rethink in the field of education - not least because of the permanent and rapid changes that have become possible through technology. Digitalisation is only one part of this, which on the one hand favours the adjustments, but on the other hand also requires them. Knowledge can be accessed at any time. Information on every topic can be found on the internet. Therefore, it is important to develop competences in dealing with the diversity of data, but also to recognise that the mere teaching of knowledge is no longer up-to-date and does not prepare our children and young people for what they will be confronted with in their working lives. The acquisition of competences such as communication, creativity, critical thinking and collaboration (4Cs) move to the front and replace pure knowledge acquisition. Therefore, the question arises, how we can use tools and methods to usher in a new age of education. How can we achieve that digitality is seen as a support and not as a necessary but temporary evil in the pandemic? What ideas have we developed for hybrid learning settings? Since March 2020, we have been able to learn a lot and try out a few things and would like to share our learnings in the following report.

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This article was originally submitted in German.

1. Our initial situation

The initial situation at DIU is somewhat different from that at Dresden University of Technology, since as a private university we work with freelance lecturers who often only teach one course per degree programme with around 20 teaching units or less. The following experience report therefore deals with our learning in general with regard to digital or hybrid learning and shows one thing more than clearly: simply providing a platform to have presentations given digitally is by no means enough.

In the virtual world, the danger of being distracted is even greater if the course is not interesting enough. Since you're sitting at your PC anyway, you can also quickly process the incoming email or take care of your twitter profile. With one click, the participants are there or gone again. This means that it is important to create exciting formats that are as interactive as possible to take the participants along with you. That is why we like to talk about learning as a journey and not a lecture.

However, the discussion is no longer just about digital, hybrid or analogue, it is about what education should look like in both school and higher education contexts.

For us, it is clear that students need more individual support and that collaborative projects and self-directed learning are more effective than the constant cramming of knowledge that students forget immediately after the exam. In order to be able to solve tomorrow's problems in today's fast-moving times, a rethink is needed in the education sector and also a new understanding of roles. Students are given more responsibility for achieving learning goals, and teachers become learning facilitators.

The following quote can be found in the method book for digital lessons[1]:

"An education to solve problems that we don't even know about at the moment."

The following table shows what is meant by this:

Away from	Towards
Knowledge	Competence
Mediate & Teach	Find out
Analogue	Digital & hybrid
Rigid structures	Linked and flexible educational contexts
Learning in sync	Individual learning
Lone-wolfism	Cooperation
(Third-party) control	Self-organisation and co-determination
One-dimensionality	Multi-perspectivity and networking
Teacher-centredness	Learner-centredness
Fixed results	Openness to results
Given meaning	Personal sense
Teachers	Learners

Tab. 1: Education of the future [1].

But how can we achieve this?

In the following sections we have gathered some of our thoughts and ideas, but we are always learning new things. Therefore, from our point of view, the first step towards a rethinking in education is that teachers also see themselves as learners and get into an open and trusting exchange with each other in order to share knowledge, to develop learning concepts together and to give up being lone fighters.

To this end, DIU regularly offers DIUTalk and has created a LinkedIn community. In addition, we pass on our knowledge to interested lecturers in free workshops.

Our motto: Sharing knowledge is culture!

Fig. 1: Logo of the DIU workshop format

2. Future Skills - the 4 Cs

Particular attention should be paid to the 4 Cs - critical thinking, creativity, collaboration and communication - in both school and university contexts. How do we get our students to think critically about issues, come up with creative solutions, network to overcome challenges together and communicate clearly and appreciatively to be able to collaborate with others?

Using a digital tool does not necessarily lead to an exciting learning scenario. So digitalisation alone is not enough to bring about the long-needed change in education. Rather, digitalisation requires us to find new ways in education to acquire competences that are useful and meaningful for us and our students in today's and tomorrow's world. The goal is not to collect certificates and degrees or hoard knowledge, but the learning journey as such and the deep understanding of the learning topic through intensive engagement with it, so that learners are able to understand concrete issues and solve problems and ask others for targeted support.

In the following sections, we show some methods, tips and hints on how "New Learning" can succeed from our point of view and how digitality supports us in this.

3. Ice-breaker and warm-up

If you meet a new study group exclusively in the digital environment, some information is lost that normally is automatically perceived in personal interaction. It is therefore more difficult to get to know a person virtually because points of reference are missing and, of course, also the breaks spent together in which people exchange ideas.

But it is not impossible to build up closeness and get to know each other even in virtual space.

It is helpful to start with warm-up exercises so that everyone can get to know each other in a relaxed atmosphere. There are numerous collections of ideas for this on the internet, e.g. also at http://tscheck.in/ or https://internetquatsch.de/.

Methodologically, we recommend "Impromptu Networking" from the Liberating Structures toolbox. In "Impromptu Networking", all participants are brought together, at best randomly and automatically, in groups of two to talk for four minutes about any introductory question, which may initially be completely independent of the learning field. There are three rounds, i.e. three questions. The group composition is redistributed three times so that as many participants as possible have already met. The descriptions of all Liberating Structures can be found at https://liberatingstructures.de/. These 33 microstructures help to work specifically on challenges and to ensure that everyone is included.

The integration of live survey tools such as Mentimeter https://www.mentimeter.com/ or https://invote.de/ can also be useful in order to get off to the most relaxed start possible and to enable people to get to know each other well. Personal questions, e.g. about the favourite holiday destination, are useful before moving on to the subject matter. This makes it easier for the students to find points of contact and build trust with each other through common ground. Our conviction is that a good bond can also develop online if you leave room for trusting and happy togetherness.

Of course, this does not mean playing too many games and forgetting about learning. Good planning of the icebreaker phase is essential. This applies equally in the analogue, hybrid and digital learning space. If certain tools and methods are to be used, enough time should be planned to introduce and explain them calmly. This should not be underestimated, because cooperation can only work well if everyone is familiar with the application.

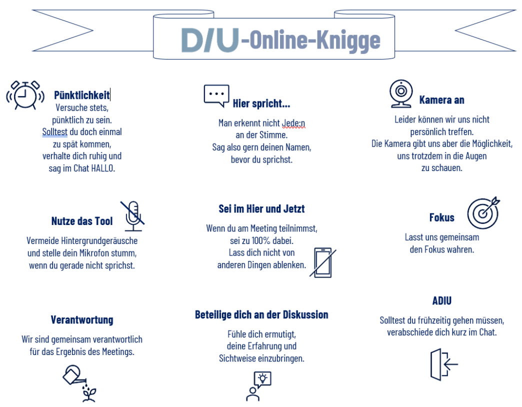

Fig. 2: Online etiquette of the DIU

Rules for online events can also be very helpful. The DIU has developed the following online etiquette guide, which can be used for meetings but can also be applied to learning events:

3. Cameras on

The topic of "camera" is also anchored in our online etiquette guide.

When all participants leave their cameras off, it is difficult for lecturers to build a bond and get feedback. People feel like they are talking to a silent black wall and fall into monologue. Often it is enough to ask the participants to turn on their cameras. This should not be worded reproachfully, but rather with a friendly hint that one would be very happy to see the participants. If, contrary to expectations, this does not lead to at least the majority showing up, there are some tips.

Playful exercises that include the camera image are particularly helpful, e.g. the lecturer can ask yes/no questions and those who answer yes switch on the camera and those who answer no leave it off for the time being. In this way, it can be asked right at the beginning which topics are particularly interesting for the participants or are absolutely necessary to catch up on, and in addition, the participants now use the camera. Another game to start with is to hold objects up to the camera and ask all participants to look for a similar object and show it as well. This can even bring real movement into the learning event and one or two happy laughs will also be heard.

A wonderful method, originating from improvisational theatre, is the participants speaking their names one after the other and perform a gesture that also serves to remember the names of the others.

Planning such playful approaches already into the icebreaker phase is a double win from our point of view.

4. Activation of the participants

In analogue events, it is said that attention wanes after 20 minutes. In online events, according to Andrea Heitmann in one of her workshops on digital rhetoric, this is already the case after 7 minutes.

Therefore, it is important to regularly include interactions in the learning event. This does not mean that you should permanently embed games or elaborate surveys. Even short queries, smaller polls or the like are enough to maintain or regain attention. With live reactions, most online platforms offer a good opportunity to give or solicit feedback in between. A chatstorm is also a wonderful option. A question is asked, the participants are given a short time to formulate their answer in the chat, but only all click on send at the same time on command. This avoids ideas being copied.

Nevertheless, playful approaches with a challenge character are very popular with the students. There are many tools such as https://kahoot.it/ that can be used to generate a live quiz in between. Nevertheless, the playful character should always go hand in hand with a critical examination of the question posed if you want to incorporate a quiz not just for fun, but actually as a method to support learning.

Here are some more examples:

https://jeopardylabs.com/, Monday painters at https://skribbl.io/ or https://stadtlandfluss.cool/.

Especially the latter can be fun because of the option to include your own categories. Creativity is unleashed and speed is rewarded.

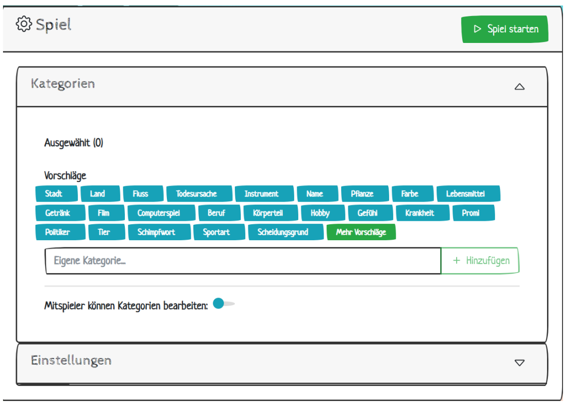

Fig. 3: Categories for urban-rural-flow digital

5. Work in small groups

Small group work in between is an important means of bringing students into an exchange that otherwise tends to take place at the coffee machine. This is therefore not necessarily only didactically helpful. Nevertheless, it should be well considered whether the respective question is suitable for group work. It is also important to communicate clearly what kind of documentation is desired and when to return to the main room. Most platforms offer the possibility to automatically close the breakout rooms so that all participants get directly back to the event, but a time limit and at best also a note in between with the remaining time, help the students to structure the joint work.

The aim of group work is to enable all participants to contribute their ideas and knowledge. This is the purpose of all methods in Liberating Structures. The composition of the group changes depending on the method and the goal or question.

Digital whiteboards or pinboards are indispensable for supporting and documenting the results. Tools such as Mural, Miro or Padlet or the whiteboards integrated in the learning platforms are important for recording what the participants take away from the group work, just as in the analogue environment.

Digital whiteboards achieve a particularly positive dynamic in our view, as the many possibilities stimulate creativity. A well thought-out structure of the board and a patient introduction to its use are essential to ensure that everyone enjoys participating. We are convinced that a digital whiteboard can be an excellent basis for learning journeys and that the 4 Cs (communication, creativity, collaboration and critical thinking) can be promoted with the help of boards.

6. Learning journeys on the whiteboard

Digital whiteboards can be used to design learning journeys for learning events in which the lecturers' content and presentations, suitable videos, podcasts or books or work surfaces with concrete questions are anchored in the board. This enables students to learn independently at any time, as the synchronous and asynchronous learning phases can be cleverly linked with the help of a digital whiteboard.

To collaborate, a link to the whiteboard is generated and sent to all participants, e.g. via the chat function of the video conferencing tool. The participants can use this link to access and edit the board either anonymously or by name.

Digital whiteboards have numerous functionalities that you should know well yourself. Although the tools used by the DIU, Miro and Mural, are basically intuitive, it is advisable to deal intensively with the chosen tool in advance and, at best, to send an explanatory video to all participants in advance so that not too much time is lost in the learning event for explanations. Experience has shown that the first application is always associated with many questions about the use of the tool. This should be taken into account when planning the concept.

Especially for elaborate layouts with many different building blocks, we recommend showing and explaining the board first, e.g. via a split screen, before publishing the link.

Digital whiteboards can be designed according to the theme. There are hardly any limits to creativity. It is advisable to place an agenda or an overview plan at the beginning and to link from there to the relevant exercises, tasks, information, recommendations, etc. on the board so that it is as easy as possible for users to find their way around the board. A test beforehand is useful to make sure that everything is fixed that belongs to the structure of the board and that the links on the board work. If there are many participants on the board, it can otherwise become chaotic.

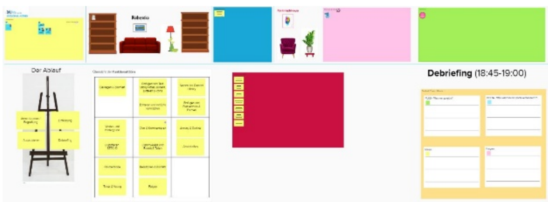

Fig. 4: Extract from the DIU team meeting template (mural)

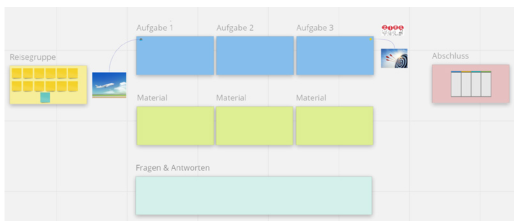

Fig. 5: Learning journey simplified on a Miro-Board

All whiteboard tools offer numerous ready-made templates that can simplify the design of a learning journey. The areas and templates can be saved, so we recommend saving consistent basic content and then using it again and again. This saves valuable time and achieves a high recognition effect.

We have always included an area for feedback, questions and recommendations in our templates, so that the interaction is encouraged and we can also develop ourselves and our workshops further.

Students and teachers can usually benefit from free educational licences.

7. Self-organised asynchronous learning

"Give learners back their learning." (K. Pape, Managing Director of the Corporate Learning Community, slogan in his LinkedIn profile)

Part of the knowledge transfer should take place asynchronously, e.g. via learning videos that students can watch independently. It is helpful to include a question about the video, which then finds a place in the synchronous course and leads to an exchange among the students. This blended learning principle combines self-organised learning with joint learning time. Initially, it is completely irrelevant whether this is done digitally or analogue. Digitisation basically only increases the diversity of the preparation of the learning content.

Since there are different types of learners, it makes sense to provide information not only as a copy from a book, but also audiovisually as a video or aurally as a podcast.

This goes hand in hand with the fact that it is not expedient to conduct full-day courses synchronously in digital form. The flipped classroom principle is a far more sensible method and enables students to learn in a self-organised way and still repeatedly exchange what they have learned with lecturers and fellow students and also put it to the test.

In the exchange with part-time students at DIU, it was nevertheless clearly communicated that firmly planned learning time is necessary in order to create space for learning alongside the job and also to keep to it. This is where the principle of regular joint learning events comes into play. In WOL (working out loud) or lernOS circles, a one-hour weekly meeting of the circle is arranged to motivate, exchange and give impulses. The circle meets and supports each other regularly for 12 weeks. With the help of guidelines with small exercises, a clear framework is set for the meetings. During the rest of the week, each circle member invests as much time and energy as they want in achieving their personal goal.

Due to the success of these circles, it has evolved into a seven-week learning-out-loud cycle that can be adapted for own learning journeys.

We are convinced that in the future teachers will become learning guides who motivate, support, listen and provide impulses and a framework for the learning experience of their students. Similar to the aforementioned circle methods, the learning guides regularly bring the students together and encourage exchange and, if necessary, correct the direction of the learning journey. In this way, students are given the freedom to formulate their goals, contents and methods independently and to work out their learning processes.

8. Use of MS teams

At DIU, Office365, especially MS Teams, is mainly used for learning events. Many helpful apps are already integrated here, which enable lecturers to design the learning event interactively and promote self-organised learning outside the actual learning event. Students and lecturers receive a free education licence.

With MS Teams, meetings can be planned with a calendar function that is synchronised with Outlook. In a team, the respective students and lecturers are added and can add a variety of functions there, such as OneNote for notes, a task planner or a survey tool to the menu. Contributions can be published for everyone, but there is also the option of using the chat with one or more people. Files can be exchanged and also edited together at the same time - e.g. Word documents, Excel tables or Power Point presentations.

Meetings (video calls) can be started from any point in MS teams to clarify questions in person.

Of course, it is also possible to be unavailable at some point and to leave a suitable status message.

9. Hybrid scenarios

We have given a lot of thought to hybrid learning in particular, as this will be the order of the day at DIU in the future.

Hybrid learning refers to a synchronous setting in which some people are in the seminar room in analogue form and others connect digitally.

With the digitalisation of learning events, some students and lecturers who previously had to plan for a long journey would like to stay in the digital space. Even in the event of illness, being able to switch on temporarily and at least listen is a good option for students. Other participants are very much looking forward to seeing and exchanging ideas in person in the seminar room. We want to offer a pleasant and substantial setting for both groups.

Good hybrid formats should be designed in such a way that all participants - whether they are on site or digitally connected - are equally involved in the teaching process. In our view, there is no way around embedding digital aids and tools in the originally purely analogue events. For this, it is advisable that the students on site also have a terminal device with which, for example, live surveys can be conducted digitally. A smartphone is usually sufficient. For group work in which digital and analogue participants are to be mixed, it is necessary that each group has at least one notebook or tablet (with camera and microphone) available. Instead of the blackboard, a tablet with a pen can be used so that both the participants on site and the digitally connected students can see what is being written or drawn. This rethinking and the resulting redesign of the learning process are initially costly, but necessary.

Literature

[1] Adam, Björn; Holle, Judith; Köpnick, Franziska: Das Methodenbuch für digitalen Unterricht. Dein Praxisbegleiter für gute digitale Lernräume, 1. Auflage, Lüneburg 2021

Links to tools and methods: Overview

http://tscheck.in/
https://internetquatsch.de/
https://liberatingstructures.de/
https://www.mentimeter.com/
https://invote.de/
https://kahoot.it/
https://jeopardylabs.com/
https://skribbl.io/
https://stadtlandfluss.cool/
https://www.mural.co/
https://miro.com/
https://de.padlet.com/
https://cogneon.github.io/lernos/
https://workingoutloud.com/
https://learningoutloud.de/
https://www.microsoft.com/de-de/microsoft-teams

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Imagine it's "Corona" - and no one has noticed

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Abstract

Der deutschsprachige „Ableger“ der seit 20 Jahren im Regellehrangebot der Professur Informationsmanagement an der Fakultät Wirtschaftswissenschaften der TUD fest verankerten, internationalen Gruppenlernprojekte im virtuellen Raum (VCL – virtual collaborative learning) [1] hat sich längst emanzipiert. Im Wintersemester 2020/21 fand mit der 66. VCL-Veranstaltung im Bachelor-Modul „Fallstudienarbeit im virtuellen Klassenraum“ eine bereits bewährte, hochschultyp-übergreifende Lehrkooperation zwischen der TU Dresden und der HTW Dresden [2] zum vierten Mal ihre erfolgreiche Fortsetzung – trotz „Corona“. Das etablierte didaktische Format eines selbstgesteuerten, fallorientierten Lernens in standortübergreifend gemischten Kleingruppen unter tele-tutorieller Begleitung konnte aufwandsarm an die pandemiebedingten Restriktionen angepasst werden. Die langjährigen Vorarbeiten haben sich gelohnt!

The German-language "offshoot" of the international group learning projects in virtual space (VCL – virtual collaborative learning) [1], which have been firmly anchored in the regular teaching programme of the Chair of Information Management at the Faculty of Business and Economics of the TUD for 20 years, has long since emancipated itself. In the winter semester 2020/21, the 66th VCL event in the Bachelor's module "Case Study Work in the Virtual Classroom" was the fourth successful continuation of an already proven, cross-university teaching cooperation between TU Dresden and HTW Dresden [2] – despite "Corona". The established didactic format of self-directed, case-oriented learning in mixed small groups from different locations under tele-tutorial guidance could be adapted to the pandemic-related restrictions with little effort. Many years of preparatory work have paid off!

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This article was originally submitted in German.

1. Preliminary remark

Case-based learning as a student-centred, authentic offer for the realisation of situational learning environments has a long tradition in economics. Defined by the Association for Case Teaching as "a means of participatory and dialogical teaching and learning by group discussion of actual events" [3], this didactic approach is ideally suited for the

- combination of theoretical/methodological knowledge with practical practice (transition from the second to the third competence level of Bloom's Taxonomy [4]),
- linkage of individual learning with joint (collaborative) problem solving, developing social competences, and
- enabling of situational learning by using authentic scenarios with open-ended problems to bring the learning environment closer to a typical later professional context of action and to facilitate the transfer of "inert knowledge" from studies to practice [5].

In addition, case-based learning is very well suited to be mapped in a digitalised arrangement, even under the intensified "Corona conditions" (fully online learning and social distancing).

In the following, we present the arrangement in the form of a modified, collaborative flipped classroom format, go into the course sequence and the associated subject-specific and interdisciplinary learning objectives, discuss the business case study and the work assignments in detail and finally reflect on our lessons learned.

2. Digitised didactic format

The foundation of the didactic format behind the cross-location learning project presented here was laid as early as 2001 to 2004 in a dissertation at the Chair of Information Management at the TU Dresden (TUD) [6]. It was iteratively developed further in the following years and adapted to international contexts [7, 8]. Virtual Collaborative Learning (VCL) is project-oriented and primarily addresses the development of soft skills such as self-organisation, collaboration, digital and intercultural competence, which are central components of 21st Century Skills [9]. VCL projects such as the course presented here are based on a complex framework developed iteratively in several dissertation projects with four interlocking components (see Figure 1).

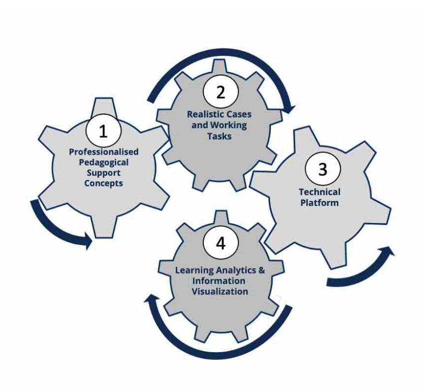

Fig. 1: Four interlocking components of the VCL framework

Component 1: An essential feature of VCL projects are small groups that span locations (often international) and are as interdisciplinary and heterogeneous as possible. Their representatives work together exclusively online (virtually) and in a self-organised manner and bring various individual competences into the collaboration for the jointly responsible result. The participants receive support in this complex setting from learning process facilitators (e-tutors [10]) who have been specially trained for this purpose at the TUD's Chair of Information Management. In order to be able to check the intended development of interdisciplinary competences (teamwork, self, time and project management, media competence and, in international projects, also intercultural and foreign language competence), the e-tutors apply concrete indicators for formative use in the supervised learning groups. On the basis of these indicators, they provide orientation and interpretation aids for the tasks, feedback on team performance and determine learning progress at group and individual level to support the final assessment of performance.

Component 2: For VCL projects, authentic, complex case scenarios are developed that are specifically adapted to the learning objectives of the course and the respective knowledge levels of the participants. The cases should be only weakly structured in order to leave the learning groups as much room as possible for interpretation and independent decisions on procedure, methodology and the negotiation of alternatives. So the interdisciplinary collaboration and project management skills [11] are strengthened. For the case-based, collaborative learning, which takes place over approximately two to four months depending on the setting, weekly tasks are usually provided whose solution paths are predominantly open (not predetermined), but require punctual submission of result artefacts (protocols, documentations, analyses, calculations, prototype websites or apps, etc.). In the form of realistic work assignments, these tasks link the case scenario with the methodological competences to be deepened (subject-specific learning objectives of the course) and at the same time integrate the use of suitable digital tools from the technical platform (interdisciplinary digital competence).

Component 3: In order to make interactive, case-based learning in cross-location, mixed small groups in virtual space as smooth as possible and to grant participants flexibility in terms of temporal (synchronous, asynchronous) and local (mobile, stationary) access, a powerful collaboration platform is required. This should provide suitable functional modules for communication and coordination of group work, as well as for the implementation of individual work assignments. In order to strengthen the situative nature of the learning environment, we have been using for a year now the Microsoft 365 platform under the collaborative MS Teams interface, which is widely adopted in the professional environment. It is provided as a cloud service on European servers in compliance with the relevant regulations according to the General Data Protection Regulation.

Component 4: Since 2019, the didactic indicators used as intervention tools have been gradually processed on the basis of social learning analytics, mapped as dashboards and, since 2020, additionally supplemented by chatbots, which provide relevant information in dialogue form as active conversational agents [12]. Thus, the daily, time-consuming learning process support by e-tutors in terms of resources can be relieved and a higher range of support be arranged, to justify the decisions for certain didactic interventions more clearly and ultimately. Furthermore, the documentation of the intended competence development can be objectified. This data-driven information supports two sides:

- The e-tutors can be made aware of mistakes in project management, but also of interaction deficits in the groups they accompany (example: indicating the exclusion of a group member from the communication processes triggers an intervention to check whether it is possibly bullying by the others or social loafing by a "free rider").
- The individual learning groups can be shown their performance progress over time or their position in relation to the other groups (competitive gamification elements as extrinsic motivators).

The international VCL projects in the Master's and Diploma programmes at the TUD usually consist of an intensive six- to eight-week virtual project work with subsequent separate additional examination performances adapted to the respective local module requirements of the international partners involved. At the TUD, for example, an individual written reflection phase follows in the second half of the semester in the Master's/Diploma module "Collaboration in the Virtual Classroom" to complete the 150 h workload, which is supplemented by surveys, individual interviews or focus group workshops in the context of research-oriented learning by evaluating the setting.

For the implementation of the "Corona" course discussed in this article for advanced Bachelor's students of different business programmes at the TUD and HTW Dresden, the VCL concept discussed here was modified. Each university integrated the joint event into already existing modules, based on local examination regulations (TUD Bachelor module: "Case study work in virtual space", HTW Bachelor module: "Business models and digitalisation").

In order to meet the restrictions caused by pandemic and at the same time not to leave the students without guidance for too long in their independent online group work, the continuous, four-month case-based learning in VCL format presented here was divided into three compact phases from October 2020 to January 2021 by two workshops, each of which took place for 4 hours as online conferences, according to the flipped classroom principle [13], and concluded by a third workshop with short synchronous online group work in breakout rooms. The resulting modified flipped classroom thus differed from the usual standard in two respects:

- **Phases of knowledge acquisition**: instead of individual learning by means of materials provided online (e.g. e-lectures), →three phases of case-based, collaborative learning in online working groups composed across locations and disciplines.
- **Phases of knowledge consolidation**: instead of small group work in 90-minute classroom sessions in real seminar rooms, →four-hour synchronous online conferences with presentations of the group results and an online workshop at the end with synchronous group work.

Figure 2 depicts the resulting arrangement in its temporal and thematic progression.

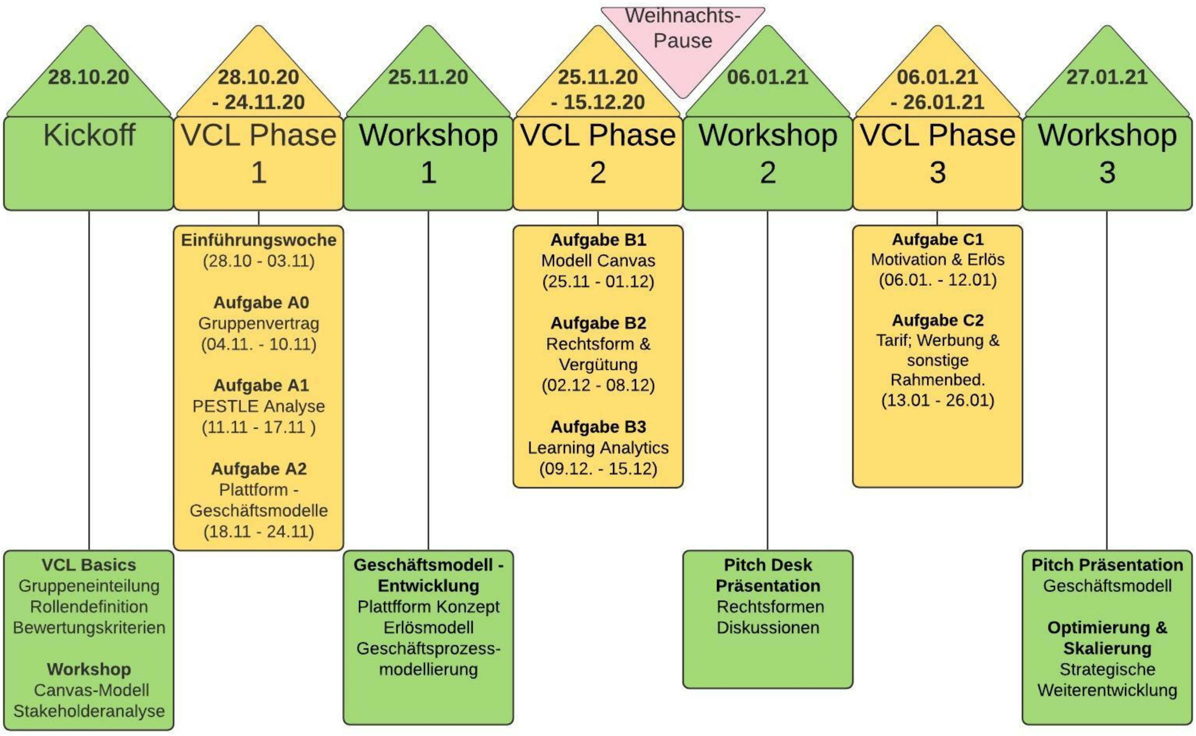

Fig. 2: Timeline of the course "Case Study Work in Virtual Space" according to the modified Flipped Classroom Format

3. Course of the project

As part of our competence-oriented VCL project approach, almost 80 students from TU Dresden and HTW Dresden worked exclusively online in a common collaborative environment in 12 mixed teams of 6-7 participants each on a case study on the topic of e-mobility in Dresden in the winter semester 2020/21. They were accompanied by three experienced e-tutors under the professional and didactic direction of the authors of this article .

In 4 months of virtual collaborative work, the participants - Bachelor and Diploma students of both universities in their 5th or higher semester - created new platform business models which were to be presented and reflected upon in two online pitches in front of a jury consisting of the authors of this paper, resulting in sharpened project outlines at the end.

The collaborative work was based on three roles to be assigned independently in the teams (project manager, project reporter, project members).

Fig. 3: Logo of the fictitious company as case scenario (cover story) for collaborative case-based learning

They organised their teamwork independently and made ample use of the functionality provided by the collaborative platform MS Teams. The small groups held numerous virtual video meetings with each other, used shared calendars, communicated via chats and threads and edited files (partly synchronously). The participants independently divided the processing of their weekly tasks according to their assumed roles. The teams developed comprehensive platform business models on the topic of e-mobility in Dresden. They were introduced to the topic via a total of 9 work assignments and were able to present their ideas in 2 workshops in 10-minute pitches per team.

First VCL phase: At the end of October, after the synchronous online kick-off conference, the teams began to draw up group contracts in which they defined their forms of collaboration, defined the distribution of roles and tasks and also addressed appropriate solutions for any problems that might arise in the collaboration. Furthermore, they were given the opportunity to ask their e-tutors initial organisational or technical questions in a virtual get-to-know-you meeting. So they were prepared for the online monitoring and moderation, taking place on a daily basis during the 4 months. After the teams had familiarised themselves with the platform, they prepared a PESTLE analysis on the topic of e-automobility. The participants then applied their knowledge of platform business models to their case scenario, followed by an exploration of pitches and the presentation or structuring format canvas in preparation for the first interim presentation.

In the next phase, the participants had to research pricing models and legal forms and were able to use as guidance impressions from a presentation given by the start-up *Africa GreenTec*. The teams then prepared for the second workshop and pitch at the beginning of January. This phase was interrupted by the Christmas and New Year break.

At **the end of** the project, the students dealt with motivation theories, revenue models, collective agreements and advertising concepts. In the final third workshop at the end of January, the teams worked on a "transfer task" in 12 break-out rooms, in which they used the soft and hard skills they had acquired as well as the tools provided. By means of a "customer journey", they had to put themselves in the customer's perspective of their start-up approach to e-mobility in Dresden developed in the project. Their journey along the business contacts with the projected company had to be visualised collaboratively on the virtual whiteboard Miro using various "touchpoints" and then explained in the plenary. Numerous innovative ideas emerged. Under intensive supervision by the teachers and close monitoring by the e-tutors they were developed with great commitment by the students (almost) to the point of start-up maturity and defended with heart and soul.

4. Case-based learning in detail

The selected complex case study *Dresden NRG* served the acquisition and development of professional and interdisciplinary competences. The subject-specific business competences were in detail:

Business models: In a world characterised by digitalisation, the modelling of adapted and new business models is becoming increasingly important. There are many examples of business models that are based on platforms or serve two markets, so-called two-sided markets. For example, Uber as a mobility platform brings drivers and passengers together, or AirBnB brings accommodation providers and demanders together. There are also examples of platform economies and two-sided markets in the business-to-business (B2B) sector, e.g. the Zentrada network for the wholesale of consumer goods. These examples provide precisely the impetus to critically question and further develop existing business models with regard to the changing framework conditions in order to map new opportunities in new markets through new products and services.

Today, business model development is the standard method for exploring and developing future strategy options. Business Model Canvas is a proven model for this purpose, which presents the fields of action for the development of business models in a structured way. The core of every business model is the generation of added value for target groups through value creation within the company. The Business Model Canvas thus serves as a guideline for the targeted development of business models. The nine key factors represented in it and their interdependencies can be seen in Figure 4.

In preparation for the course, the students already had worked out the basics of business modelling on their own. In the online KickOff workshop, the lecturers deepened this central expertise using illustrative examples and thus prepared the teams for its application to the *Dresden NRG* case scenario in the subsequent first VCL phase.

Project management: The central cross-sectional competence for all requirements and activities in the professional world is project management. It reflects the dynamics of business field and project implementation in practice. In the current digital transformation of business and social processes, agile project management methods are generally of great importance as a basis for future developments in companies and for the rapid generation of competitive advantages, not only as a method in the area of IT and digitalisation.

In the course, the students were familiarised with the Scrum method, a simple method of not only producing results quickly by means of iterative, time-interleaved cycles (sprints), but also being open to spontaneous internal and external changes. The resulting transparency ensures a better assessment of the development process [14]. Through feedback from the lecturers in the two pitches between the VCL project phases, the students were able to experience the inherent dynamics of the project and learned to react in an agile manner and adapt their modelling in iterative coordination processes in the learning groups.

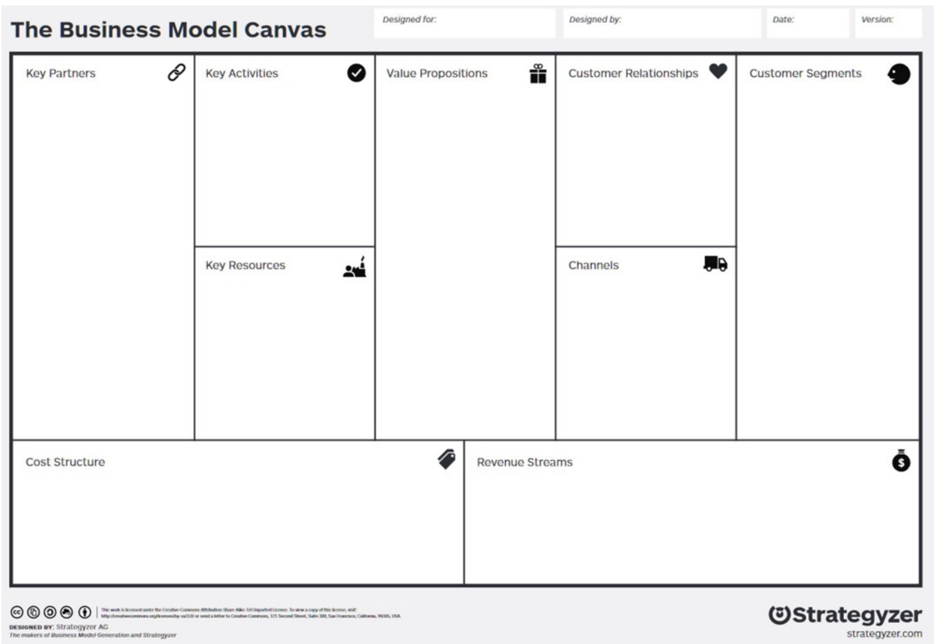

Fig. 4: Business Model Canvas as depicted by Strategyzer.com (Source: https://assets.strategyzer.com/assets/resources/the-business-model-canvas.pdf)

Marketing: A customer journey describes the individual purchase experience process of each customer. The goal of marketing is to describe this process and to measure and map it within the framework of performance marketing. A customer journey consists of so-called customer touchpoints. These touchpoints are points of contact between companies and customers. They are often referred to as "moments of truth". These touchpoints also stand for proximity, familiarity and a knowing understanding. Touchpoints are changeable and individual for each person, each customer. Marketing must therefore strike a balance between (cost-intensive) contacts as touchpoints with potential or existing customers and performance in the sense of performance-oriented management of customer relationships, based on key performance indicators.

The teams realised the implementation of the customer journey for their target groups in the concrete case context in orientation to Figure 5 in the synchronous online final workshop in parallel break-out rooms with the help of the tool Miro integrated in MS Teams. In order to segment and describe the target groups, they created so-called personas in the sense of representative customers with socio-economic characteristics, with attitudes, values as well as with information on media use. In addition, the students created an advertising concept for the platform or the project based on this.

In addition to the central business skills in the field of entrepreneurship, the students were also able to deepen their soft skills. The self-directed negotiation processes in the learning groups strengthened self- and social skills, and the intensive work with a start-up idea for a digital platform promoted entrepreneurial thinking and digital competence. The participants were also able to establish social contacts across university boundaries and demonstrate their ability to work in a team. Through several months of dealing with MS Teams as a complex collaboration platform widely used in business practice, they were able to acquire or

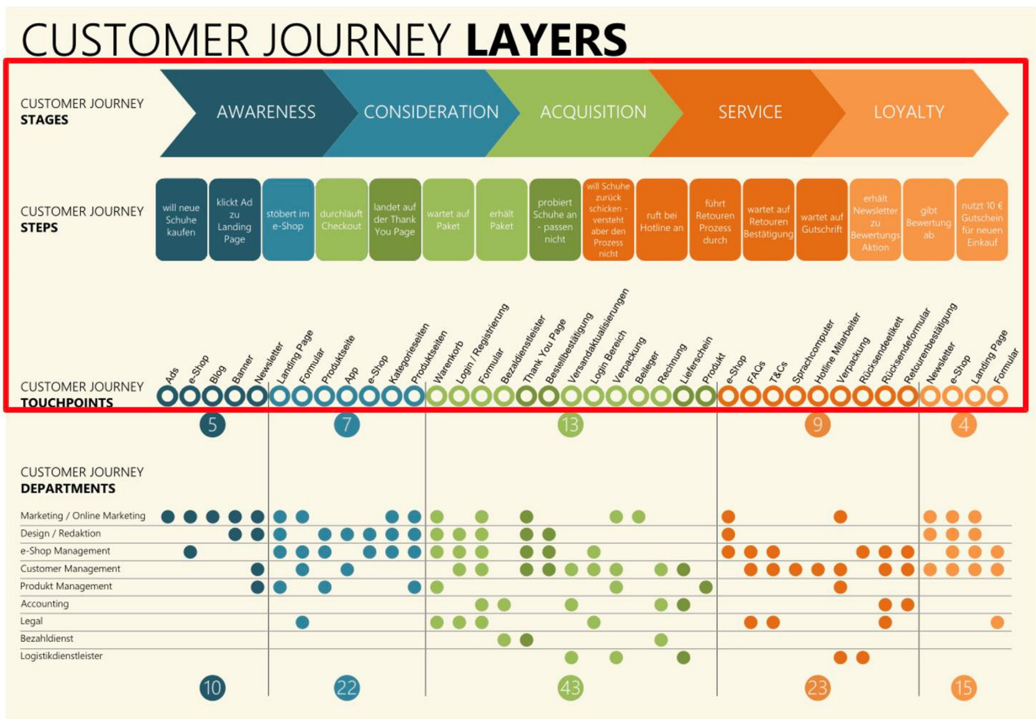

Fig. 5: Customer Journey Map.
(Source: http://www.omkantine.de/wp-content/uploads/2016/04/4_Customer_Journey_Departments.png)

deepen important technical skills and thus ideally prepare themselves for the later requirements in professional practice.

Through the combined addressing of subject-specific (moderated by the HTW) and interdisciplinary/social goals (accompanied by the TUD), the module provided the participants of the TU Dresden with a lively contribution to the focus area "Learning and Human Resource Management", in which it is structurally arranged.

Of course, all participants at both locations/institutions received their achievements rewarded in the form of 5 ECTS points and task-specific weighted grades according to the examination formats anchored in the respective modules (at TUD: project work).

5. Our Lessons Learned

Overall, we were able to determine that the VCL format, which has been established for years and is embedded in a flipped classroom architecture, proved to be excellent (especially) in the context of the restrictions caused by the pandemic. For reliable planning, the three project milestones, originally intended to be organised as face-to-face workshops to deepen knowledge via pitch presentations and joint discussions, were already in September 2020 transformed into synchronous online conferences via MS Teams. Due to this powerful platform, the conferences seamlessly integrated into the collaboration environment.

As a **lesson learned** for the "time after Corona", we can state that the arrangement offers the possibility of a flexible return to a hybrid format. The milestone workshops between the interactive, exclusively online project phases and, if necessary, the supplementary professional consultation windows with the teachers will certainly be moved back into the real space due to the additional potential that can be realised through the usual, flexible personal communication.

Then the circle closes and the positive insights gained from earlier projects[1] regarding synchronous appointments interspersed in VCL projects to deepen knowledge and reflection via personal group work in face-to-face seminars come into play again. However, this new modified flipped classroom will be hybridised to the extent that the data and functionality of the collaboration platform and its tools can be accessed on a mobile basis and participants who are unable to attend can be integrated without friction.

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Design of digital block days

Field report from the area of Social Entrepreneurship

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Abstract

Im Rahmen des Seminars „Gründen in der Sozialen Arbeit“ werden Studierenden gründungsrelevante Kenntnisse vermittelt. Das Seminar wurde im Wintersemester 2020 / 2021 als digitales Blockseminar im Teamteaching angeboten. Der hier vorgestellte Erfahrungsbericht beschreibt diese Veranstaltung beginnend von den Herausforderungen über die Konzeption hin zur didaktischen Umsetzung. Abschließend werden zentrale Erkenntnisse in den Lessons Learned beschrieben.

Within the framework of the seminar "Founding in Social Work", students are taught foundation-relevant knowledge. The seminar was offered in the winter semester 2020 / 2021 as a digital block seminar in team teaching. The field report presented here describes this event, starting with the challenges, through the conception, to the didactic implementation. Finally, central findings are described in the lessons learned.

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This contribution was originally submitted in German.

1. Challenges

The seminar "Foundations in Social Work" was offered in the Master's programme in Social Work at Mittweida University of Applied Sciences. It was embedded in the module "applied specialisations" in the area of management and could be choosen by students as one of several elective options. Within the winter semester 2020/2021, the lecturers offered this for the third time.

The group of Master's students was heterogeneous in terms of previous education, age, gender and media competence. The participants were of different ages, already had different professional biographies and had diverse ideas about their jobs after graduation. It was important to leverage this prior knowledge, to use the experiences fruitfully and to offer a critical and enthusiastic examination of entrepreneurial modes of action. The students were in the 5th semester of their part-time master's programme or in the 3rd semester of the full-time master's programme in social work. Most of them worked in different fields of social work and had little to no experience in the field of business start-ups.

In addition, the students in the current seminar had a few experience with digital tools outside of programmes such as Zoom. The seminar relied on a high proportion of collaboration and self-activity, discussion and group work. At the same time, experiences in the previous semester showed that the students' attention span in the digital space was not very long. This could be related to the "zoom fatigue" [18] already studied or also to the double burden of care tasks as well as distraction by other digital media and devices.

The course broadened the knowledge horizon in various areas. The students dealt with the basics of economics and (general) project management, which have hardly been addressed in the curriculum so far. Due to newly developing fields of work, social workers will also not only work in their profession. Therefore, competences that go beyond one's own professionalisation are of decisive importance [1].

Thus, the activation and enthusiasm for the topic of reasons posed an additional challenge. By using practical case studies and the lecturers' own professional backgrounds, as well as an open, reflective approach to the topic, the students were to be won over for the topic.

2. Concept of the seminar

The seminar with its high practical components was understood as a space of experience for the students. In principle, an experiential space can either be embedded in formalised educational measures or experienced in the social environment of the start-up process of companies [2]. Experiential spaces can be used in the context of teaching as competence-promoting teaching-learning arrangements. This teaching-learning situation must be structurally-organisationally and didactically-methodologically designed in such a way that new knowledge as well as new skills and abilities can be acquired in professional and social respects [3].

Experiential spaces are suitable for the development of competences relevant to entrepreneurship if they are complex in their design, can be actively experienced by the students and have a time limit. The teachers should support the students throughout the entire work process [4].

For the students, this experiential space must also be challenging in that this teaching-learning situation is completely new and motivating. Furthermore, the situation should support the participants individually. In entrepreneurship education, this situation should be used to reflect on one's own handling of new and challenging problems, for example in the context of developing a business idea within the course, and thus to make one's own behaviour in these situations transparent and thus also changeable [2] [4].

Entrepreneurship education can contribute to teaching students entrepreneurial thinking and action through various formats and approaches. It is relevant for social work in that students develop their own ideas in project seminars, for example, or work on practical and application-oriented problems. The students deal with the basics of business administration as well as (general) project management, which have hardly been addressed in social work studies so far. Through Social Entrepreneurship Education, students are enabled to think in a user-centeres, creative and innovative way and to reflect on their own actions. In addition, students are enabled to transfer their specialised knowledge to real-life contexts. Furthermore, entrepreneurship education enables constant reflection on one's learning process and experiential learning [5].

Entrepreneurship Education was implemented in the winter semester 2020/2021 as part of a digital block seminar for Master's students with a maximum group size of 15 people. This group size made it possible to optimally involve the students in the design of the seminar. All students could be involved and actively acquire knowledge with the support of the lecturers. It relied on a high proportion of cooperation and own application, discussion and group work.

The seminar concept was based on constructive alignment. Here, the learning objectives, the methods and the examination performance are aligned with each other. This enables students to understand the objectives of the course much better. In addition, the course was oriented towards competences by the teaching team [6].

Furthermore, the lecturers unterstood theirselves as learning guides who accompanied the students on their way through the seminar. This also meant that students had to actively participate in shaping the seminar, contributing their ideas and suggestions and gaining knowledge by applying the theoretical content they had heard. This kept the students in the seminar and at the same time promoted motivation. In addition, students were also bearers of experience, as many of them were already in professional life and enriched the course with their knowledge and experience. Discussions and exchanges among the students encouraged them to question working conditions and methods. With the "shift from teaching to learning", students were accompanied more holistically. For the seminar, this meant designing a student-centred learning environment that was conducive to learning [7].

Specifically, the students dealt with business model planning during the four block days. They started with the identification of a socially relevant problem and dealt with it by means of entrepreneurial approaches as well as with the development of corresponding business models.

An important aim of the seminar was to provide the students with methods that they can also apply and use in their everyday working lives as employees.

The seminar was based on the following teaching-learning objectives:

Through the use of creative methods, the students' self-reflective, innovative and actively creative thinking and acting is promoted.

By applying and practising on the basis of their own case studies, students are able to transfer specialised knowledge to real contexts.

Students get able to develop business models from their own project ideas with the help of Canvas.

These teaching-learning objectives are made clear to the students in advance; this also promotes transparency between students and teachers of the course and avoids misunderstandings between them.

The decision in the winter semester 2020/2021 for synchronous courses was based on a thorough survey of the thematic points at which the students had experience or non-experience. In addition, the appeal of the concept lay in the mix of methods, so that short intensive knowledge inputs were followed by timely application exercises. These had to be reflected on and questions of understanding clarified. Different levels of prior knowledge also led to flexibility in time planning and in the planning of the main topics.

The units were also adapted to the needs and requirements of the students or a larger period of time was made possible for exchange with each other, as learning also means social learning [8]. In this context, the students' social competence was promoted through synchronous teaching sessions, in that they were constantly in exchange with each other and with the lecturer. Attention and activity also had an influence on learning success.

Through the work with PowerPoint presentations, lectures, the self-learning phases and the presentation of one's own work status, different learning types were addressed. In addition to the visual type, the auditory and kinaesthetic type were also addressed, especially through the application of theoretical content and the use of various digital canvas and print templates for working with pen and paper. The communicative type of learner was mainly stimulated by the discussions and own speeches. A balanced change between the different forms was essential for the block event in order to address all senses to the same extent and thus enable the students to learn on different channels.

3. Didactic design

The basic structure of the seminar was based on Bloom's Taxonomy [9]. In the course of the seminar, the students expanded their competence from "knowing" to "analysing and evaluating". Each taxonomy level was represented by the use of different digital media.

Before the start of the seminar, all students received a welcome email. In terms of content, the students were informed about the course of the block days, time units, learning objectives and the form of the examination. They were also asked about their initial expectations of the seminar and offered support in the event of technical difficulties or special needs. In addition, the students received a link to the virtual seminar room with information on its use and possibilities. The students had the opportunity to communicate their own topic wishes and suggestions for the seminar design at any time.

In the first unit, a first approach to the topic of social entrepreneurship took place, in which students worked out their definition of foundation. This raised already existing levels of knowledge. The students were encouraged to actively think about themselves and their own environment and to engage in exchange within the framework of Think-Pair Share [10].

The Zoom conference platform was used as the digital tool for implementing the seminar. Due to the various possibilities, such as the digital whiteboard, the possibility of screen sharing and working in breakout rooms, the tool offered good conditions for the implementation of the content to be conveyed.

The digital whiteboard mainly offered the possibility of brainstorming in the large group and thus approaching specific topics, such as social entrepreneurship. At the same time, this tool was also used for collecting ideas or compiling work results in the small groups. In addition, the digital whiteboard was also used in the context of social entrepreneurship to gather moods and feedback.

In particular, setting up breakout rooms and working in small groups there promoted (digital) togetherness and the possibility of working together in teams. For the teachers, this also offered the opportunity to have different groups work on different assignments and present them afterwards. The teachers could enter the rooms at any time or bring the teams back to the main room. Precise work instructions and clear wording were just as important as a clear time limit to counteract queries and ambiguities. In addition, buffer time was planned, as the groups first had to familiarise themselves with each other and with the task. Regular enquiries by the teachers regarding additional time needed or difficulties in implementing the method also had to be planned for.

In order to improve collaboration among the students, different tools were used during the seminar. Among other things, the idea tower [11] was used to develop ideas. This is a form of brainwriting and is completed by several students in rotation. The padlet was used here as a digital alternative. Afterwards, the idea generators talked about the ideas they had developed and exchanged ideas about their feasibility. A particular challenge for the teachers was to create enough padlets and assign them correctly to the respective persons.

Furthermore, canvases were used for the group work. These worksheets basically offered good possibilities, among other things, for working out who was the user and who was the customer of the product/service that the students were developing. The canvases also provided a good structure and overview. For example, it would have been easier to create a business plan from a (social) business model [12] in a next step. These templates could be used again and again for further or later ideas, so that they offer good methods for everyday practice in the students' different fields of work beyond the seminar.

Furthermore, feedback was an elementary method for the continuous improvement process as teachers, but also for the students' reflection in order to find out where they stood in their process of acquiring knowledge. The following feedback methods were used in the seminar:

The flash focused on the questions "What helped you to find an access to the topic?"; "Which practical references contributed to a better understanding?" and "The most important insight today was ...". [13].

By means of a one-minute paper at the end of the course, the students were given one to three questions in order to receive (anonymous) written feedback on learning gains, difficulties in understanding or the design of the course. In the digital room, the Etherpad or the Padlet was used for this. Another use was to write down three essential contents of the course, which were not evaluated by the lecturers, but served as a reflection by the students [14].

With the help of the five-finger method, feedback was also requested from the students. In the context of the seminar, the fingers had the following meaning: the thumb: "This is what I have learned", the index finger "This could be improved structurally or in terms of content in the context of the seminar", the middle finger "This was not implemented well in terms of content", the ring finger "This is what I will take away thematically" and little finger "The topic was dealt with too briefly" [15].

After each block day, the lecturers briefly summarised the contents and gave an outlook on the following block days. The students were always invited to contribute their own ideas, suggestions for topics or wishes for the next event. In addition, the students were given a self-study task to tie in with the contents they had learned and to deepen them further. These tasks were taken up at the beginning of the next event and discussed in plenary.

The seminar was offered in team teaching [16]. For the teaching team, this meant that they were relieved by a better distribution of tasks. Each person was assigned different tasks at different points. While one teacher imparted theoretical content to the students, the second teacher prepared breakout rooms and assignments, for example. In addition, the teachers were able to supervise the chat in parallel and register any technical problems that arose in a timely manner. In addition, it became possible to accompany students during the collaborative tasks at the same time and to react to questions about the content.

Statements, comments and questions from the students were recorded in their entirety by the teaching team and were not lost. Due to the different types of teaching, ways of speaking and the presence in the digital space, the attention span of the students was maintained for longer.

Due to the different experiences and professional backgrounds, the teaching team additionally enriched the seminar by stimulating discourse and exchange and by being able to bring in their own practical examples.

Nevertheless, good and precise consultation was needed in the teaching team. Different interests and approaches had to be taken into account in the planning and implementation in the team. Differences in content had to be discussed promptly. Furthermore, it could have been challenging for students to get involved with two people and to meet their demands [17].

At the end of the fourth block day, a part of the examination performance was taken by the students. Each group, consisting of two people, presented their business idea in the form of a digital pitch. Each group could use the split screen to illustrate what they had said with a poster or a presentation. After this five-minute presentation, there was an opportunity for questions. In a second step, the students evaluated and reflected on the seminar and their knowledge acquisition in a written reflection report.

4. Lessons Learned

The teaching team takes away the following insights from the digital block seminar "Foundations in Social Work":

The plannable is often not plannable in its entirety. The Corona pandemic showed that all previous (didactic) ideas and approaches had to be discarded and redesigned within a very short time.

For the digital block courses, the lecturers should actively plan breaks in order to counteract digital fatigue and the drifting away of the students' thoughts. In addition, the breaks also serve as a short rest for the lecturers and for brief consultations.

Furthermore, short units are a key insight. Theoretical input should not exceed 20 minutes. An activating exercise afterwards additionally promotes internalisation and transfer to one's own circumstances.

In the digital space, a diverse selection of collaborative tools is available and should be used. This also promotes exchange and social interaction among students. Nevertheless, these should always be selected with regard to their usefulness.

Furthermore, constant and continuous feedback in the digital space is essential in order to check for difficulties in understanding, problems in the use of digital tools and wishes for improving the course.

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From the face-to-face to the hybrid event. Experiences with the transformation of a conference series to online network research

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Abstract

GeNeMe steht seit mehr als 20 Jahren für „Gemeinschaften in Neuen Medien“ und behandelt Online Communities an der Schnittstelle zwischen bzw. aus Sicht mehrerer Fachdisziplinen wie Informatik, Medientechnologie, Wirtschaftswissenschaft, Bildungs- und Informationswissenschaft sowie Sozial- und Kommunikationswissenschaft. 2020 haben sich die Autor:innen in ihrer Funktion als Ausrichter der Konferenz bewusst für den Fokus des Transfers bzw. Zusammenspiels von hybriden Realitäten zu hybriden Gemeinschaften entschieden. Überraschenderweise führte dies zu einem sprunghaften Anstieg der Beitragseinreichungen um ca. 80%.
Der Aufsatz beschreibt, welche Erfahrungen mit der Transformation der Konferenzreihe zur Online-Netzwerkforschung, ausgerichtet durch mehrere Hochschulen am (virtuell-hybriden) Standort Dresden, die Autor:innen dabei gesammelt haben und macht Vorschläge, wie diese für die akademische Lehre verallgemeinert werden können.

GeNeMe has stood for "Communities in New Media" for more than 20 years and deals with online communities at the interface between or from the perspective of several disciplines such as computer science, media technology, economics, education and information science as well as social and communication science. 2020, the authors, in their capacity as conference organisers, deliberately chose to focus on the transfer or interplay of hybrid realities to hybrid communities. Surprisingly, this led to a jump in paper submissions of about 80%.
The paper describes the experience the authors have gained with the transformation of the conference series on online network research, hosted by several universities at the (virtual-hybrid) location of Dresden, and makes suggestions on how this can be generalised for academic teaching.

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1. General

GeNeMe[1] has stood for "Communities in New Media" for more than 20 years and deals with online communities at the interface between or from the perspective of several disciplines such as computer science, media technology, economics, education and information science as well as social and communication science. As the forum for interdisciplinary dialogue between science, business and administration, the conference has facilitated the exchange of experience and knowledge between participants from a wide range of disciplines, organisations and institutions for 23 years now. A comprehensive thematic overview of the conference topics and their changes over time is provided by Köhler et al [1].

Not only since the pandemic, but since the beginning of the conference series in 1998, the focus has continuously been on the scientific and application-related analysis of media-supported cooperation. The discussion and testing of education-related formats of knowledge cooperation has always been a focal point. In 2020, the organisers deliberately chose to focus on the transfer or interplay of hybrid realities to hybrid communities. Surprisingly, this led to a jump in the number of submissions to about 80 % to about 90 contributions - although the causality is unclear.

In the following, we want to examine what experiences the authors have had with the transformation of the conference series on online network research, organised by several universities at the (virtual-hybrid) location of Dresden. In this way, the article can be connected to current studies on the possibilities of digitally supported, cross-university cooperation in teaching. [2], [3]

2. Conference schedule, venue and programme information

The programme of GeNeMe 2020 [4] was diverse, including a one-day pre-conference and a two-day main conference.

As in previous years, the event app LineUpr[2] was used to visualise the programme structure. All information on times, rooms and speakers can be found in the programme app for speakers, participants and other interested parties. Here, conference visitors have the opportunity to compile their own individual programme plan and can use it on their smartphone or PC in a responsive design to accompany the conference[3].

The 23rd annual conference started on 7 October 2020 with a pre-conference in the form of a virtual bar camp on Open Science.[4] Although about 2/3 of the main conference is held in German, the barcamp, which was organised in cooperation with the Leibniz Research Network "Open Science"[5], was able to address an entirely English-speaking clientele.

On the afternoon of the pre-conference, interested parties from education, politics and science were invited to join the opening event at the HTW Dresden face-to-face. Here, the exchange of experiences was implemented in the form of a world café. In total, there were about 50 online participants in the barcamp and about 40 face-to-face participants at the pre-conference.

The main conference took place in the following days from 8 to 9 October in the DGUV Congress Centre in Dresden. The conference was held in a hybrid format in 2 workshop rooms plus a foyer and catering area for the breaks, with a maximum of 50 participants on site at any one time. The DGUV Conference Centre offered sufficient space for the conference to be held in the presence of the participants at this location - taking into account the specially developed safety concept.

3. The hybrid implementation

Since the call for papers was already written during the (first) lockdown, it was clear from the beginning that only a hybrid, extremely flexible concept would make it possible to hold the conference in autumn 2020. At least the organisation team and the conference manage-

[1] http://www.geneme.de
[2] https://lineupr.com/de
[3] https://geneme.lineupr.com/

[4] https://www.open-science-conference.eu/barcamp/os-cigeneme
[5] https://www.leibniz-openscience.de/

ment should be able to meet in the rooms on site, and in addition the conference should take place completely online if necessary. Against the background of the accommodation bans imposed directly before the start of the conference and rising infection figures, this flexible concept proved its worth, as every participant could switch between online and presence participation at any time.

MS Teams was chosen as the platform for the implementation; the audio-visual presentation and transmission technology on site was set up and supported by a service provider. Only through this support was it possible for the moderators on site to moderate "in the room" for the presence participants, but at the same time the sessions could also be followed online in MS Teams. In addition, the above-mentioned conference app LineUpr was used to plan the individual conference programme during the conference. [6]

During the main conference, moderation by alternating experts took place continuously on site. Due to the pandemic situation, the two days were characterised by the unpredictable presence of contributors and participants.

In total, there were about 40 face-to-face participants and 60 online participants at the main conference. However, "mixed forms" were practised, either by changing the place of participation during the two days, but also by online dial-in to the parallel session from a presence setting. Important for the possibility of such a dynamic change was the continuous online support, which included all contributions and sessions.

4. Conference didactics

Since the conference is also a testing ground for innovative approaches to conference didactics, newly configured handouts are available for the preparation and implementation of the hybrid conference for presentation and moderation (these can be accessed online via the embedded links):

A) Conference didactics for the presentation

In order to do justice to the large number of contributions, the following times resulted according to the submitted format:

1. Research contributions: 20 minutes (10 min. input + 10 min. discussion)
2. Practical and student contributions: 10 minutes (7 min. input + 3 min. discussion)
3. Interactive contributions: 40 minutes

B) Conference didactics for moderation

Facilitators were responsible for opening and guiding the sessions during the GeNeMe conference. As these took place both in presence and online via Microsoft Teams, personalised access was provided after registration for the conference. During the sessions, moderators welcomed the guests and guided their contributions, oriented to the appropriate presentation and discussion times and indicated the remaining speaking time to the speakers. Finally, they supported the discussion rounds with stimulating input and structured notes to secure results on the virtual whiteboard. All moderators were supported by a student assistant.

Students of the Master degree programmes "Continuing Education Research and Organisational Development" and "Economics" were involved systematically in the implementation - as far as time allowed - within the framework of selected and thus thematically appropriate courses.

5. The evaluation

Fig. 1: Conference evaluation in general

[6] https://geneme.lineupr.com/geneme2019

On the basis of an online survey of all participants conducted during the conference in the form of a voluntary and anonymous evaluation, some empirical findings could be collected.

Among other things, the evaluation (cf. the following two figures 1 and 2) showed a high level of satisfaction among both face-to-face and online participants.

In this context, 78% of the respondents fully agreed with the statement "mood and atmosphere were very good". The conference in the hybrid format was also predominantly (very) positively evaluated, as the following figure 2 shows.

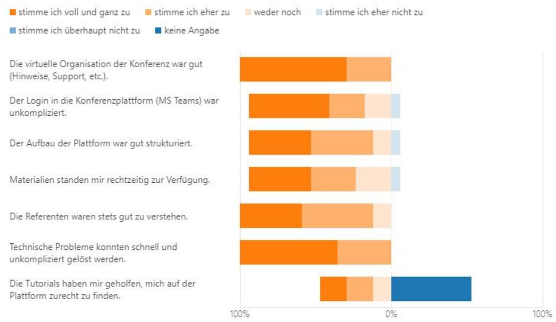

Fig. 2: Conference assessment hybrid format

6. Lessons Learned

All in all, the conference "Communities in New Media" (GeNeMe) presents innovative technologies and processes for organisation, cooperation and communication in virtual communities and forms a forum for professional exchange, especially in the fields of knowledge management and e-learning.

Due to the high demands on the flexibility of the operational implementation as well as the overall high workload of all participants, but also the clear limitations for face-to-face activities, the didactic design of interactive breaks and exchange formats traditionally practised at GeNeMe had to be greatly reduced in 2020. The breaks were also shortened as a result of the extremely full programme this time.

Online conference organisation with specific systems has been studied for some time as a problem of cooperative knowledge organisation [5]. In a non-pandemic setting with more planning security (i.e. also binding booking of online or presence participation), even more interactive formats should be integrated in the future and hybridity should be further extended to these as well.

Here, socialising tools such as wonder.me[7] could also be increasingly used to organise the breaks. Initial experiments with hybrid interactive conference formats such as hybrid panel discussions and a hybrid workshop on the topic of gamification were very positively evaluated and will continue to be integrated into the conference in the future.

To what extent can the experiences documented here be adopted for academic teaching? Some concluding reflections show the potential that exists despite all the complexity:

1. The hybrid format per se lends itself to working with both small and large groups of students. However, with regard to the usual teaching, there is a big difference not so much in the digitality (which, especially in times of the pandemic, also works in teaching mostly by means of videoconferencing), but rather in the temporal dimension. While a seminar or lecture usually extends over the entire semester, the conference is only held for 2-3 days. In this respect, the group dynamics are different again, the participants hardly know each other or, at least in the context of the individual conferences, do not have the opportunity to build up long-term relationships, unlike students. In this respect, the conference would be more comparable to a block seminar.
2. Furthermore, in hybrid implementation we have a wide range of situating of the conference-related actions in a (partly virtual) conference location. This raises the question of the approach to the effectiveness of the conference, the immersion of the participants. On the one hand, this is a problem that is typical for a didactic setting and can therefore be transferred to teaching.
3. On the other hand, this requires the use of corresponding digital-spatial tools, especially for the virtual part of the conference. In the preparatory phase, GeNeMe 2020 considered at least partial use of VR-based

[7] https://www.wonder.me/

cooperation platforms such as TriCAT[8]. However, due to the complexity of the application, but also against the background of the not inconsiderable costs, the organisers were unable to decide in favour of its use. There is certainly a need for development here. Perhaps in 2021, at the 24th GeNeMe conference, tools for VR-based cooperation can be used for the first time, which are already established for academic teaching in the portfolio of the participating universities?

4. GeNeMe uses different social media tools in the three phases of conference preparation, follow-up and implementation. These are tools for conference management (indico)[9] , for conference implementation (MS Teams) and for information management (LineUpr). This diversity of completely independent tools is surprising. Moreover: at least at the TU Dresden, these tools are not used in teaching! Why is that?

As a result, it is more than desirable to support the individual use or the use of digital tools in scientific activities per se and to further develop them in a targeted manner. Empirical findings on the state of digitisation in science in Germany, especially Saxony, still show a considerable need for action here. [6]

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[8] https://www.tricat.net/

[9] https://getindico.io/

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Digital lecture seminar

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Abstract

Vortragsseminare finden klassischerweise in Präsenz statt. Der coronabedingte Lockdown im Sommersemester 2020 zwang alle Lehrveranstaltungen in den virtuellen Raum. Dieser Beitrag stellt die in drei verschiedenen Vortragsseminaren an der Fakultät Maschinenwesen der TU Dresden implementierten Anpassungen zur Durchführung unter Kontaktbeschränkungen vor und evaluiert, welche Lernziele mit den jeweils gewählten Formaten erreicht werden konnten. Besonderes Augenmerk liegt außerdem auf den Inhalten und der Durchführung des Einführungsvortrags, bei welchem den Studierenden Hinweise für eine erfolgreiche Vortragsvorbereitung und Vortragsdurchführung gegeben werden. Diese mussten an virtuelle Vorträge übertragen und angepasst werden.

Die Erkenntnis, welche Lernziele erreicht wurden und welche nicht, aber auch welche Vorzüge eine virtuelle Durchführung bietet, soll Anreize und Hinweise für die Gestaltung zukünftiger Formate geben.

Lecture seminars typically take place in in-person sessions. The corona-related lockdown in the summer semester 2020 forced all courses into the virtual room. This paper presents the necessary adaptations in three different lecture seminars at the Faculty of Mechanical Engineering at the TU Dresden for implementation under contact restrictions and evaluates which learning objectives could be achieved with the chosen formats in each case. Special attention is also paid to the content and presentation of the introductory lecture, in which students are given tips for successful lecture preparation and performance during the presentation. These had to be transferred and adapted to virtual lectures.

The insight into which learning objectives were achieved and which were not, but also which advantages a virtual lecture seminar offers, should provide incentives and hints for the design of future formats.

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1. Introduction

Presentations are of great importance in engineering practice and are used as a means of communication in a wide range of areas, from internal project meetings and presentations to customers to scientific conferences and contributions to the media. Therefore, learning and practising an expedient, effective presentation technique is an integral part of the course of study at the Faculty of Mechanical Engineering at TU Dresden. When presenting student papers and defending diploma theses, one's own results must be prepared in such a way that they stand up to scientific discussion and thus justify the final grade. In order to prepare students in the best possible way for their final examination and their subsequent professional life, there are a number of presentation seminars at the Faculty of Mechanical Engineering. These seminars are usually held in larger seminar rooms and thrive on the atmosphere of general tension that most feel before a presentation, the enthusiasm with which the students present their topics and the direct exchange between students, staff and professors.

At the beginning of the summer semester 2020, the start of the lecture seminars was initially pushed back. When it became clear that the time period of contact restrictions in the context of the coronavirus pandemic would not be over after a few weeks, the three seminars thematised here took place in different ways in semi- or fully digital form.

This change in the teaching format and the associated adjustments, e.g. to the content to be taught, inevitably place these lecture seminars in a new light. In order to now shape the future of lecture seminars, a number of questions need to be answered:

What do we want to teach the students? Can we teach this content digitally, and if so, how? Can we assess digital lectures in the usual way?

This article does not presume to answer all these questions comprehensively. Rather, it aims to discuss the learning objectives, (virtual) course of action, problems and successes of each event on the basis of three lecture seminars from the summer semester 2020 in order to provide a basis for the design and evaluation of future hybrid courses and thus to integrate the findings from the virtual space into the education of the future once contact restrictions have ended.

In the second chapter of this article, three lecture seminars, as they are conducted at the Faculty of Mechanical Engineering at the TU Dresden, are presented and compared. Similarities and differences, especially with regard to the learning objectives, are discussed in detail. Furthermore, the schedule for the summer semester 2020, which has been adapted to the lockdown, will be presented. The introductory event, with which all three seminars were opened, is presented with its learning objectives. Methods to be taught are examined for their practicability for virtual seminars and the advantages and limitations of a virtual course of action are discussed. Finally, all presented components of the seminars are discussed, student feedback is presented and the success of the seminars is evaluated.

2. Selected lecture seminars

As an example, three presentation seminars at the Faculty of Mechanical Engineering, as can be seen in Tab. 1, are presented and compared in this chapter. (i) The presentation seminar at the Chair of Magnetofluiddynamics, Measuring and Automation Technology (MFD) is a voluntary course aimed at all students in the main course of study in mechanical engineering and purely aims at improving individual presentation techniques based on freely chosen presentation topics. (ii) The Mechanics Seminar has a long tradition at the Institute of Solid Mechanics (IFKM) and offers students who write their theses at IFKM or the Chair of Fluid Mechanics (PSM) the opportunity to present them voluntarily and thus practice defending their thesis. (iii) The latest presentation seminar is the literature seminar in the Master's programme Computational Modelling and Simulation (CMS), which is an integral part of the corresponding curriculum and is intended to teach students how to deal with scientific literature. In contrast to the other two seminars, grades are awarded here that are relevant to the success of the study.

While the number of participants of the seminars does vary, the usual procedure is almost identical. In a first event, appointments are made, topics are selected or announced and an introductory lecture is given. The introductory lecture goes beyond the usual guidelines for slide design and focuses on adequate lecture preparation and structuring and is intended to raise awareness of various presentation techniques. The contents of this introductory lecture and the necessary adjustments for the summer semester 2020 are discussed in more detail in chapter three.

Tab. 1: Overview of the lecture seminars discussed here

	(i) **Presentation Seminar**	(ii) **Mechanics Seminar**	(iii) **Literature Seminar**
Target group	Students of the Faculty of Mechanical Engineering	Students at the Institute of Solid Mechanics and the Chair of Fluid Mechanics with completed thesis	English-language Master's programme Computational Modelling and Simulation
Responsible for the course	S. Odenbach	T. Wallmersperger	M. Beitelschmidt
Number of participants	10 – 15	5 – 15	40 – 60
Grading	no	no	yes
Learning objectives	• Students should develop their own style of presentation • Teaching presentation techniques	• Preparation for the later defence of the thesis • Teaching presentation techniques	• autonomous understanding of the contents of a scientific publication and presentation of the contents [1] • Teaching presentation techniques • Practising teamwork where possible
Procedure	• Introductory event • Presentation session 1 incl. feedback on presentation technique • Presentation session 2 incl. discussion of the topic and feedback	• Introductory event • Lecture incl. discussion of the topic and feedback	• Introductory session and presentation of the available topics • Lecture incl. discussion of the topic and feedback
Adapted procedure in SS20	Introductory event digitally recorded in the seminar room and made available on YouTube [2] with parallel GoTo meeting [3]	Introductory event and lectures in GoTo Meeting [3]	Introductory session and presentation of the topics, as well as the lectures in up to four parallel sessions online in GoTo Meeting [3] Multi-level enrolment in OPAL [4]

Enrollment

Status	Name	Beschreibung	Anzahl Plätze	Eintragen	Austragen
	Students in Literature Studies		58 / ∞	Erlaubt (bis 24.04.2020 23:59)	Erlaubt (bis 24.04.2020 23:59)

(a) General course enrolment

Topic List

	Dateityp	Name	Größe	Zuletzt geändert
☐		additional_Topics_MMFS.pdf	133,8K	am 21.04.2020 um 17:07 Uhr
☐		DMT_Topics_update.pdf	384,1K	am 16.04.2020 um 17:28 Uhr
☐		MMFS_Topics.pdf	611,2K	am 09.04.2020 um 10:48 Uhr
☐		NEFM_Topics_update_200416.pdf	487,6K	am 16.04.2020 um 15:03 Uhr
☐		PSM_Topics.pdf	989,2K	am 14.04.2020 um 08:25 Uhr

(b) Overview of the topics offered

		Name	Verantwortliche/r	Termin Einschreibung	Anzahl Plätze
☐	⃠	DMT01: Aerial Manipulation: A Literature Review	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2
☐	⃠	DMT02: Control of Fully Actuated Unmanned Aerial Vehicles with Actuator Saturation	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	1/1
☐	⃠	DMT03: Model Predictive Control of Unmanned Micro Aerial Vehicles	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	1/1
☐	⃠	DMT04: Vision-Based Methods for Measuring Vibration	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2
☐	⃠	DMT05: Dynamics of Threads	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2
☐		DMT06: Measuring stress field without constitutive equation	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	0/1
☐	⃠	MMFS01: Electro-Active Polymer Based Soft TactileInterface for Wearable Devices	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2
☐	⃠	MMFS02: Morphing aircraft based on smart materials and structures: A state-of-the-art review	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2
☐	⃠	MMFS03: Electrostriction of polymer dielectrics with compliant electrodes as a means of actuation	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	1/1
☐	⃠	MMFS04: Auxetic metamaterials and structures	Micha Sebastian Schuster	ab 17.04.2020 00:00 bis 24.04.2020 23:59	2/2

49 Einträge « 1 2 3 4 5 » alle anzeigen

(c) Enrolment in the topics offered

	Status	Name		Termin	Ort	Dauer	Anzahl Plätze	Bemerkungen
☐		Session 01B MMFS & PSM	Einschreiben	22.05.2020 14:50 - 16:20	ZEU/260	1 Std. 30 Min.	2/3	Only for topics from the Chairs of Fluid Mechanis and Mechanics of multifunctional Structures
☐		Session 01A DMT & NEFM	Einschreiben	22.05.2020 14:50 - 16:20	ZEU/160	1 Std. 30 Min.	1/3	Only for topics from the Chairs of Dynamics and Mechanism Design and Computational and Experimental Solid Mechanics
☐		Session 02B MMFS & PSM	Einschreiben	29.05.2020 14:50 - 16:20	ZEU/260	1 Std. 30 Min.	2/3	Only for topics from the Chairs of Fluid Mechanis and Mechanics of multifunctional Structures
☐		Session 02A DMT & NEFM	Einschreiben	29.05.2020 14:50 - 16:20	ZEU/160	1 Std. 30 Min.	2/3	Only for topics from the Chairs of Dynamics and Mechanism Design and Computational and Experimental Solid Mechanics
☐		Session 03B PSM & NEFM		12.06.2020 14:50 - 16:20	ZEU/260	1 Std. 30 Min.	3/3	Only for topics from chairs of Fluid Mechanics and Computational and Experimental Solid Mechanics
☐		Session 03A MMFS & DMT		12.06.2020 14:50 - 16:20	ZEU/160	1 Std. 30 Min.	3/3	Only for topics from the Chairs of Mechanics of multifunctional Structures and Dynamics and Mechanism Design
☐		Session 04B PSM & NEFM		19.06.2020 14:50 - 16:20	ZEU/260	1 Std. 30 Min.	3/3	Only for topics from chairs of Fluid Mechanics and Computational and Experimental Solid Mechanics
☐		Session 04D: NEFM & MMFS	Einschreiben	19.06.2020 14:50 - 16:20	tbd	1 Std. 30 Min.	0/3	exact date is preliminary
☐		Session 04C DMT & PSM		19.06.2020 14:50 - 16:20	tbd	1 Std. 30 Min.	3/3	exact date is preliminary
☐		Session 04A MMFS & DMT		19.06.2020 14:50 - 16:20	ZEU/160	1 Std. 30 Min.	3/3	Only for topics from the Chairs of Mechanics of multifunctional Structures and Dynamics and Mechanism Design

20 Einträge « 1 2 » alle anzeigen

(d) Enrolment in the sessions

Fig. 1: Multi-level OPAL enrolment for the CMS literature seminar

The main part of the semester consists of the sessions with the student presentations. Here, in all formats, a presentation of 20 minutes duration is given and then evaluated with a short discussion. In both the mechanics seminar and the literature seminar, this is a 10-minute discussion of the topic and a short evaluation of the presentation technique. A more detailed feedback of the presentation technique at the end of the course takes place individually with the respective supervisor. In contrast to this, the focus of the presentation seminar is very much on the detailed discussion of the presentation technique. Here, students give the same presentation twice on two different dates and are assessed on the basis of their improvement in the second round. A short discussion of the topic is part of the second round.

All three courses met the challenges of the 2020 summer semester in different ways.

(i) In the presentation seminar, the introductory lecture was broadcast live from the empty seminar room via YouTube and has since been available as a video via YouTube. This means that students can also access it asynchronously and watch individual aspects of the event again afterwards. Parallel to the public YouTube stream, a GoTo meeting organised the participants to coordinate dates. The student presentations took place in presence under strict hygiene regulations.

(ii) The mechanics seminar took place entirely via GoTo Meeting. For the introductory lecture as well as the student lectures, the moderator rights were handed over to the lecturer in each case. The scheduling took place in consultation between the supervisors of the thesis and the respective university lecturers.

(iii) The literature seminar also used GoTo-Meeting. Some students in this international course were unable to travel to Germany from their home countries for the summer semester, which made it essential to fully digitise this course. This also made it possible to parallelise the lectures in up to 4 sessions, so that all 55 participants could give their presentations in the time slot provided in the timetable. An additional challenge in this seminar is the enrolment and preparation of the schedule. The topics offered, from which the students are free to choose, are provided by the three professorships of the IFKM and the PSM. Once chosen, the topics must then be presented in the sessions supervised by these professorships in order to enable a professional assessment. For this purpose, a multi-level enrolment procedure, as shown in excerpts in Fig. 1, was created in OPAL. After an initial general enrolment for the course, Fig. 1 (a), students can view the topics offered, Fig. 1 (b). After selecting a topic to be worked on, the corresponding enrolment, Fig. 1 (c), takes place according to the "first come - first served" principle. The topics contain the abbreviations of the corresponding professorships, so that in a third enrolment, Fig. 1 (d), students can choose a presentation date that is supervised by the corresponding professorship. Since each topic in the literature seminar is assigned to its own supervisor, there is also a large number of supervisors in this seminar. In order to provide them directly with the current information, an additional "supervisor" enrolment has been provided in the course.

Some topics in the literature seminar were designed in pairs, for example by dealing with the first part of a publication in one presentation and the second part of this publication in another presentation, or by giving two very closely related publications as presentation topics. The aim here was to get the students to exchange ideas about subject content and presentation technique, to give each other hints and feedback in the process of preparing a presentation, and to practise teamwork. Above all, in times of isolated work in home office, this was also intended to be a deliberate trigger and incentive for communication to perhaps alleviate the often psychologically stressful situation at least a little.

3. Introductory event

The assessment of student presentations should always be preceded by a clear definition of requirements. This means that it has to be clarified and communicated what is expected of a presentation. This is best done in the introductory session of such a seminar.

Within the presentation seminar, which traditionally focuses on the individual presentation technique, a summary was developed for this purpose which, beyond general regulations on slide design, raises the participant's awareness to various communication techniques. In addition, presentation preparation is discussed intensively and it is shown that - in contrast to classical dogmatic guidelines on presentation design - the manner of presentation must always suit the presenter and the audience.

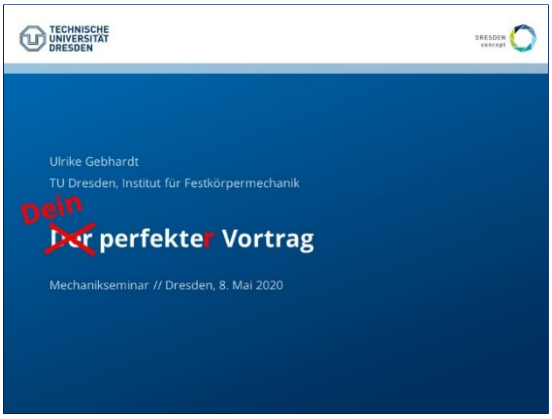

Fig 2: Title slide "Your perfect presentation" to motivate an individual style of presentation

This approach was adapted for the mechanics and literature seminar a few years ago. As illustrated by the title slide in Fig. 2, the aim is to encourage students to develop their own style of presentation in addition to the basic rules of presentation design and to test this personal style during the seminar.

So how can we measure whether a presentation is "good", beyond its purely technical accuracy? Presentations always aim to convey something to an audience. If the audience listens enthusiastically and can absorb the presented content, the presentation is good. To do this, the audience's interest must first be aroused, which can be achieved through various methods. They range from vivid motivation, appealing slide design, clear language, facial expressions and gestures to spatial audience contact. These points are equally important and can also be implemented in the virtual space. Only the spatial contact is now the chosen position to the camera and which image section the camera shows. It is taken for granted that the presentations are held with the presenter's camera running. All these points are to be applied and adjusted individually for each person. Speakers with naturally quiet voices can improve the acoustics by taking on step closer towards the audience or by moving a little closer to the microphone. In contrast, a presenter with a very loud voice and a position directly in front of the front row may overwhelm the audience. How much gesticulation suits one's own way of speaking is also individual.

The introductory lecture should give an impression of the effect of these methods. For this purpose, it is deliberately spoken too loudly or too softly, unfavourable slide design is discussed using concrete examples, etc. The effect of the individual methods is demonstrated in the lecture and discussed afterwards. For example, the lecturer loses the attention of the entire audience by showing a slide with a lot of continuous text and a video. The lecture continues with the content and after a few seconds the audience is asked to indicate by a show of hands which part of the lecture they really noticed in the last 20 seconds. About one third will have read the continuous text and two thirds will have watched the video. There are rarely individual students who report that they would have continued to listen to the lecture. By directly experiencing and reflecting on the points at which they, as listeners, enjoy listening, when they feel uncomfortable listening or at which points they are no longer attentive, the importance of these methods for a successful presentation becomes clear to them in their own experience. Afterwards, the students are asked to try out exactly these design points for themselves within the framework of the respective seminar. Furthermore, when listening to their colleague's presentations they are asked to repeatedly ask themselves the questions "What works? What is good? What doesn't work, and why? How would I do it better?" Learning by watching is important to the success of such a seminar.

4. Feedback during the presentation

In order to determine whether individual presentation techniques work out the way they are planned, the perception of the reaction of the audience is necessary. Therefore, we now have to discuss how to capture the audience's reaction.

If the audience is physically sitting in the presentation, an experienced speaker can identify at a glance how many listeners are still interested in the topic or are perhaps looking bored or even completely distracted. Even if it is difficult to follow the presentation because people are speaking too quickly or unclearly, or the topic is too complex, the ensuing perplexity can be read in the faces. This "real-time feedback" is not transferable to a virtual presentation. Usually the cameras and microphones of the audience are switched off to keep the technology stable.

Active questions from the presenter can counteract this and activate the audience, either in the form of a direct learning success question or by briefly summarising what was said and asking them to name gaps in understanding. These questions can also be incorporated very well into digital presentations, although this takes a little more time. In the authors' experience, answering the questions via the chat function leads to more feedback than the classic raising of hands in the lecture hall.

With the tools mentioned, presentation techniques can certainly be used virtually and tested selectively. Only "real-time feedback" in the form of eye contact with the audience cannot be reasonably digitised.

5. Implementation and evaluation

The students in all three lecture seminars were able to achieve the primary learning objectives, which are listed first in Tab. 1, in the summer semester 2020.

In the presentation seminar, the students worked successfully on their individual presentation techniques as usual. This was made possible by the established procedure in presence, supplemented by strict hygiene measures.

The online lectures in mechanics and literature seminars were also successful. The students took the lectures seriously and were generally well prepared. The supervision of the preparation was not significantly affected by the exclusive online contact. In some cases, contact with the students of the literature seminar was insufficient in this phase, but this was also observed in the face-to-face version of the event, although now somewhat intensified by the physical distance. In the first lecture dates, individual technical problems occurred, such as difficulties with logging in, functioning of the terminal devices, etc.

Students were asked to arrive 15-20 minutes before the start of the literature seminar in order to test the technology and to process the formalities for the later assignment of grades. Technical aspects took a little more time than in a normal face-to-face seminar. Individual students only appeared very shortly before their own slot in the seminar date, which then took additional time for set-up and testing.

According to their own statements, some students were less agitated when giving their presentation due to the greater distance to the examiner and the auditorium. Nevertheless, if they had the choice, they would prefer a seminar in presence.

In the context of the virtual seminars, as explained in section 3, it was not possible for the students to further develop their individual presentation style in detail through "real-time feedback" from the audience. The aforementioned obtaining of explicit feedback during the lecture was also not practised. This is unusual, requires more self-awareness and does not take place during a classroom presentation in a seminar, mainly for reasons of limited time. Feedback was given during the subsequent discussion, which was then moderated by the supervisor or examiner.

Another learning objective of the seminars discussed here is to get to know different scientific topics. The students are presented with a selection of different topics in a short period of time within the respective course and are expected to enrich the discussions following each presentation by asking questions. Unfortunately, especially in the mechanics and literature seminar, there was relatively little participation from the students. Even in presence, it is always difficult for students to participate in the discussion with questions and often the events are not attended before and after their own presentation date. This effect is intensified by the virtual implementation. In the literature seminar in particular, it was necessary to organise the large number of lectures in up to four parallel sessions. Here, the number of the few listeners was additionally distributed among these four sessions.

In contrast, the multi-level OPAL enrolment and course architecture in the literature seminar worked very well and will also take place in this form in future semesters.

With the points discussed here, does it make sense to integrate virtually conducted lecture seminars in the future? The lockdown in the context of the coronavirus pandemic has shown that meetings and conferences can in principle be held in virtual space. If one also takes into account the omitted travel costs and time, it can be safely asserted that virtual presentations will continue to be part of everyday life even after the contact restrictions have been lifted. If the opportunity and capacity exists, it would thus be advantageous for students to additionally develop their presentation skills in the virtual space. Lecture seminars with large numbers of participants, such as the literature seminar, also require more space in a classroom setting. Setting up to four parallel lecture rooms is only feasible with enormous effort in terms of time, organisation and room capacity. Virtual sessions therefore offer a practicable alternative.

In order to raise the student's awareness to the possibilities of how one as a presenter can influence the mood of the audience and bind their attention more or less and at which points one loses it, a successful introductory lecture as described in section 3 is important. However, with the lack of "real-time feedback", it cannot be ensured that the students have perceived the learning effects presented in the desired form. This is less of a disadvantage in the presentation seminar, as students are assessed on the improvement of their presentation in the second round and receive very detailed feedback after their first presentation. The participants of the mechanics and literature seminar, however, had worse starting conditions. Here, the presentations are assessed in the first and only round and the time for public feedback on the presentation techniques is limited. However, there was an offer to discuss the slides with the supervisor before the presentation, and there was in-depth feedback afterwards. The mechanism of students making progress by critically adopting successful features from other presenters was less evident.

Beyond the pure evaluation of the presentations, these seminars should show the possibilities of presentation design and its effects, so that the students can also work on their presentation technique in the future. Especially for the mechanics and literature seminar, the introductory lecture is particularly important and should be conducted with direct audience contact in the future wherever possible.

6. Summary and outlook

Presentation, mechanics and literature seminars are important components of teaching at the Faculty of Mechanical Engineering at TU Dresden, which, adapted to the contact restrictions, were also successfully carried out in the summer semester 2020. The primary learning objectives in each case - teaching individual presentation techniques, defending one's own thesis, autonomous understanding and subsequent presentation of a scientific publication - were all achieved.

The introductory event, which had a similar structure in all three seminars, was held entirely digitally and could not fully achieve its goal of raising awareness of various presentation techniques due to the lack of direct audience contact. For the future, it should be considered whether special digital techniques such as surveys, chat during the lecture, etc. should be presented, tested and practised in more detail.

The participation of students as listeners in the lecture sessions was rather low - especially in the mechanics and literature seminar. This problem, already known from previous years, was worsened by the virtual implementation.

Not only have the students, also the teachers learn in the seminars described here. In the current edition of the literature seminar in the summer semester 2021, three things are practised differently. In the previous year, the lecturers had a list of criteria to support the assessment and help with uniform grading. However, it was internal and not handed out to the students so as not to guide them too much. In the summer semester of 2021, the criteria list was revised and handed out to the students at the beginning of the semester. In addition, inspired by the procedure in the presentation seminar, the grading is now split up and a partial grade is given in advance for the quality of the slides, with the possibility of improving the quality of the slides before the actual presentation, which is also included in the grade. Finally, all topics are now basically dealt with in group work. At the time of writing this article, the presentations have not yet taken place. The authors are curious to see the effect of these measures.

When planning future lecture seminars in general, it is worth asking what content should be taught in each case. Hybrid and digital formats can compensate for a lack of room capacity, minimise travel distances and teach the skills of digital presentation, which are probably important in the long term. However, virtual formats have limitations when it comes to developing a personal presentation style; students should first learn to interact with a physically present audience before transferring the knowledge they have gained into the virtual space.

Literature

[1] CMS Literature Seminar: Module description (accessed on: 14.05.2021) (https://tud.link/w339)

[2] Presentation Seminar: YouTube Introduction (accessed 26.05.2021) (https://youtu.be/d0zubK2pTXk)

[3] GoTo Meeting (accessed on: 14.05.2021) (https://www.gotomeeting.com/)

[4] Online Platform for Academic Teaching and Learning (OPAL) (accessed on: 14.05.2021) (https://bildungsportal.sachsen.de/opal/)

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Online lectures with the paella player

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Abstract

Online-Vorlesungen können in verschiedenen Arten angeboten werden. Dazu gehören das Echtzeit-Streaming, vertonte Powerpoints sowie einfache Videos. Alle diese Angebote haben Vor- und Nachteile. So ist bei großen Hörerzahlen das direkte Streaming häufig aus technischen Gründen unmöglich. Vertonte Powerpoints sind für den Studenten nur sehr unkomfortabel zu nutzen. Videos haben da eine Reihe von Vorteilen. Allerdings hat es sich gezeigt, dass es sehr sinnvoll ist, wenn gleichzeitig sowohl die Präsentation als auch der Dozent sichtbar sind. Dies ermöglicht der von der Universitat Politècnica de València entwickelte Paella-Player. Die Funktionalität sowie die Voraussetzungen der Nutzung dieses Players sollen im Beitrag vorgestellt werden.

Online lectures can be offered in different ways. These include real-time streaming, powerpoints set to music and simple videos. All of these offerings have advantages and disadvantages. For example, with large numbers of listeners, direct streaming is often impossible for technical reasons. Powerpoints with sound are very uncomfortable for students to use. Vi-deos have a number of advantages. However, it has been shown that it is very useful if both the presentation and the lecturer are visible at the same time. This is made possible by the Paella Player developed by the Universitat Politècnica de València. The functionality as well as the requirements for using this player will be presented in the article.

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This article was originally submitted in German.

1. Intention

I would like to report on the use of the paella player for the online lectures in engineering design and computer science.

After it became clear that the lectures in the large basic courses in the summer semester 2020 could only be implemented online, I had tried different formats.

An online lecture in real time was not considered further because of the large audience (>500 listeners).

The first attempt was lectures as videos of Powerpoint-Sequences. However, these were almost 100% deselected in the evaluations given to me. The biggest problems with this variant are:

- Free choice of certain passages is hardly possible
- Repetition of individual phrases is difficult
- Dropouts in the audio stream when changing slides; This is mainly due to the fact that one often does not pause when speaking when the slides move on. Since PowerPoint places the sound directly in the slides, these interruptions are inevitable.

In the second attempt, I then posted the lecture as complete videos on Youtube. The solution was generally described as very favourable, as many disadvantages of the Powerpoint variant are no longer relevant.

After the winter semester was also not possible in presence, a decision had to be made about the online offer.

I also had a few points about the simple Youtube videos that I didn't like:

- Still quite difficult to navigate between the individual slides or to select a specific slide.
- Cumbersome preparation of the Videos, if the lecturer is also to be visible
- and in this case missing navigation between these streams

Then, by chance, I became aware of the Paella Player.
This is an open source JavaScript video player that synchronises an unlimited number of audio and video streams and provides them in different forms (including live stream or ZOOM). It works with all HTML5 browsers (Chrome, Firefox, Safari and Edge) as well as iOS and Android. The player was mainly developed at the Universitat Politècnica de València and can be used free of charge for educational purposes. [1]

An enquiry at the media centre revealed that they know this player and like it, but want to develop something of their own first (?!).

So a first attempt was made with the original paella player on my own. With this, all the major lectures in the first semester (design theory, computer science) and the fifth semester (constructive development process) were implemented.

2. Appearance and functionality

The student starts as usual in OPAL. From there he is redirected via a link to a WEB page that contains the links to the lecture videos. This is necessary because the paella player cannot be started directly in OPAL.

The videos for the presentation (e.g. Powerpoint) as well as the lecturer can be stored locally or also e.g. (as in our case) on Youtube.

After the start, an interface with (at least) two video windows and various function buttons for controlling the videos is offered (Fig. 1).

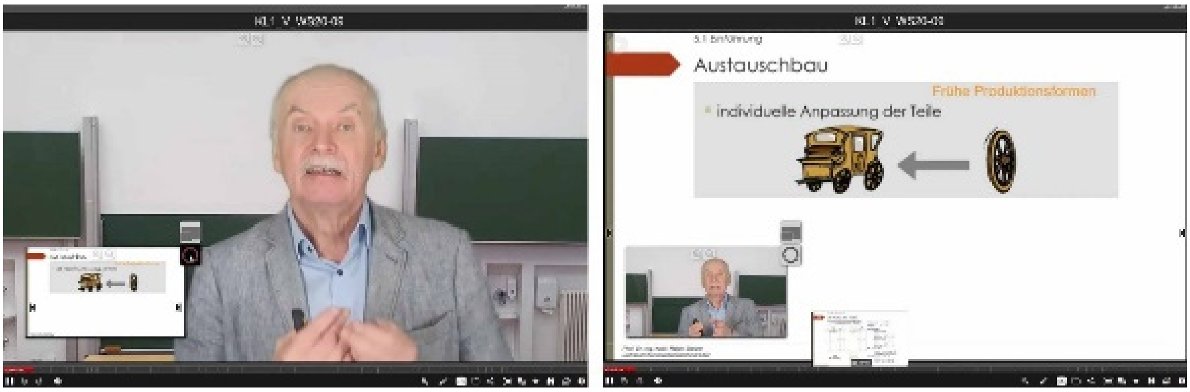

Fig. 1: Variants of the screen layout when working with the paella player

A variety of different functions are now available for practical use, including:

- The lecture can be interrupted at any point and continued later.
- It is possible to switch between the display of the videos in size and positioning (Fig. 1, left or right).
- The individual video windows can also be completely hidden.
- Return exactly to the beginning of the respective slide or to the beginning of the next or previous slide.
- Start any slide via the navigation bar in the lower area of the viewer. There, the red bar shows at any time how far the lecture has progressed as well as the length of each individual scene (slide).
- Small images of each slide can also be displayed at the bottom of the screen to facilitate targeting (Fig. 2).
- Switch to full screen
- Set the video quality depending on the speed of the WEB connection.

Already here, a problem should be pointed out which arised in the variant we had used in autumn.
As it turned out that a lot of students really watch the lecture simultaneously at the time scheduled in the syllabus, this results in a very high load for the streaming server.

Fig. 2: Navigation between the individual slides using thumbnails

This could not be secured internally at short notice. The videos were therefore placed on the YouTube platform. This also has the advantage that the videos can be accessed individually at any time later. However, it became apparent that at the moment when the lecture was paused (e.g. to transfer content from the presentation video to the script), YouTube overlaid the lower part of the presentation with advertising. Unfortunately, this unpleasant side effect could not be avoided in the short term, but it was very annoying.
To make it easier for students to work with this previously unfamiliar player, an introductory video has been provided:
(https://www.youtube.com/watch?v=AxmJ2J0pWSk&t=334s)

3. Creating the presentation

Two videos are required, both of which must be provided on the server platform. These are

- The video of the PowerPoint presentation and
- The video of the lecturer

In addition, the following are needed:

- Thumbnail images for the individual slides to facilitate direct navigation.
- A structure file that contains the assignment of the thumbnails to the individual video sections and enables navigation in the videos.

The videos should be in mp4 format and must be synchronised with each other. The video of the lecturer is recorded by means of a camera (e.g. mobile phone). The presentation must be recorded on the screen. I used the tool *Movavi for* this. [2]
Since the videos are streamed by the student and not downloaded, they have to be stored on such a powerful server platform that allows simultaneous access by the users (i.e. over 500 people in the foundation lecture). For this reason, as already mentioned, we decided to store them on YouTube.
To enable targeted navigation in the viewer to the individual slides, a small preview image is required in each case. These should be available in jpeg format and can be created very easily by "Save as..." when working with PowerPoint.

Finally, the storage paths of the videos, the time stamps for the beginning of the individual sections (usually the slides) and the thumbnails assigned to each section must be specified in a structure file. This file has the json format commonly used on the Internet.

Although this format is readable, the structure is not readily comprehensible to the uninitiated and is also relatively complex to create.

For this reason, an addin is available for PowerPoint, which can be activated in the menu bar if required. (Fig. 3).

To do this, the user only has to set a flag at the marked point "Paella marks". PowerPoint then automatically generates the structure file during the presentation, including the time stamps for the slide changes, synchronised with the lecturer's video.

Independently of the use of the Paella Player, this add-in provides a variety of other functions to support the work with PowerPoint in the lecture, including:

- Extensive drawing functions in vector and pixel graphics for working with the pen when making additions to the slides
- Dynamic setting of markers in slides for free navigation during the lecture
- Synchronisation of annotations and free sketches between individual slides
- Integrating a camera
- Fade in of a whiteboard
- Linking embedded objects

For more information you can contact me directly.
The video of the presentation must now be synchronised with the time stamps and the corresponding thumbnails for the slide transitions.
Another application is available for this purpose (Fig. 4).

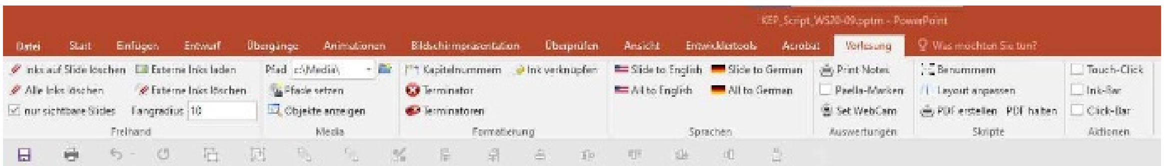

Fig. 3: Interface of the extension add-in for PowerPoint

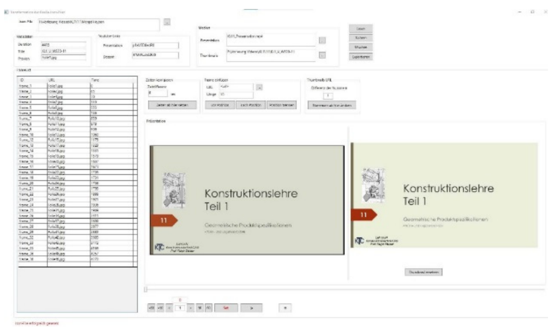

Fig. 4: Editing the navigation elements for the lecture

To do this, the presentation video is loaded and the json structure and the path of the thumbnails are specified. The transitions between the slides can now be manually fine-tuned with the displayed thumbnails. Alternatively, additional placeholders can be inserted. This is useful, for example, if further videos are to be included in the presentation (e.g. a demonstration of an external tool recorded later, such as work in a CAD system.
Finally, all generated files (two videos, thumbnails, structure file) are uploaded to the streaming server.

4. Experiences and continuation

Working with the player is quite comfortable and has proven itself.
A disadvantage is the aforementioned effect that the YouTube streaming platform sometimes displays advertisements.
We are currently working on a solution that will allow the videos to be made available on another server.

Navigating within a lecture is relatively easy with this player. It would be desirable to be able to set context-dependent jump labels in order to directly select content across lecture boundaries.
This would then enable students to directly select content from other lectures at points where reference is made. This function can be added in principle. The prerequisites for implementation are currently being investigated.

Literature

[1] Paella Player - the multistream player for lectures https://paellaplayer.upv.es/
[2] Movavi Screen Recorder https://www.movavi.de

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Production of lecture videos with green screen technology

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Abstract

Sollen Vorlesungsvideos zum Download oder als Livestream mit guter Qualität produziert werden, ist die Einrichtung eines Videostudios unumgänglich. Der Aufbau eines Studios mit einfachen Mitteln in einem umfunktionierten Seminarraum wird beschrieben. Dabei kommt Greenscreen-Technik zum Einsatz. Diese ermöglicht es, den Sprecher oder die Sprecherin vor seine digital generierten Inhalte zu stellen und ihn wie vor einer klassischen Tafel agieren zu lassen. Erfahrungen bei der Einrichtung und dem Betrieb des Studios werden dargestellt sowie eine Bilanz nach mittlerweile ca. 100 produzierten Lehrstunden gezogen.

If lecture videos are to be produced for download or as livestream with good quality, the establishment of a video studio is inevitable. The set-up of a simple studio in a converted seminar room is described. Green screen technology is used. This makes it possible to place the speaker in front of his digitally generated content and let him act as if he was in front of a classical blackboard. Experiences with the installation and operation of the studio are presented and conclusions are drawn after approximately 100 hours produced lessons.

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1. Introduction and retrospective

Within the framework of online teaching, videos for lectures, exercises and similar formats have been produced by the staff of the Chair of Dynamics and Mechanism Design since the summer semester 2020. From the very beginning, the lecturers at the chair have been using digital lecture formats, which they have been used to for years, in a video presentation. Lectures at the professorship often consist of a mix of "live" handwritten parts based on Microsoft OneNote on a tablet PC and PowerPoint slides, with handwritten additions if necessary. In the summer semester 2020, this form of presentation was implemented with the help of the video production program Open Broadcaster Software® (OBS), partly with the inclusion of a small lecturer video (Fig.1Fig. 1).

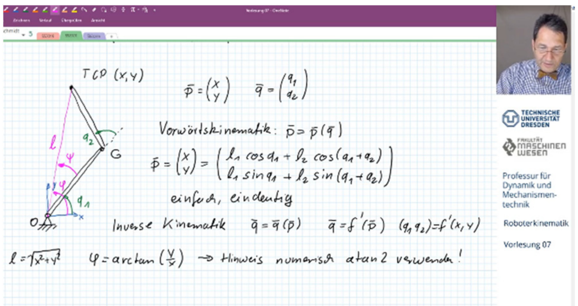

Fig. 1: Screenshot of a conventional teaching video with small lecturer image

In the summer semester 2020, the videos were generally produced by the lecturers in their home offices. Although this worked well, considering the short preparation time, from the authors' point of view it has the following disadvantages:

- The quality of private cameras, e.g. a laptop camera, is not optimal. Moreover, in the summer of 2020, it was virtually impossible to buy cameras.
- High-quality sound requires good microphones. These were also either not available or not procurable.
- It was not possible for the lecturers to have a set-up in the home environment where they could produce the videos in the better speaking posture while standing.
- When producing elaborate scenarios, e.g. with the integration of an experiment, a recording assistant was missing.

In order to eliminate the disadvantages mentioned above, we decided to set up a studio in the facilities of the professorship where the lecture videos could be produced in a more professional environment. For this purpose, a seminar room that used to be suitable for up to 30 students, was converted. There, the lecturers can either record videos that are later offered for download or produce live streams that are broadcasted via online platforms such as YouTube. Extensive use was made of both formats from the 2020 winter semester onwards.

2. Green screen technology

The authors are convinced that a lecture video gains massively in quality if the person speaking can be seen in the video. The reasons for this are as follows:

- Speech comprehension increases when the facial expressions and mouth movements of the person speaking are visible. This is particularly important with regard to non-native-speaking listeners and for English-language lectures of the professorship.
- The speaker can underline his or her remarks with gestures. It is also possible to include demonstrations and experiments.
- The commitment of a lecture increases when a speaker is visible and not just sound coming from the "off".

Modern television studios today are usually green screen studios. The studio is largely empty and equipped with a green back wall or even a green floor. With this technique it is possible to record the person speaking in the foreground, "crop" it and fade in arbitrary content in the background.

The green screen technique as a form of "chroma keying" is based on digital image processing. In this process, the video software detects the uniform green colour in the background of the main video and treats these areas as transparent. This image can now be digitally placed in front of any other static or moving video image.

This technology was also used for the videos of the Chair of Dynamics and Mechanism Design. This makes it possible for the lecturers (Fig. 4) to act in front of their content as if in front of the classic blackboard. For example, the hand can be used to point to virtual content in the background (Fig. 2).

The authors hope that this will make the videos particularly lively. This technique is used on television for weather forecasts, among other things, when meteorologists present in front of a weather map that is only virtually shown.

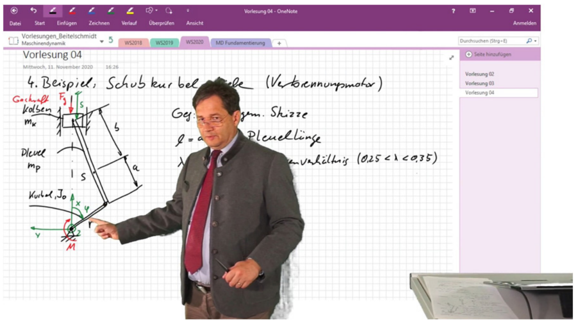

Fig. 2: Possible action of the lecturer in front of the background image. A "shadow" can be seen on the lower back area, which is caused by less than optimal illumination.

3. Arrangement in the studio

As already mentioned, a green background is required. It was decided that only the upper body of the teacher should be visible, as this is sufficient for a university course. Thus, only a hanging green curtain from ceiling to floor is required. Suitable fabrics are available from specialist video equipment distributors.

For a good result, it is necessary that the green background is illuminated as uniformly as possible. This requires several spotlights, as even the shadowing by the speaker can distort the green tone of the background in such a way that the video software no longer clearly recognises it as a "background" (Fig. 2).

For good acting in front of the camera and pointing on the virtual content, it is very important that the speaker can see itself. For this purpose, a 65-inch TV was set up directly opposite the movement zone as a control screen.

The best camera position has turned out to be a mounting at the upper center of the control screen. This is similar to the function of a teleprompter, because when the speaker looks at the control screen, he or she automatically looks at the camera.

The speaker is placed to the side behind a pen tablet on a lectern. The purpose of this is that the person presenting usually stands at the side of the image and does not cover the content on the virtual board. For pointing and interacting with the image, the lecturer can leave the lectern and step in front of the virtual image (movement area in Fig. 3).

For the sound recording, a RODE-NT-USB microphone on a stand as well as a Sennheiser EW 100 G3 clip-on radio microphone are used. Behind the screen, at an appropriate distance, is the operator desk. Here, a recording assistant can take a seat to monitor the recording process, switch between recording modes, alert the speaker to content-related and technical faults and, in the case of live streams, coordinate communication with the audience. The layout of the studio is shown schematically in Fig. 3. Unlike the symbol representation in Fig. 3, modern LED panels instead of classic headlights are used. However, the arrangement is shown correctly: A main light source directly above the control screen illuminates the person speaking. Due to the width of 30 cm of this panel, a sharp silhouette of the person is already partially softened. The two lateral spotlights illuminate only the green wall behind the speaker to further reduce the shadowing.

Fig. 4 shows the inside of the studio with a lecturer. Above the control screen, the camera and the main light source can be seen. One of the two lateral light sources (small white rectangle highlighted with the red circle) has been switched off for the photo to avoid backlighting in the picture. That is why the shadow of the person on the green wall is relatively sharply visible. On the control screen, the lecturer can see the completed composite video image.

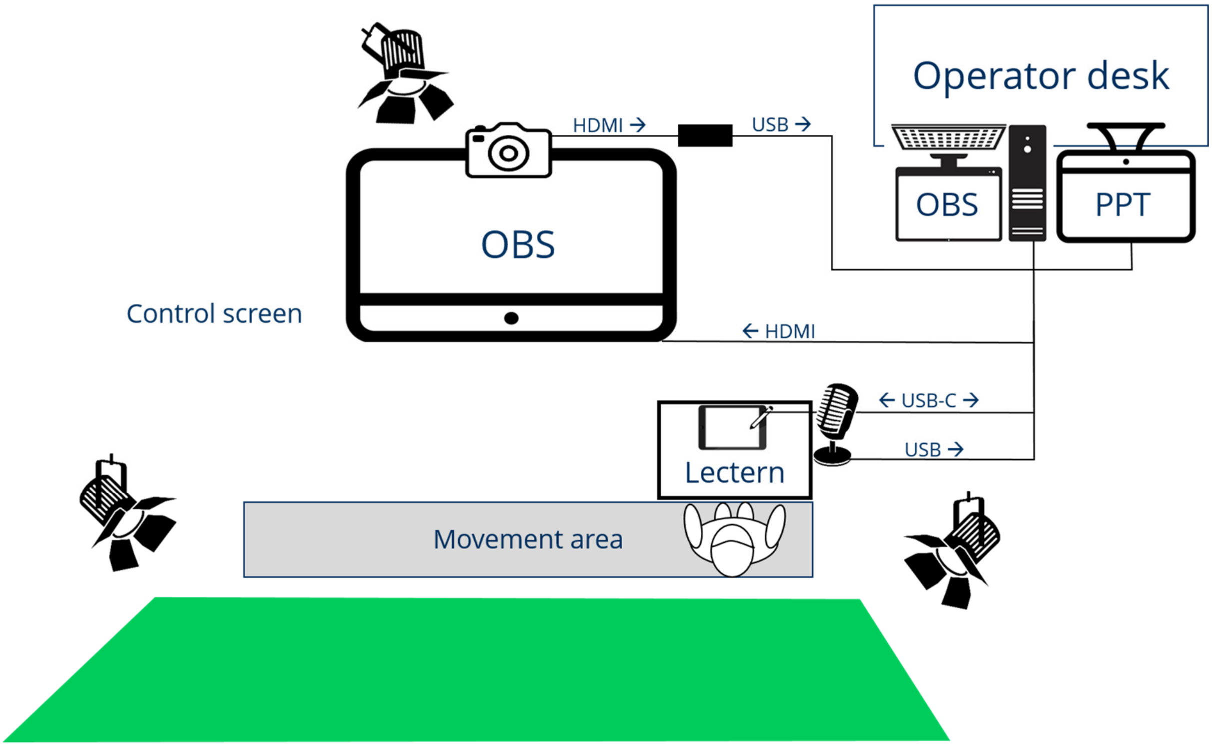

Fig. 3: Top view of the studio

Fig. 4: Picture from the studio (Photo: M. Beitelschmidt)

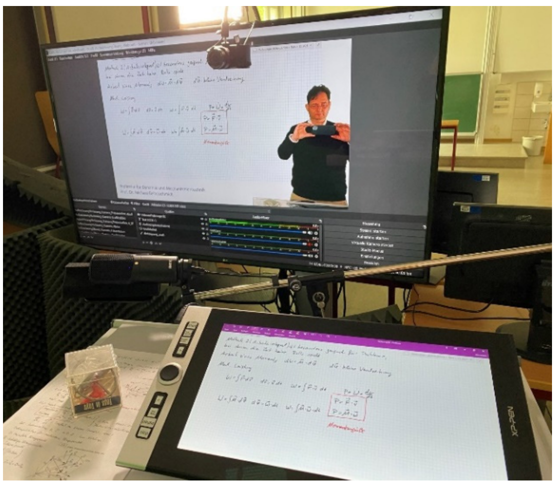

Fig. 5: Perspective of the speakers (Photo: M. Beitelschmidt)

Fig. 5 shows the perspective of the lecturers in the studio. In front of the lecturer is the tablet on the lectern, behind it is the microphone mounted on a tripod. Opposite is the control screen on which the lecturers can see themselves as if in a mirror.

4. Software and hardware

The entire recording technology is controlled by a standard PC, which is operated by the recording assistant. The microphone and camera are connected to this PC via an HDMI-USB converter. The pen-sensitive tablet (XP-Pen Innovator 16) on the lectern is connected to the PC via USB-C using an adapter (Fig. 3). The OBS software used on the computer has the green screen functionality. The PC is equipped with an Intel Xeon E6-2667 processor (3.2 GHz) and has 32 GB of RAM. However, the performance of the device is not fully utilised during video recording. Four screens are connected to the PC:

1. On one screen, the assistant can see the OBS interface.
2. The second screen is the presenters' control screen (large screen TV), onto which

the assistant screen with the OBS interface is duplicated.
3. A third screen displays PowerPoint presentations.
4. The pen tablet is another screen.

The operation of the four screens is possible with the video outputs available on the PC, one DVI output and two DisplayPorts. Screens 1 and 2 receive the same signal via DisplayPort, which is duplicated by an external splitter. Screen 3 is connected to the DVI output. The tablet as screen 4 is connected to the second DisplayPort with a special adapter.

As mentioned in the first section, two main display modes are used: In OneNote mode, the presenters see their OneNote page on the tablet and can write in it with the tablet pen. OBS picks up this screen and makes it the screen background in front of which the cropped speaker video is placed.

In PowerPoint mode, on screen 4 the presenter view is used, and on the third screen, the presentation is displayed, which is picked up by OBS. This is then again overlaid with the speaker video.

Table 1: Approximate acquisition costs of the most important hardware components

Device	***Type***	**Price**
Camera	*Sony Alpha 6000*	500€
Microphones	*RODE-NT*	150€*
	Sennheiser EW 100 G3 (with portable transmitter and receiver)	700€*
Tablet	*XP-Pen Innovator 16*	500 €
65 inch screen	*LG 65UK6400*	700€*
Lights	*Walimex Pro Nova 300 or 150*	160€
Background	*Neewer 2.6 x 3 m Greenscreen*	110€

*did not need to be procured

With the help of pre-assigned function keys on the tablet (Fig. 5, left edge of the tablet), the speaker can also switch independently between the modes and start, stop and pause the recording. For simple recordings, this can even eliminate the need for assistance. The pause function can be used by the speakers, for example, to prepare texts or illustrations in OneNote "offline" and then explain them while the video is running, which increases the liveliness.

Table 1 shows a list of the approximate costs for setting up the studio. In addition, there is the described PC, HDMI and USB cables as well as two ordinary 24" screens. Tripods for microphone and spotlight were already available at the professorship.

5. Experiences

In principle, it was quickly possible to produce good videos in the studio. A first insight concerned the camera: a normal "webcam" is not sufficient for a good cropping of the green background. Even if it delivers a high-resolution image, image noise causes problems when cropping. A Sony Alpha 6000 camera with full HD video resolution turned out to be very suitable.

No optimum has yet been found for the microphones. For speakers who mainly stand at the lectern and do little in front of the background, the stationary microphone on the stand in front of the lectern provides the better sound. If the speaker moves away from the lectern a lot, the plug-in wireless microphone is probably the better choice.

After the production of the first lecture series, it became apparent that, regardless of the choice of microphone, there was too much "reverberation" in the sound. This is certainly due to the fact that the seminar room, which was converted into a studio, essentially has six reflective wall, floor and ceiling surfaces.

Therefore, sound-absorbing material was installed in the studio (partly visible in Fig. 4 and Fig. 5). This has been and is still being done experimentally. A measurement, e.g. of the reverberation time with different arrangements of the absorption materials, has not yet been carried out. Acoustic optimisation of the studio is still in progress.

A big challenge for the lecturers is to interact with the preview image on the control screen.

This is the only way they can point to contents on the superimposed presentation (Fig. 2). For this, it is necessary to show the presenters their own mirror image on the control screen (Fig. 5). However, since all content (texts etc.) should be laterally correct, it is necessary to mirror the speaker in the video. For the viewers, a mirror-inverted image of the speaker appears in the final video. In the chosen arrangement, viewers see the presenter pointing with the "right" hand, but in fact the left must be used, which requires some practice for right-handed people. Particularly tricky are the hands used to indicate turning movements or the "right-hand-rule", as these have to be performed in the opposite direction.

The technology is used both for recording asynchronously provided videos and for producing livestreams. The OBS software offers an interface for YouTube for this purpose.

After the asynchronous content has been recorded, it is subjected to a simple post-processing with the open source software ShotCut, in which the footage can be edited and any major errors can be removed. The production can thus be described as "live on tape".

Since the studio is set up in the building of the professorship, it is easier to incorporate demonstrations and experiments from the inventory into a video than to transport corresponding material into a lecture hall (Fig. 6). This will be used more intensively in the future.

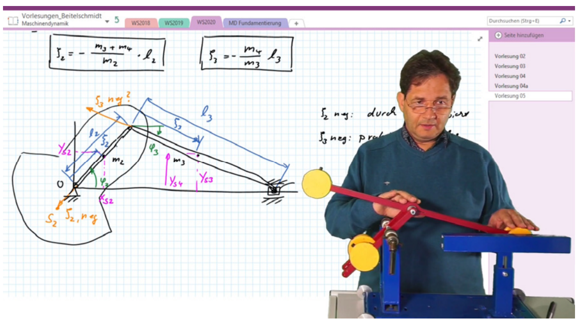

Fig. 6: Demonstration of an experiment in the lecture video

For the following courses, videos were produced in the studio during the winter semester:

1. "Maschinendynamik" (Machine dynamics)
   - 20 h Lecture
   - 10 h Central Exercise + Exercise Introductions
2. Coupled Simulation/Real-Time Simulation (held in english)
   - 14 h YouTube livestreams
3. „MKS in der Fahrzeugtechnik“ (Multibody systems in automotive engineering)
   - 10 h lecture + exercise introductions
4. Introductions to online laboratory courses

Overall, the authors and other members of staff at the Chair of Dynamics and Mechanism Design value the use of the studio technology as a great step forward, with which high-quality videos could be produced in the winter semester of 2021. The positive feedback from the students, both individual statements and the teaching evaluation, also confirm this view.

The studio will continue to be in use in the summer semester of 2021.

Acknowledgement

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Production of long-term usable academic learning/teaching videos and their incorporation into lecture series

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Abstract

Die Erstellung von Lern-/Lehrvideos zum Ersatz von Präsenzvorlesungen und Übungen ist aus Anlass der Schließung der Universitäten im Jahr 2020 vielerorts in den Fokus gerückt. Derartige Videos können jedoch auch abseits derartiger Ereignisse einen wertvollen Beitrag zur universitären Lehre leisten. Im vorliegenden Beitrag zum *Lessons Learned* Journal werden Erfahrungen zur Produktion von langfristig nutzbaren digitalen Formaten dargestellt. Dazu wird ein Überblick über die Schritte der Erstellung von Lern-/Lehrvideos und Vorlesungsvideos gegeben. Dies beinhaltet Beispiele für Hardware und Software sowie Details zu Vor- und Nachbereitungsschritten. Des Weiteren wird auf die Integration der Videos in Lehrveranstaltungen eingegangen und ein Ausblick auf die Nutzung der Produktionen im Kontext des maschinellen Lernens gegeben.

The production of teaching/learning videos as a replacement for lectures and tutorials has come into focus in 2020 due to the close-down of the universities. However, this kind of video productions can also add value to university teaching when the usual presence teaching is resumed. In the current contribution to the *Lessons Learned* Journal, we share experiences about the sustainable production of teaching videos that can be used long-term. We give insights about the production steps, the hardware and software requirements and the integration into university courses. Finally, we give an outlook of the usage of the videos as a database for machine learning applications.

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1. Introduction and purpose of the learning videos

The creation of digital formats to replace classroom lectures and exercises has come into the focus of attention in many places due to the avoidance of classroom teaching in the summer semester of 2020. However, particularly learning/teaching videos, i.e., videos in which the content of science and engineering courses is presented, can also make a valuable contribution to university teaching beyond this singular event.

Screencast videos, in which a computer screen is recorded and the depicted steps are supplemented with verbal explanations, are known in particular from software training [1]. In the academic context, however, the recording and provision of lectures in the form of image recordings was already used in times before the home computer, for example in the University of Iowa's 1955 televised lecture series "The secret of flight" (republished [2]). Especially for the explanation of mathematical relationships, there are now plenty of materials available online that can contribute significantly to the learning success of students [3], [4].

Since 2019, a framework for the efficient creation of learning videos in the engineering sciences has been created in cooperation between teachers at TU Dresden and Wilhelm-Büchner-Hochschule Darmstadt. The experience gained in the process was successfully transferred for the spontaneous switch to digital distance learning at the Institute of Solid Mechanics at TU Dresden, which was necessary in the summer semester of 2020.

In this contribution to the *Lessons Learned* publication, the experiences of efficient production of high-quality learning videos are to be shared. Special attention is given to long-term usability. In doing so, the learner-centred form "learning videos" rather than "teaching videos" is used in this paper in accordance with the constructivist understanding of teaching - in which teachers take on a more supportive and facilitating role [5], [6].

The present publication is structured as follows: After the current chapter that deals with the definition of the purpose and different types of videos, chapter 2 follows with the prerequisites and the technical basis that is necessary for the creation of learning videos. Chapter 3 presents the stages in the creation of a learning video. Chapter 4 is dedicated to the integration of learning videos in hybrid courses. Chapter 5 broadens the view towards new digital opportunities in the context of using learning videos as a database for machine learning, before summary and outlook are drawn in Chapter 6.

Types of learning videos - Before creating a video, its purpose must be clearly defined. For example, a distinction can be made between the following four types:

1. In "lecture videos", frontal lectures are transferred into the digital space. They thus serve to shift the passive consumption of knowledge units into students' independent work phases. This opens up the possibility for more interactive use of face-to-face lecture times. However, in the current situation with the widespread standstill of face-to-face teaching at universities, lecture videos must completely take over the role of lectures.
2. If the video serves to highlight a specific, narrowly defined aspect of a subject area, e.g., a short, animated video can fulfil this purpose. Topics can be, for example, in Engineering Mechanics the calculation of the centre of gravity or the definition of tension. Videos of this type can be called "crucial point videos".
3. If the video is to be used to demonstrate a laboratory set-up or a manufacturing process, the video must be recorded on site under real conditions. In the case of a video that is intended to demonstrate various production steps, these individual steps are shown in detail and include all the materials used.
4. If the intention is to record a "mathematical derivation video" in which students are to learn a task type - for example, in preparation for an examination - the video should be oriented towards what has been defined as the learning objective and will be asked in the examination (according to *constructive alignment* [7], [8]). Since

the final examinations in STEM subjects usually have a character in which mathematical tasks are solved with handwritten derivations, the written presentation of tasks of the same level offers a great advantage for students. In these derivation tasks, the specific crucial points are then brought together in a calculation chain. Also, different calculation chains can be compared and different *dos and don'ts* for the task type can be highlighted.

In the present work, we focus on learning videos according to type (4), which present a calculation chain for a task in writing, supported by the spoken word. For this purpose, 49 learning videos of this type were created for Engineering Mechanics (Statics and Strength of Materials) at the Wilhelm-Büchner-Hochschule. Since lectures in basic courses of mechanical engineering and in mathematically specialised courses in "Simulation Methods of Mechanical Engineering" often have a similar character, many of the findings can be transferred to lecture videos according to type (1). For this purpose, 48 videos were produced for the course "Mechanics of Beams and Shells" (summer semester 2020) and 20 videos in the course "Continuum Mechanics and Fluid-Structure-Interaction" (Part 1: Structure, winter semester 2020/2021) at the TU Dresden, cf. table 1.

Table 1: *Videos produced with number N, total time ΣT and average duration of videos $ØT$.*

Type	N	ΣT	ØT
Engineering Mechanics	49	525min	10.7min
Mechanics of Beams and Shells	48	517min	10.8min
Continuum Mechanics and Fluid-Structure-Interaction	20	277min	13.9min

The following chapter presents the findings on the individual steps in the production process with regard to the long-term usability of these videos.

2. Prerequisites and technical basis

For the creation of learning videos in which mathematical-technical relationships are to be derived step by step, the use of tablet computers and screen capturing is highly suitable. In the current chapter, examples of hardware and software will be shown. Subsequently, the use of visual material and the planned duration of use of the videos will be discussed. The section on "Other preparations" deals with vocal and manual preparation.

Hardware - In principle, any tablet computer or convertible with a built-in or externally connected digitizer is suitable as a technical basis. However, it is important to ensure that the screen resolution, which is also the maximum achievable resolution of the recording for screen capturing, is high enough for the purpose of the application.
If possible, an external headset should be used for the audio recording, as otherwise scratching noises from the pen or - in the case of a desktop microphone - losses in sound quality occur depending on the direction of speech. For an adequate quality of the recording, the extensive knowledge of the pod-casting scene can be used [9]. For noise-free recording, e.g., condenser microphones connected via an audio interface and USB, are a good choice.

Table 2: Hardware used in the present case.

Type	Product
Tablet/PC	MS Surface Book Gen.1
Pencil	Microsoft Surface Pen
Microphone	Beyerdynamic DT-297-PV/80 MKII
Audio interface	Focusrite Scarlett 2i2 3rd Gen
External hard disk	Western Digital WDBC3C0020BBL-WESN 2TB

In the case at hand, the technique according to Table 2 was used. The recording of handwritten derivations can also be realised with the help of a visualiser, however, the occlusion of the writing with the hand must be heeded.

Software - Many software solutions are available on the market for recording the screen (screen capturing). Commercial solutions can be chosen that allow not only the recording but also the editing of the videos. In this case,

the *Screencast-o-matic* software was used. Another variant is *Camtasia*. Alternatively, a combination of programmes for recording and editing can be used (e.g. *Open Broadcaster Software (OBS)-Studio* combined with *DaVinci Resolve*), for which a suitable workflow should then be defined. For videos based on slide sets, for example, the recording function integrated in *Microsoft PowerPoint* can be used.
Any software tool with a whiteboard function can be used to create the notes. Depending on personal inclination and practice in writing on tablets, graph lines/ruled paper can be used. However, these lines make post-processing more difficult, especially when using overlays. It is a good idea to use the same software to write the script. In the current case, Microsoft OneNote was used.
Table 2 also refers to an external hard drive, as large amounts of data can be generated in the course of a lecture series. In raw format, the aforementioned *Screencast-o-matic* software results in an average of 1-2 GB storage space requirement for an educational video, which can, however, be significantly reduced with simple compression. The data size of the videos exported in MP4 format (HD videos 1920 x 1080 pixels) is particularly relevant for transmitting and publishing. An educational video with a duration of 15-20 minutes can have a size of 60 MB. With graphic elements such as intro and outro as well as sound editing, this results in up to 250 MB. The servers for providing and archiving the files should therefore have sufficient storage capacity.

Graphics and images - The use of graphics, images, drawings and tables lighten up the video and give an additional impression of the learning content. In order to ensure the smooth use of copyrighted material outside of the academic context, one should make sure that these are under a free licence (e.g. Creative Commons https://creativecommons.org/licenses) or that a corresponding licence has been acquired for use (e.g. from archive/stock material). The easiest way is to use a self-made graphic and to indicate this clearly. When reusing and sharing the video, it is important to consider the licence or to re-license accordingly. The use includes the published environment, duration of use and the owner.

Ageing of learning videos - The question of the life span of learning videos should be discussed before production. On the one hand, the topicality of the topics covered and, on the other hand, the technical side must be taken into account. In the present case of learning videos and lectures in Engineering Mechanics, no major change in the technical content can be assumed in the foreseeable future. Thus, special attention must be paid to creating the technical prerequisites for the longevity of the material. This concerns both the image format and the resolution of the videos.
Many images are usually in a pixel-based format, such as .jpg or .png, and their enlargement is limited because they quickly look *rasterised/pixelated.* In contrast, an .svg format is vector-based and can be enlarged and reduced without loss. It is recommended to use the largest possible image size and not to enlarge it later by more than 15%-20%.
Since a screencast is naturally pixel-based, care must be taken to use the appropriate resolution. In this case, the videos were used and made available in HD format (1920 x 1080 pixels). However, it is foreseeable that development will continue and higher resolutions will become necessary. In order to plan for the long term and to be prepared for future format changes in video production, for example to the image resolution 4K (3840 x 2160 pixels), it is advisable to record at the next higher quality level (HD 4K→; 4K 8k→) as far as technically possible and to downscale to the lower resolution format in editing and rendering. If it becomes necessary, the material can be used again later and rendered at a higher resolution.
It is possible that current developments in the subsequent increase of resolution with the help of neural networks (*super-resolution* [10], [11]) will make these steps superfluous in the future.

Other preparations - In addition to expenditures for technical equipment, investments in one's own preparation are equally necessary. This concerns, on the one hand, getting used to writing on a digitizer. It is advisable to use basic writing exercises (e.g. the alphabet line by line), as *on-the-fly* practice does not lead to satisfactory results in most cases. At this point, you should also consider which stroke width is suitable for the intended use (e.g. display on a smartphone or display on a PC screen), as this has a great influence on getting used to writing on a digitizer.

The general preparations should also be extended to the way of speaking. It is possible to practise speaking slowly and clearly [12] and to optimise one's own performance with the help of self-recordings. Further details on speech and voice are given in the section "Implementation" in chapter 3. This chapter also deals with the preparation and follow-up of the recordings.

3. Stages of the creation of learning videos

In this section, the stages of production and their share in the total time required are briefly discussed. The individual steps are then explained in more detail.

The steps to create a learning video are as usual (1) preparation, (2) execution and (3) post-processing, see Figure 1. In addition, there is another step of (4) distribution/dissemination.

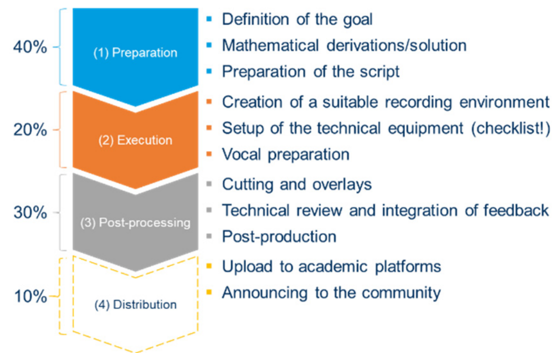

Fig. 1: Steps and corresponding percentage of the total time needed to create the video. In the present work, the proportions (40-20-30-10) resulted.

In the overall production time of a video, the percentages between the first three steps (here as an example 40%, 20% and 30%) can be shifted according to personal preference, but the fourth step of distribution is generally constant.

If, for example, a great deal of effort is invested in preparation (e.g. verbatim formulation of the script), fewer recording attempts (takes) are necessary. In most cases, this also reduces the amount of post-production work (50-20-10-10). If, on the other hand, very little effort is invested in preparation, entire mental paragraphs must occasionally be reformulated during the recording in order to achieve the same quality. The incomplete sentences or pronunciation mishaps must in turn be cut out in post-production (10-40-40-10).

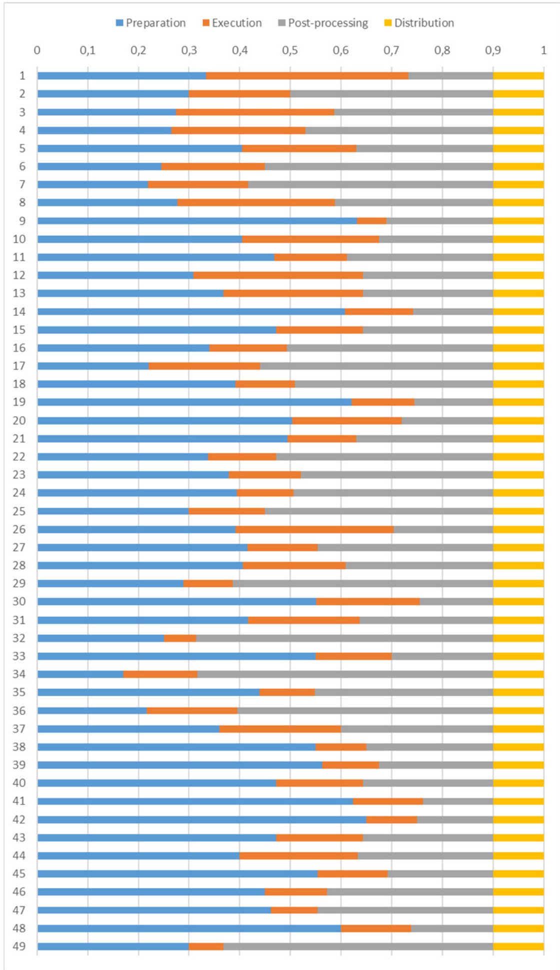

Fig. 2: Percentage of the phases (1) preparation, (2) implementation, (3) post-processing and (4) distribution in 49 produced learning videos (Engineering Mechanics).

Figure 2 shows the percentage shares of the individual stages for 49 learning videos of Engineering Mechanics. By shifting the proportions from (50-30-10-10) to (10-40-40-10), no global time saving could be realised that could not be explained by the individual improvement of each step. However, this was only true insofar as a minimal script (specific text, calculations, intro and outro) was used. A spontaneous calculation/improvisation always proved to be too error-prone.

It is advisable to keep a record of the times for the individual steps for a better understanding of one's own efficiency in production and for optimisation. From this, similar to the principle of pipeline optimisation known from software technology, it can be identified in which process step the greatest efficiency gains can be achieved with the least effort.

(1) Preparation - The first step is to define the goal of the video. For learning videos in which a single exercise/problem is to be solved, this is the task; for lecture videos it is a clearly defined section (topic). From the solution of the task or the writing down of the topic, a script can be created in which the texts and equations to be written are listed. This can be supplemented by additional instructions in bullet point form (reminders for extemporising) up to fully formulated text passages. Instructions can also include the occasional reference to slow and clear speech and consistent use of colour. It is also helpful to formulate a consistent introduction and conclusion.

(2) Execution - The actual recording begins with the creation of a suitable recording environment and a technical check. Ideal video recording conditions occur in a quiet environment, in an insulated room with little external noise (construction work, car or aircraft traffic, children's noise). Recording in the evening/night hours can help if certain noise sources are otherwise difficult to control. An increase in the quality of the recording is achieved by using partitions covered with soft, damping material and placed close to the person. A thick, sound-absorbing curtain or acoustic foam panels on the walls and ceiling elevate the room to the next professional level (recording studio).
The microphone position of the headset should be at lip level if possible and give the impression of speaking upwards. Speakers should adopt a standing posture, whether in the "on" (in the picture) or the "off" (not visible in the picture) position. This straight posture has a positive effect on good speech performance, but the effect varies from person to person.
A "bad day" can also be recognised in the voice. It is often better to postpone the recording or to take a longer break, because even with great effort not all shortcomings of badly recorded videos can be corrected: "You cannot force *a good video*". For a good voice and to avoid "smacking noises", a sip of water can be drunk occasionally.
During longer paragraphs and explanations, it is recommended to lower the voice at the end of the sentence to make it easier for the listener to listen. The interplay of clear voice, slow speech and structured language result in a pleasant learning and listening experience.
Establishing ideal recording conditions and setting up the technical equipment can be ritualised by using a checklist. A short test recording also enables to identify further environmental noises and to be able to assess one's own current condition.
(3) Post-processing - The recording should be followed by individual post-processing. It is advisable not to do this immediately after the recording, as this would not allow sufficient mental distance from the work. With the help of the script, the complete video can now be checked and - where necessary - corrected by cuts, partially new recordings and fade-ins/overlays.
The raw version of the videos should be technically reviewed (e.g. as a peer review) for quality assurance. The aim here is to provide well-founded independent feedback. In the case of the learning videos in Engineering Mechanics described above, particular attention was paid in the approval process to ensuring that

- The title fits the content,
- The calculation steps/instructions are comprehensible. A distinction must be made as to whether the calculation steps are of a subordinate category, such as solving a system of equations, or whether they are core points that belong to the learning video and must therefore not be omitted.
- The contents are correctly calculated.
- The notation/symbols from the lecture are used.
- The explanations are purposeful and complete.
- The author's pronunciation is understandable.
- A conclusion or summary may be drawn at the end.

The feedback must be inserted in a further post-processing step. The same type of feedback loop must be followed for feedback throughout the learning video lifetime.

Professional post-production - To create high-quality videos that will be useful for the longer term, a further step of professional post-production can be carried out.

The first step after reviewing the content is to create the repeating elements, such as visual intro, title, introduction of the creator and outro/credits (conclusion of the video). These can be created as templates in a graphics programme (e.g. *Adobe After Effects*) and integrated into the editing of each video. It is not absolutely necessary to use animated templates for a good video. A simpler graphic with the appropriate information can also be created at this point. An overlayed permanent logo in one corner and the inclusion of the title serves as orientation and creates a professional impression. The editing of music and sound can be done in a sound editing software that allows for cuts, fades and stereo sampling. It is advisable to use music for the intro, because it increases attention. The type of music also serves to set the mood for the content and creates the pleasant feeling that "*you know what to expect*". Once you have found a piece of music, you should check where it is registered. The associated label administers the performance rights and GEMA. Music is usually not free of charge and can, on the contrary, be very expensive, depending on the work and its popularity. If the author has been dead for more than 70 years, on the other hand, it is possible that the music is *GEMA-free.* If it is intended to show the video publicly, special attention should be paid to whether the licence allows this; the GVL (Gesellschaft zur Verwertung von Leistungsschutzrechten) is responsible for this.

Many music publishers offer a wide range of GEMA-free background music (e.g. Sonoton, Epicmusic, Audiohub, allesgemafrei.de), in other places the licence can be purchased to suit the use.

In professional post-production, small noises can also be removed, such as clearing of the throat, *ehms*, inhalations, scratching noises of the pen or clattering of the keyboard. However, it is not necessary to remove all minor oversights; "*some things are lost* in transmission", i.e. they are not consciously perceived by the listener. For example, a brief image slip, a blinking cursor or a manually corrected drawing may well remain in the video, especially if the correction in post-production takes a disproportionate amount of time.

(4) Distribution - In order to make the videos available to the user community, the appropriate channels of the university or college should be used, such as academic online platforms. The processes of uploading, linking, tagging and, if necessary, announcing the videos can be simplified and professionalised by using checklists, just like the other steps.

Now that some aspects in the steps of the recording have been dealt with, the following chapter will focus on the integration of the recordings in courses.

4. Integration in hybrid courses

The videos created according to the rules of art described above are to be used sustainably as part of academic courses.

Lecture videos - A complete replacement of the classroom lecture by online lectures or lecture videos is not recommended - mainly due to the lack of interaction between teachers and students. Mullamphy et al [13] describe a high level of acceptance as a means of supplementing teaching as the result of a survey of students on the use of screencasts. However, it was found that excessive use did not meet their expectations of a face-to-face university. This could also be seen in feedback from students at the TU Dresden.

Nevertheless, lecture videos can make an important contribution to the transition from lecturer-centred teaching to learner-centred teaching. Lectures, which are often very one-sided due to the large amount of material to be taught, can be transferred to the students' own preparation in this way. The time in which personal interaction between students and teachers is possible (e.g. lectures and exercises) can instead be used for interactive formats such as discussions or joint project work. However, particular care must be taken to ensure that an appropriate overall effort for the course (according to the credit points in the study regulations) is maintained.

A key point for the long-lasting use of high-quality produced lecture videos is updating. In order to be able to use the videos or parts of them again in the following semester, videos should be reviewed at the beginning of each semester and updated if necessary. If only minor changes or updates are necessary, the video from the previous semester can be adopted or used as a basis. However, the effort required varies depending on the method chosen: If a set of slides was used, as described in chapter 1, only the affected slides or the associated text need to be modified. In the case of handwritten lecture and learning videos, in the event of major errors, the corresponding sequences - regardless of whether there are changes on the transcript or in the text (sound) - must be completely recreated in each case. However, small changes can also be inserted in the editing software as an overlay. In any case, it should be made clear within the video that updates are available, as it is difficult to exclude the parallel use of different video versions.

Another important point is the possibility, occasionally requested by students, to print out the contents of a video. A set of slides or a manuscript offers students the opportunity to add their own points, which is a great advantage in terms of follow-up and preparation for the exam. A conscientiously prepared recording script can provide a useful basis for this.

Overall, it has been shown that the development of equations or the step-by-step explanation of calculation steps is absolutely necessary in the lectures of Engineering Mechanics.

Learning videos - For videos in which sample exercises are calculated, they can be used as a bridge between lectures and exercises. In this way, the introduction to exercises can also be shifted to the preparation of the students in favour of interaction during the attendance time.

5. Instructional videos as a data source

The widespread shift to digital formats opens up an exciting new field of application from the perspective of *data science* [1], [14]. For example, various machine learning methods from different application areas (OCR, speech-to-text, natural language processing) can be combined to make entire lecture video series searchable [14]. If this technology is applied to the entirety of the lecture and learning videos of a university degree programme, a wide range of possible applications arise, ranging from the harmonisation of the characters/symbols/abbreviations used within a field of study to the automated design of examination tasks (based on keywords from Bloom's Taxonomy [15]).

On the other hand, the self-produced videos can form a database for machine learning for lecturers themselves. This opens up the possibility, for example, of training a "*deep fake*" model of one's own voice and thus making it easier, for example, to add additions to videos [16]. However, the authors of videos must be aware that this data set is also available to others (*bad actors*) when it is published [17].

6. Summary and outlook

The current paper provides an insight into the production of lecture and learning videos that are intended to be usable in the longer term. The prerequisites and specific steps for the production of high-quality videos are discussed. Furthermore, aspects of the integration of video recordings in lecture series are presented and a brief outlook on the use of videos as a database for machine learning is given.

While some of the details mentioned here are not helpful for the current shift from face-to-face to distance learning, addressing them can contribute to a better understanding of the complexity of the process and help professionalise video production by teachers in universities and colleges.

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Experimental case for experimental practicals@home

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Abstract

Experimentalpraktika sind ein wesentlicher Baustein im Studium der Ingenieurwissenschaft. Auch wenn virtuelles Lernen (u.a. Virtual-Reality-Experimente) eine gute Unterstützung für die Studierenden darstellt, spielen reell durchgeführte Experimentalpraktika insbesondere im ingenieurwissenschaftlichen Studium eine unverzichtbare, wichtige Rolle. Die experimentellen Versuche verbinden die Theorie und Praxis und motivieren die Lernenden zum Problemlösen.

Dieser Beitrag beschreibt am Beispiel des Projektes „Ingenieurkoffer für Experimentalpraktika@home“, wie Studierende trotz der besonderen Situation infolge der Coronavirus-Pandemie experimentelle Versuche auf dem Fachgebiet Dynamik eigenverantwortlich durchführen können, sowie die ersten Erfahrungen. Die Vor- und Nachteile der Nutzung des mobilen Ingenieurkoffers werden diskutiert und Ansätze zum effektiven Nutzen vorgestellt.

Experimental practical courses or practicals are an essential building block in the study of engineering. Even though virtual learning (including virtual reality experiments) has benefits for students, real experiments play an indispensable and important role, especially in engineering studies. The experimental trials connect theory and practice, and motivate learners to solve problems.

Using the example of the project "Ingenieurkoffer für Experimentalpraktika@home" (engineering case for experimental practicals@home), this paper describes how students can conduct experimental trials in the field of dynamics on their own, despite the special circumstances resulting from the coronavirus pandemic, as well as the initial experiences. The advantages and disadvantages of using the mobile engineering suitcase are discussed and approaches on how to effectively use them are presented.

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1. Introduction

Experimental practical courses are an essential building block in the study of engineering. Their importance is reflected for example in the following aspects: linking theory and practice, increasing motivation to learn, increasing willingness to solve problems, willingness to work in groups, validating calculations, and promoting the ability to innovate. Through experimental practicals, previously learned theoretical knowledge is tested for its correctness through practical examples, and the content is illustrated more vividly and memorably for students. This makes it easier for students to acquire subject-specific and interdisciplinary skills. Even if virtual learning (e.g., virtual reality experiments) has benefits for students, real experimental practical courses play an indispensable and important role, especially in engineering studies.

The subject area of dynamics (e.g., vibrations, acoustics) is perceived by students as interesting, but difficult at the same time. This is often due to the lack of the so-called "dynamic feeling" about vibration and acoustics. This feeling must first be formed and developed through cognitive learning. In order to make the basics of vibrations better and more vivid for students, the Chair of Dynamics and Mechanism Technology has procured seven "Engineering Suitcases for Sound and Vibration Analysis". In the following article, a brief overview of the possible applications of the suitcase will be given, as well as initial experiences with the Experimentalpraktika@home and approaches on how to effectively use them will be presented.

2. Concept of the engineering case

The experimental cases enable simple vibration and acoustic measurements to be carried out. These can be done on machines, vehicles or structures. With a useful frequency range of the data recorder of up to 20 kHz, the complete vibration and acoustic frequency range is covered. In particular, it is intended to give students the opportunity to learn how to use professional measurement technology by carrying out measurements themselves, to validate a finite element method (FEM) calculation and to gain a better understanding of the material and calculation models. This gives students the opportunity to deepen and expand their technical and experimental skills.

Fig.1: Engineering case

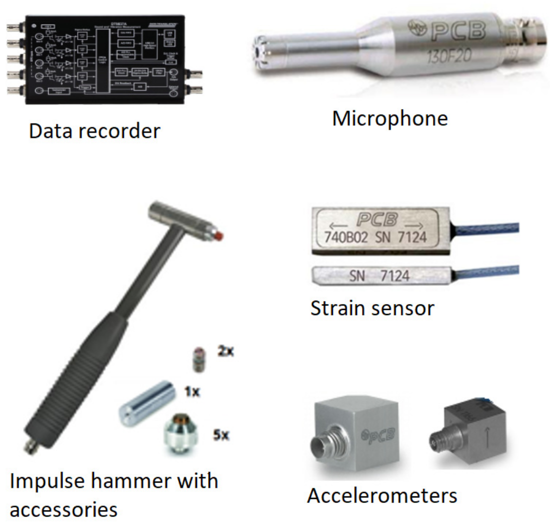


Fig.2: Components in the engineering case

The central component of the case is a 4-channel data recorder that can also generate signals. To be able to measure mechanical vibrations, two uniaxial and one triaxial piezoelectric accelerometers are provided. Strains, which can also serve as measurement variables for mechanical vibrations, can be measured with the enclosed strain sensors. Finally, two microphones enable the measurement of airborne sound, which often occurs alongside mechanical structural vibrations. All sensors (incl. microphones) are piezoelectric sensors with built-in electronics, so-called IEPE (Integrated Electronics Piezo Electric) or ICP (Integrated Circuit Piezoelectric) sensors. Thanks to the integrated signal conversion, such sensors are easier to handle and less sensitive to electrical interference.

An impulse hammer with an integrated force sensor can be used for controlled excitation of vibrations.

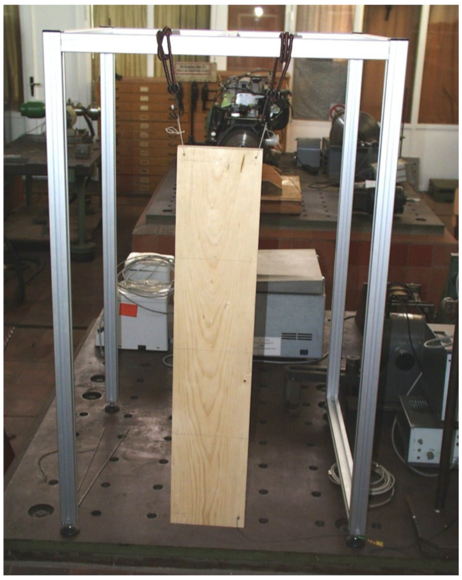
The PC-based data recorder is connected to a computer via USB. Additional signal conditioning is not required for the use of common sensor technology. With the associated software, the unit can be used to record and display measured values, as well as save them to the computer's hard drive. In the frequency analysis mode of the software, analyses such as spectrum, auto spectrum, power spectral density, window weighting and digital filtering can be performed. In the extended mode, spectral analyses can be carried out over two signals, such as the determination of transfer functions, cross spectra as well as coherence functions. The unit can also be used under all common measurement technology applications such as LabVIEW, Matlab, Dasylab or Visual Studio. In particular, the programmability with MATLAB as well as common programming languages such as .NET and Python allow students to combine measurement and analysis tasks and to deepen and expand their knowledge of hardware, measurement process and data processing. Finally, it creates the opportunity for the user to develop new applications and thus promote innovation.

Since several data recording devices can be coupled together, more complex measurements can also be carried out by combining the content of more than one experimental case.

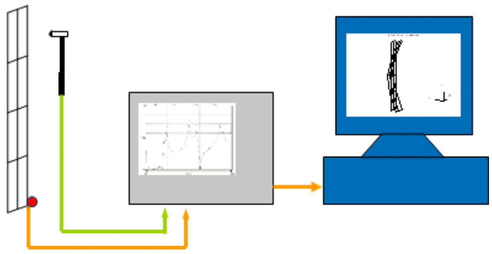
3. Application in teaching

In the summer semester 2020, the students were able to borrow the experimental cases for the first time in the course "Experimental Modal Analysis" and experiment with them at home. First, the theoretical knowledge of vibration analysis and modal analysis was taught by online lectures. The students were able to understand the learning material and internalize the theory through exercises and discussions in question-and-answer sessions. However, the experimental practical course that normally accompanies lectures could not take place on site because of the ban on face-to-face lectures. This was compensated by handing out the cases to the students.

From the end of May, limited face-to-face teaching was possible again. In the first classroom session, a demonstration experiment was conducted on the vibration analysis of a coated wooden panel (Fig. 3).



a) Measurement object



b) Measuring chain

Fig. 3: Measurement setup for modal analysis of a wooden panel a) Measurement object b) Principle measurement setup

The students thus got to know the practical procedure. They were allowed to work with the measuring equipment such as different measuring sensors, excitation devices (e.g., modal hammer of different sizes 5 g - 10 kg, vibration exciters of different types), touch the measured object and feel the vibrations up close. This facilitates the understanding of the theoretical basics as well as the development of a "dynamic feeling".

With experimental modal analysis the so-called modal parameters, such as natural frequencies, natural damping, and natural modes of vibration of a structure can be obtained through testing. The main objectives of experimental modal analysis are, for example:

- Detecting and avoiding mechanically or acoustically disturbing resonances
- Comparison of the results with the calculated vibration behavior from numerical simulations, such as the finite element method (FEM), in order to check the assumptions about geometry, material parameters, calculation model, etc. necessary in the calculation and, if necessary, to correct them until satisfactory agreement with the experimental results is achieved.
- Derive constructive measures to change natural frequencies if excitation frequencies cannot be influenced.

In the second classroom session, a somewhat more complicated measurement object was analyzed. The possible resonance frequencies of a block foundation (Fig. 4) as well as their natural vibration modes are to be determined. This task has great practical significance, as foundation vibrations have a great influence on the precision and service life of machines as well as the well-being of an operator. More complicated measurement objects (car body and tram structure) were not used this semester, as it was impossible to carry out an experiment due to the applicable distance and hygiene regulations.

Fig.4: Determination of the natural frequency of the block foundation.

After the two introductory experiments, the briefing on the engineering case took place once again in summary. This included the explanation of the calibration documents, the set-up of the measurement chain, the software installation, the setting/operation of the measurement software up to the complete measurement. Six students were each handed out an engineering case.

With the engineering case manual written especially for our students, they were provided with even more extensive learning material for reference and self-study. The manual begins with an introduction to measurement technology, especially measurement technology in engineering, as well as practical tips on measurement technology. After the detailed description of the contents of the case, the possible uses of the hardware and software are presented. Particularly helpful for students are the detailed step-by-step instructions for various usage scenarios, such as recording the time course of vibration quantities, using measurement triggers, ad-hoc frequency analysis, determining the transfer or coherence function, controlling the excitation signals as well as evaluating and interpreting the measurement results, etc.

With the mobile engineering case and the basic theoretical knowledge, the students are to be enabled to independently conceptualize, prepare, and carry out a self-selected experiment in the field of acoustics and vibration engineering. The aim is to promote experimental skills such as the conception, planning and recording of series of measurements, plausibility checks and evaluation of experimental data within the framework of the task processing. At the same time, subject-related knowledge is deepened through measurements, processing of measured values and interpretation of results.

The students had 2-3 weeks for their experiment, after which an investigation report was to be submitted.

4. Supervision concept

The home internship requires a high degree of self-organization and self-discipline on the students' part. But it does not mean that the students are completely on their own for the home practical. A wide range of support is available to the students for the conception, preparation, and implementation of individual experiments. Specially adapted learning materials are provided. In addition, digitalization makes a multimedia supervision concept possible, which consists, among other things, of the elements of forums, chats, learning videos, video conferencing, etc. Outside the classroom, students can get in touch with the lecturer or supervisor to discuss the learning materials, gaps in knowledge, technical questions or problems that arise. Communication usually takes place via OPAL forums, chats, e-mail or even by telephone. Depending on the urgency of the problem, questions are answered via e-mail, forums or video conferences are organized. Through (asynchronous) discussions and/or video conferences, questions and problems are identified, solutions are shown, and the work processes are reflected upon.

The supervisor kept one case in order to be able to follow up on any technical problems the students might have and to help with online support step by step.

5. Results

One among six students admitted that he had not done anything with the case. He justified it by saying that he did not want to take time for it this semester because he had learned that, according to the examination regulations, he could not obtain credit points through this subject.

Three students stated that they had examined corresponding test objects with the measurement technology, but they did not want to prepare a test protocol due to time constraints. They reported orally on their test object and their experiences at an attendance meeting. The protocols finally submitted by the remaining two students were of high quality. Both students had chosen a small table as their test object.

In the experimental protocols, the experimental concept and the experimental set-up were documented in detail, the measurement results obtained were interpreted and an error analysis was carried out. In addition, the students voluntarily compared their measurement results with FEM simulations to verify and validate the simulation model (Fig. 5).

The comparison of the experimentally determined modal parameters with the calculations shows that the calculation does not quite match the measurement result. Therefore, a search for the cause and discussion of various questions regarding the calculation and the experiment was carried out, e.g.

- Are the results plausible? The plausibility check is a basic tool with which calculation or measurement errors or interpretation problems can be detected.
- Is the FEM model, the material parameters and geometry, correct? Were the special properties of the wood material (plastic, lightweight material, ...) sufficiently considered in the modelling? Are my FEM calculations therefore trustworthy?
- Are the boundary conditions, e.g., storage of the test object, suitable?
- Are the excitation forces in the vibration test sufficient and suitable?

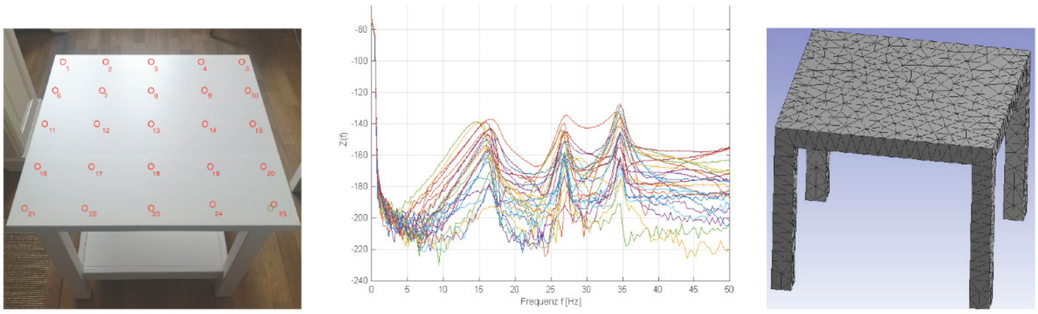


Fig. 5: (left) measured object and measuring points, (centre) measured frequency responses, (right) CAD/FEM model (evidence from student L. Hollas and V. Scholz)

- Are the components of the measurement system (transducer, shaker, modal hammer, data acquisition device, amplifier, cables, etc.) matched to each other for the experiment?
- Is the experimental setup and the measurement chain, correct?
- Are the measurement data evaluated correctly?

In a feedback discussion, the students stated that they had expanded their competence about scientific thinking and empirical work through the experimental internship.

6. Advantages and disadvantages

The shift of university teaching from the lecture hall to the digital space due to the Corona pandemic, as well as the strict hygiene rules, mean that the internships cannot be carried out in the classical form. Even though the home internship arose out of necessity, many advantages seemed to speak in favor of such practicals@home:

- Flexibility in terms of time and space, as the acquisition of knowledge is not bound to fixed dates but is possible at any time. This makes it possible to learn according to one's own rhythm without having to coordinate with lecturers or other participants.
- Free choice of learning speed and intensity: Students can decide which and how much information they want to absorb at a time, i.e., how quickly and intensively they want to learn - for example, whether they want to repeat a particular experiment in full or only in part.
- Retrieve additional information according to individual needs and demands without having to absorb information that is not of interest to them.
- Digitalization enables good communication with supervisors and group work between fellow students.

Another significant advantage of the home practicals is that the measurement objects are usually authentic and close to reality, (such as a small table here). Other possible measurement objects would be, for example, the vibration behavior of one's own car or the floor load caused by a spinning washing machine. The motivation for the practical courses increased. The students are given freedom to realize their own creative ideas. From the reported results, it can be seen that most students were very motivated for the home practical, although the quality of the submitted protocols has no direct influence on the grade.

Nevertheless, our pilot test shows a sobering result, at least partly. The opportunity offered does not necessarily lead to better learning competence and more knowledge. Conducting experimental trials without direct assistance from lecturers may promote students' independence, but can be demotivating for others because of the lack of opportunity for immediate queries. Misinterpretations and errors are rarely detected and in the worst case prevent learning success. In addition, uncertainties and irritations are not absorbed and can therefore lead to frustration in the long run. Creative problem-solving dynamics, which often arise in face-to-face events, also do not come about in this way.

Another very general problem is: Not all students are willing to take their learning into their own hands. Learning at home requires a high degree of self-discipline, which not everyone is able to muster [2].

Of course, the problems mentioned here do not mean that the advantages presented earlier are not valid. It is clear to us that the home internship needs to be complemented: It must be coupled with face-to-face teaching or at least video conferencing. The combination of home practicals and various video conferences/presence teaching can also compensate for the didactic problems typical of self-learning. Even after the pandemic, the home practicals can be a useful and promising additional offer, but not a substitute for the on-site practicals.

Another problem for home practicals is the increased wear and tear on the measurement technology, which is associated with increased operating costs and the need to purchase replacements. Both the measurement technology such as sensors and the accessories such as various cables and adapters are sensitive to improper mechanical stress. The first small damages have already been detected. The reasons for this can be many and varied. On the one hand, the individual components in the engineering case are not built robustly and hard-wearingly, on the other hand, the students still lack the experience to handle sensitive measurement technology despite detailed instruction. Gaining this experience, however, is precisely one of the learning objectives of an experimental practical.

7. Conclusion

The first pilot for home internships has provided important insights for future implementation. Home internships can offer motivated students a great opportunity to apply their acquired knowledge and implement it across subjects. In addition, home internships strengthen their independence and action orientation. Students' self-discipline, learning organization, time management and, finally, motivation influence the outcome of home placements, with motivation being the most important factor for success. It is crucial to find ways to increase motivation.

Various didactic methods were used to increase motivation, for example, within the framework of the course, students were given the opportunity to complete their tasks under their own steam and thus to perceive their own actions as effective and efficient (experience of competence). They were given the freedom to decide for themselves which test object they would like to examine, to what extent they would also deal with the topic in an interdisciplinary way, and to design their experiments in such a way that an optimum is achieved in terms of task completion (autonomy), and the feeling that they have something very practical and important to do (meaningfulness) [1]. This requires structured planning of the course, the task, and the learning objectives. The lecture and the theoretical exercises must be coordinated with the assignment in such a way that the tasks for home practicals are challenging and at the same time manageable. The necessary preparation, or any problems that may arise during the execution of the experiment, should be discussed in advance in an attendance round, so that the students are not overwhelmed during home practicals and enjoy the tasks on their own initiative. In addition, they should know exactly which contents are important, which learning objectives are to be achieved in each practical (transparency). Prompt (online) support should be guaranteed for technical and methodological questions.

The additional activation of extrinsic motivation, i.e., motivation based on incentive from outside, is also useful, as not all students have the intrinsic motivation for their work. This is true because the decision for the subject is often stimulated to a certain extent by extrinsic factors, since the course "Experimental Modal Analysis" has a very high practical relevance and is an essential mainstay compared to computational simulation. A possible incentive would be to anchor additional bonus points for the practical courses in the module assessment. The bonus scheme offers students an incentive for continuous learning during the semester and thus promotes better learning. For example, students can earn an 'extra' for the upcoming exam through graded homework or experiments. However, this must be provided for accordingly in the examination regulations.

8. Outlook

The first impressions formed make it clear that Experimental Practicals@home bring a special added value for the acquisition of competences. In the future, the engineering cases will be used in addition to the subject "Experimental Modal Analysis" in other courses such as measurement processing and diagnostics and vibration theory.

With the commencement of the new study and examination regulations, students of the specialization "Simulation Methods of Mechanical Engineering" and "General and Constructive Mechanical Engineering" will also attend the above-mentioned courses from the summer semester 2021, thus increasing the need for engineering cases. The Chair of Dynamics and Mechanism Technology is endeavoring to purchase additional cases and software, as well as to provide funds for corresponding operating costs.

Acknowledgements

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Practical courses without presence - is that possible?

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Abstract

Praktika stellen eine zentrale Komponente der ingenieurwissenschaftlichen Ausbildung dar. Im Rahmen von Präsenz-Veranstaltungen werden derartige Praktika in Vorlesungen mit großen Hörerzahlen in der Regel in dicht besetzten Praktikumsräumen mit Gruppen von deutlich über 10 Studierenden durchgeführt, um überhaupt die Verteilung der Praktikumsversuche über das Semester gewährleisten zu können. Unter Pandemie-Bedingungen waren diese Präsenzpraktika nicht mehr durchführbar, wodurch entweder die Möglichkeit bestand, (i) die Praktika ausfallen zu lassen, (ii) sie als Computer- oder Vorführversuche im Videostream zu gestalten oder (iii) neue Konzepte zu suchen, mit denen reales Experimentieren zu Hause möglich werden kann. Da der Ausfall zu signifikanten Störungen des Studienablaufs geführt hätte und reine Computerversuche einer experimentellen Ausbildung geschadet hätten, wurde am Lehrstuhl f. Magnetofluiddynamik, Mess- und Automatisierungstechnik der TU Dresden eine Praktikum@home–Struktur entwickelt, die sowohl die erforderlichen Lehrinhalte transportiert als auch experimentelles Arbeiten ermöglicht. Die entwickelten Konzepte und die damit gemachten Erfahrungen sind Gegenstand dieses Beitrags.

Practical courses are a central component of engineering education. In the context of face-to-face courses, such practicals in lectures with large numbers of students are usually carried out in densely occupied practical rooms with groups of well over 10 students, in order to be able to guarantee the distribution of the practicals over the semester at all. Under pandemic conditions, these face-to-face practicals were no longer feasible, which meant that there was either the possibility of (i) cancelling the practicals, (ii) designing them as computer or demonstration experiments in a video stream, or (iii) looking for new concepts with which real experimentation at home could become possible. Since the failure would have led to significant disruptions in the course of studies and pure computer experiments would have been detrimental to experimental training, a Praktikum@home structure was developed at the Chair of Magnetofluiddynamics, Measuring and Automation Technology at the TU Dresden, which both transports the required teaching content and enables experimental work. The concepts developed and the experiences made with them are the subject of this article.

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1. Practical courses in the context of the overall teaching concept

Practical courses are a central component of the education, especially in engineering studies, but also in many natural science courses. By working on real existing plants, they create a link between the often very theoretical lecture content and the real working and living conditions. At the same time, the number of practical courses offered in engineering degree programmes is constantly decreasing, especially in the basic subjects with large numbers of students, due to the immense demands on personnel, time and space.

When considering practical courses - especially considering the Corona pandemic situation, which has massively impaired teaching activities at universities since the summer semester 2020 - a fundamental distinction must be made between practical courses within the framework of special lectures and those within the framework of basic lectures. Practical courses for special lectures with low numbers of up to 50 students can also be carried out in presence, even with contact restrictions with increased personnel and time expenditure.

In contrast, this possibility is actually excluded from the outset in the case of practical courses for basic lectures with several hundred listeners. Nevertheless, in these subjects in particular, the practicals are an essential component that, in addition to subject knowledge, must also provide enthusiasm for the subject in question and thus the motivation to deal intensively with the content. Under the conditions of the pandemic and lockdown, the motivation aspect was already a very important aspect in the summer semester of 2020, and its significance continues to grow with the increasing duration of the restrictions in academic teaching.

In all considerations regarding the implementation of practical courses in the pandemic situation, it also always had to be taken into account that it is not possible to cancel practical courses that are anchored in the curriculum and that postponing them to later semesters would lead to extreme additional burdens on the students.

2. The course

The course, Measuring and Automation Technology (MAT) is a two-semester module starting in the winter semester. It consists of 2 SWS lecture, 1 SWS exercise and 1 SWS practical course.

The course was held in the summer term 2020 with 450 participants. From the winter semester 2020/21 onwards, there will be approx. 600 students per semester due to a change in the study and examination regulations.

Under the conditions of the Corona pandemic, the lecture was made available as a YouTube livestream [1], as other streaming structures did not have the necessary stability for the large number of listeners, and at the same time only a live event allows interaction, albeit limited, between students and lecturers. In addition, livestreaming on YouTube offers the advantage that an asynchronous form of the course is available directly after the event, which was indispensable under the conditions of the lockdown. In addition, the recordings on YouTube can be implemented comparatively well in terms of data protection law, as no conclusions can be drawn about the students present due to the fading out of the live chat, via which interaction with the students takes place during the lecture.

Matrix rooms and in individual cases ZOOM meetings were used for the exercises.

The biggest problem for the implementation of the course is obviously the practicals. In terms of the concept, the course is designed in such a way that three experiments are carried out in attendance per semester.

In the summer semester 2020, the advantage was that the students had already participated in the first group of events on measuring and automation technology in the winter semester and were therefore familiar with the teaching concept and the people involved. This advantage ceased to exist with the winter term 2020/21, because a new cohort started the module here.

The semester ends with a written examination, which has been conducted in digital form via the BPS OpalExam online examination tool since the summer term 2020. Experiences with the creation and implementation of the online exams are reported elsewhere [2].

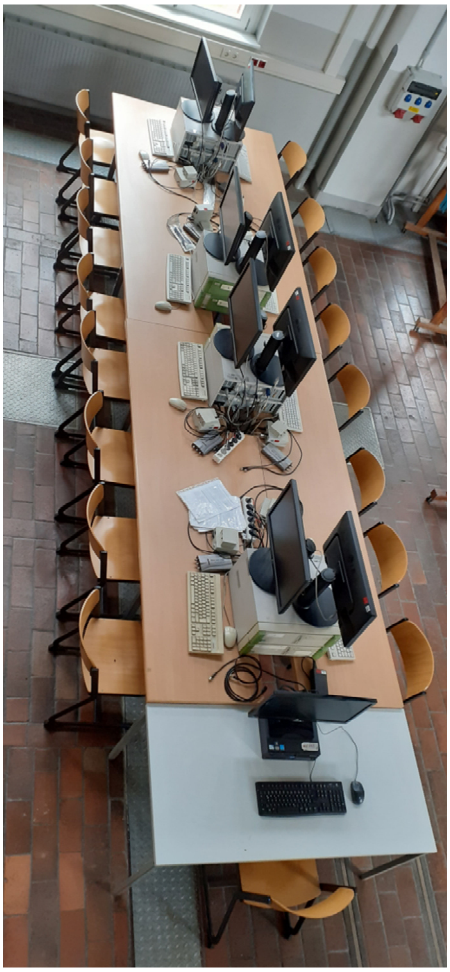

Fig. 1: Typical arrangement for a classroom practical (here measurement dynamics) for 16 participants and one supervisor.

In normal attendance semesters, the practical experiments are implemented in groups of 16 students, who carry out the practical in groups of two at eight experimental stations with a supervisor. The practical experiments are accommodated in areas of the order of 25 m² for the corresponding 16 participants and the associated supervisor (see Fig. 1). If one takes the spacing rules into account that the university management has set since the summer semester 2020, at least up to and including the summer semester 2021, this means that practicals could be carried out with three, at most four participants, depending on the spatial arrangement. With a total number of around 110 practical course units that have to be carried out per semester for 600 students in a year group, this represents an enormous additional burden in terms of personnel and spatial resources. This results in up to five times the amount of supervision required.

This meant that a comprehensive redesign of the practical course operation had to be carried out as early as the 2020 summer semester, which then had to be significantly expanded - with a view to the completely digital 2020/2021 academic year.

With a view to a later comparison between face-to-face practicals and practicals with a high proportion of digital components, it is also worth pointing out at this point the quite well-known problems in face-to-face practicals. First and foremost, this includes the fact that only a very limited amount of classroom time is available. In this short time, the students have to familiarise themselves with the practical, carry out the individual experiments and evaluate them. Since the preparation is usually done via written practical course instructions, this leads to the fact that the effective learning success of such practical courses hardly justifies the technical and personnel effort that is associated with the preparation and implementation of the practical courses. Only those students who have prepared for the practical course with a correspondingly high level of effort will gain a real benefit in terms of content from carrying out the practical course. This has been a problem within the framework of the implementation of the practical courses for many years, which we have dealt with, but for which we have not been able to find a solution, because the motivation of the students to study on their own is often very low.

3. Initial situation in the summer semester 2020

Due to the Corona crisis and the lockdown associated with it, it was not clear for a long time in spring 2020 whether and to what extent face-to-face teaching would be possible. For the practical course in MAT, this meant that as time went on, the time window available for carrying out the practical experiments became smaller and smaller, so that even before the decisions of the university management on the implementation of face-to-face teaching, it was clear that even with normal full occupancy of the practical course rooms, it would no longer be possible for all students to carry out the experiments purely in terms of time.

Since MAT is a two-semester module starting in the winter semester, the students who were registered for the course in the summer semester had already carried out three experiments in presence in the winter semester. This automatically reduced the selection of experiments that could be used for a digital practical and adapted to the material of the course.

As a rule, i.e. in semesters with classroom teaching, three practicals are scheduled for the summer term:

One experiment on **measurement dynamics**, one on the **control loop** and a third on the **programmable logic controller (PLC).**

The experiment **Measurement Dynamics** deals with the influence of signals by transmission elements with time delay as well as with the conversion of analogue signals in digital measurement systems. Questions of the true-to-shape reproduction of signals are to be experienced in practice as well as the effect of the sampling theorem on digitally recorded signals. The experiment for the classroom teaching consists of a function generator, electronics that represents the time-dependent behaviour of the transmission element, and an oscilloscope card in a computer that records the input and output signal and makes it available for evaluation via corresponding software.

The experiment **Control loop** consists of an elevated tank that is filled with water via a submersible pump. The pump is to be controlled via an external electronic controller in such a way that the water level, which is determined via a pressure sensor at the bottom of the elevated tank, can be maintained at a given setpoint. The task is to characterise the controller and the track and to practically implement the control task as such.

The **PLC experiment** is by far one of the most popular experiments in the MAT practical course, as a large railway system equipped with many points, reed switches to determine the position of the train and controllable transformers to set the speed has to be programmed for certain driving tasks with the help of a Siemens PLC. For this purpose, the students create the programmes for the PLC on available computers, which are then uploaded to the PLC during the evaluation of the experiment with the supervisor of the practical course, whereupon the movement of the train on the layout can be observed, which makes possible errors directly visible.

4. The situation for the winter semester 2020/21

In the winter term 2020/21, it was again not possible to conduct classroom practicals, as the number of students had risen to 600 in the winter term and the spatial restrictions, together with the spacing rules, the available practical time and the available staff, made it impossible to conduct classroom practicals.

Since a fundamental reorganisation of the lecture was necessary anyway due to the shortening of the semester by two weeks, this reorganisation was realised specifically with a view to the practical course. Two experiments that had been made available as home practicals in the summer term were taken over into the winter term. The home experiment on digital image processing and the computer experiment on measurement dynamics could be integrated well into the course of the lecture in terms of content and topic, and by structuring the lecture accordingly, it was possible to ensure that, in contrast to the usual classroom practicals, the necessary lecture material had been taught before the practicals were carried out.

The third experiment in the programme is a new home experiment for **planning experiments and calculating errors.** This involves the fundamentally simple problem of determining the acceleration due to gravity from the period of oscillation of a pendulum, which is already familiar from the physics practical course at the beginning of the degree course. In principle, this is a simple experiment in terms of the theory behind it, but the tricky part lies in the details when it comes to setting it up and carrying it out.

5. Implementation possibilities within the framework of digital semesters

Two basic preconditions were set for the implementation of the experiments as a presence-free practical course: On the one hand, a purely digital practical course was not to be created under any circumstances, as experimentation is and must be a significant component of practical training. The second precondition was aimed from the outset at combating the expected loss of motivation among students in an online semester and with massively reduced contact opportunities. In a nutshell, this meant that the practical course had to be fun!

The lab course **measurement dynamics** can obviously be implemented digitally without any serious compromises. For this purpose, a programme had to be developed that allows a time-dependent input signal to be generated, modified via the known response functions of time-dependent transmission elements and output in a graph (Fig.2). The programme was developed using Python and the students were provided with an executable file depending on the operating system, which generates a "laboratory number" when started, which means that all students have different parameters set in the software, which means that the results cannot simply be taken over by fellow students.

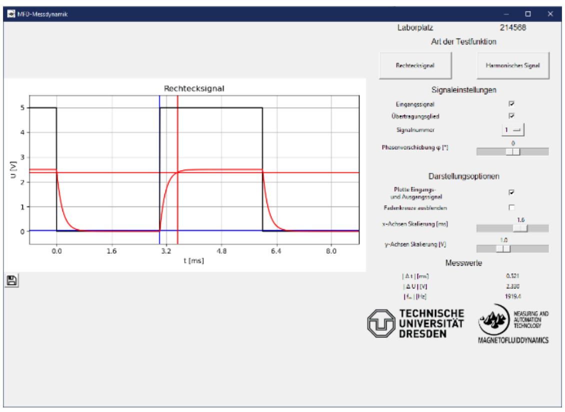

Fig. 2: Software interface of the measurement dynamics experiment with input and output signal and measurement data display.

In theory, such a programmatic solution is easy to implement. However, it must be taken into account that the realisation of a software that runs stable on a wide variety of operating systems can be an extraordinarily complex challenge. Programming and testing the practical programme under Windows, Linux and IOS are tasks that required an extraordinary amount of time, so that this experiment could only be used at the very end of the summer term.

The **control loop** experiment, which already causes the students the greatest problems in the classroom practical, could in principle also be implemented with a programming solution. However, the programming proved to be too complex for the time available, so that this experiment had to be abandoned in the summer term 2020.

Fig. 3: Camera view of the railway system in the PLC experiment to observe the train movement.

The **PLC** experiment, on the other hand, can be implemented relatively well in a digital version, since the students can also create the corresponding programme on their own computers. The necessity is also given by the fact that the licensed development environment for the PLC cannot be made available to the students to such an extent.

In order to enable the automatic insertion of variable names into the programme code, which is typical for the Siemens Step7 development environment, the freeware text editor Atom was used, in which a text file with the variable names can be integrated, whereupon these are available as auto-completion. The challenge was then to make the moving railway visible to the students, thus retaining an essential motivational aspect. For this purpose, multiple cameras were mounted on the railway system, which could be used to observe the movement of the train during a GoToMeeting session (Fig. 3).

Thus, one experiment was missing for the complete implementation of the practical course in the summer term. For this purpose, a topic from the MAT1 lecture - the characterisation of a camera with regard to its resolution, i.e. the determination of the modulation transfer function - was used, which could be implemented as a real home experiment. This experiment (**digital image processing**) can be carried out with any camera without impairing the learning effect. This ensures from the outset that every student can carry out the experiment. Regardless of whether the camera of the mobile phone, a tablet or laptop, a webcam or an elaborate SLR camera is used - the experimental steps are the same. The questions of interpreting the result can also be dealt with in an identical way. The only additional component required is a razor blade or, if one is not available, a straight edge such as is typically found on a kitchen knife. With this, a real experimental home test can be carried out.

The additional experiment **design and error calculation** developed for the winter semester requires an extremely detailed experiment design for a precise determination of the acceleration due to gravity.

This can easily be seen in an example that was carried out with considerable effort at the Chair of Magnetofluiddynamics Measuring and Automation Technology.

A large mathematical pendulum with a pendulum length of 11.83 m was installed in the stairwell of the Mollier Building (Fig. 4), the period of oscillation was determined using digital image processing and all the essential and recognisable requirements for using the theory for a mathematical pendulum were met.

Fig. 4: Experimental set-up "Pendulum" in the stairwell of the Mollier Building

In particular, a pendulum cord made of dental floss was used, whose mass was negligible compared to the mass of the pendulum bob. The evaluation of this experiment resulted in a gravitational acceleration of (9.818+0.012) m/s2 and thus a deviation of 0.06 % from the value [8] of 9.81168 m/s2 given by the Physikalisch Technische Bundesanstalt (PTB) for Dresden. We will return to this deviation later.

In total, a good 500 values for the acceleration due to gravity were determined in the practical course. Fig. 5 shows the distribution of values obtained. The mean value is (9.81085+0.0068) m/s2 (the fact that more digits are given here than is usual for the given error is due to the comparison with the PTB value) and thus deviates only 0.008% from the value given by the PTB.

The fact that this deviation is significantly smaller than that of the aforementioned pendulum experiment in the Mollier Building is due to the fact that the dental floss used as the

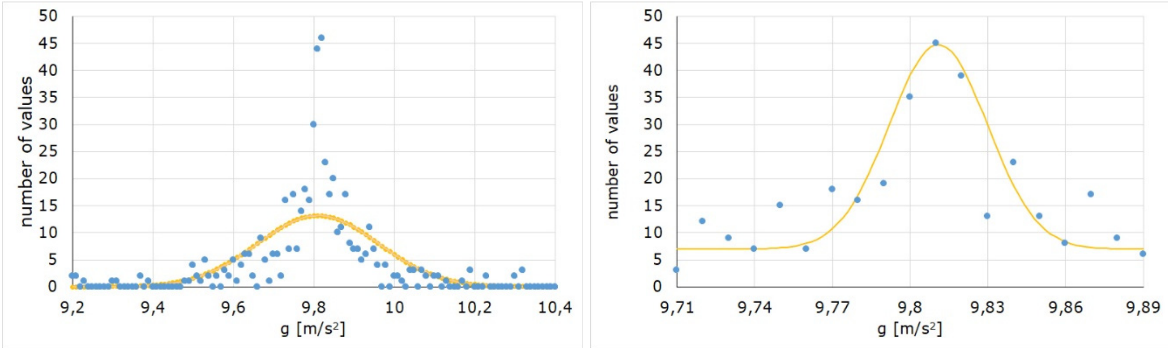

Fig. 5: (a) Overall distribution of the data obtained in the practical course and (b) Gaussian distributed data around the expected value.

pendulum cable is slightly flexible. This stretching causes a change in the length of the pendulum at the reversal points, which in turn leads to deviations in the period of oscillation, which in turn give rise to an, albeit small, incorrect determination of the acceleration due to gravity.

This example shows that the experimental design is of central importance for the measurement result at this point.

The finding that there is a deviation from the normal Gaussian distribution in the distribution shown in Fig. 5a is due to the fact that we are looking at the overall distribution here. If we only look at the data in Fig. 5b that are close to the expected value for the acceleration due to gravity, i.e. those that only deviate from this value due to random errors, we see an excellent Gaussian distribution for a total of a good 320 values. Through the debriefing of the experiment with the students in the lecture, the fact that randomly erroneous measured values are Gaussian distributed could thus be proven with a practical example far beyond the normal theoretical discussion of this lecture content and thus strengthened the further understanding of the students.

6. Overall implementation

For the overall implementation of the digital practical, the practical manuals first had to be converted to the modified experiments for home use.

As a substitute for the introduction to the practical course typically provided by the practical course supervisor, introductory videos were created for each experiment in which all steps of the practical course were explained in detail with concrete instructions for implementation [4-7]. These videos, like the lecture videos, were made available on YouTube.

The practical instructions, the programmes required for the experiments measurement dynamics and PLC as well as a sample protocol were made available on the Opal learning platform in the respective MAT courses.

From the start, each experiment had three weeks to complete. After approx. 1-1.5 weeks, chat rooms for real-time communication were opened for groups of approx. 60 students, in which questions about the experiment could be asked in consultations. These rooms can be created at the TU Dresden using the ***Matrix*** tool [9], after which a further 1.5-2 weeks were available for final processing.

The resulting protocols of the practical experiments had to be uploaded by the students in the Opal course in folders sorted by field of study.

In the introductory videos, it was explicitly pointed out that it makes sense to work together in groups during the practical course. Even though these groups could essentially only confer digitally due to the contact restrictions in both the summer and winter terms, it could be determined that the students had actually specifically come together in groups to work on the corresponding experiments.

It was not possible for the students to download the protocols, so that no unauthorised exchange of protocols could take place.

After uploading the protocols, the evaluationand awarding of grades could take place comparatively quickly, as the questions in the sample protocols had to be answered specifically and then points could be awarded accordingly, which could be registered via an Excel sheet and converted into the practical course grades. The standard grading system for measuring automation technology was used to calculate the marks.

7. Experience with the digital practical courses

The first experience with the digital practical course was that we noticed a quasi 100% participation of the students in the experiments.

Furthermore, it could be seen that the students came to the consultations in the matrix rooms extraordinarily well prepared. It became apparent that after the 1-1.5 weeks that were available until the consultations, they had already worked intensively on the experiments, so that questions could be asked in a very targeted manner. This extremely positive trend continued in the examination of the results of the practical tests. It became apparent that the performance achieved to a considerable extent went far beyond the required tasks.

To give two examples: In the summer term, in the experiment for the characterisation of digital cameras, the creation of two modulation transfer functions and their comparison was required. In very few protocols, only two corresponding modulation transfer functions had been recorded. Most students had changed a large number of parameters, determined the corresponding modulation transfer functions and subsequently written down extremely extensive discussions of the results. These evaluations often showed a profound understanding of the corresponding task and its core problems.

In the winter semester, a similar trend was seen, for example, in the experiment to determine the acceleration due to gravity. Here it could be observed that the students had planned and set up this experiment with considerable effort in some cases. Measuring systems with light barriers and Arduino controllers, measurements using digital image processing, complex determinations of the moments of inertia of the pendulum masses and the like were found in hundreds of protocols.

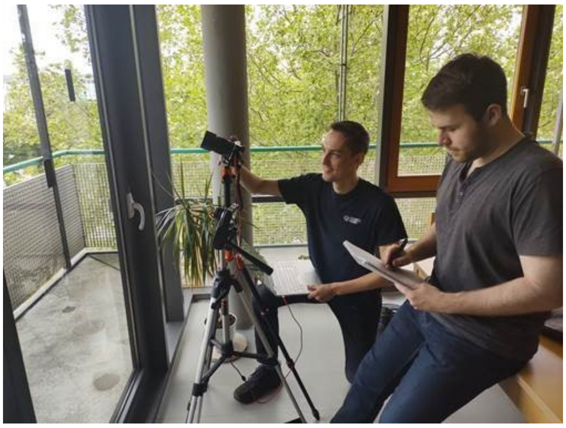

Fig. 4: 2 students in an empty dormitory performing the camera characterisation experiment. [10]

Thus, the learning effect in this practical course appears to have been significantly higher than in the previous classroom practical courses. On the one hand, this is probably due to the fact that the students had the opportunity to work on the problem over a longer period of three weeks, were able to exchange ideas with their fellow students and therefore went into the consultations well prepared. On the other hand, this form of practical course obviously offered a welcome change in the very difficult situation of the digital semester, which was able to interrupt the daily routine, which was partly demotivating and frustrating due to the lockdown, with concrete practical work.

8. Outlook for the summer semester 2021

Since, as mentioned, MAT is a two-term course, the experiments that were used in the summer semester 2020 cannot simply be used again in the summer semester 2021, since the computer experiment on measurement dynamics and the home experiment on digital image processing were already used in the winter semester. The experiment on PLC will remain for the summer semester.

Thus, two experiments are required to complete the overall curriculum of experimental training in MAT. In doing so, two decisive topic complexes from MAT are to be covered. On the one hand, the static and dynamic characterisation of measuring elements is missing with the experiments in the programme so far, and on the other hand, the subject area of control loops is also to be implemented experimentally in the summer semester.

While the characterisation of transmission elements can only be carried out in real experiments, in principle experiments on the control loop could be made available as a computer programme analogous to the experiment on measurement dynamics. However, this would mean that the students would no longer have to deal with the topic in concrete experiments.

For this reason, a new concept for home experiments, which can be expanded in the future, was installed for the summer semester with the support of the FOSTER programme of the TU Dresden [11]. These are experimental cases that are intended to enable real measurement and control experiments. I.e. these experimental cases are equipped with the sensors and actuators required for the experiments and also contain an Arduino microcontroller.

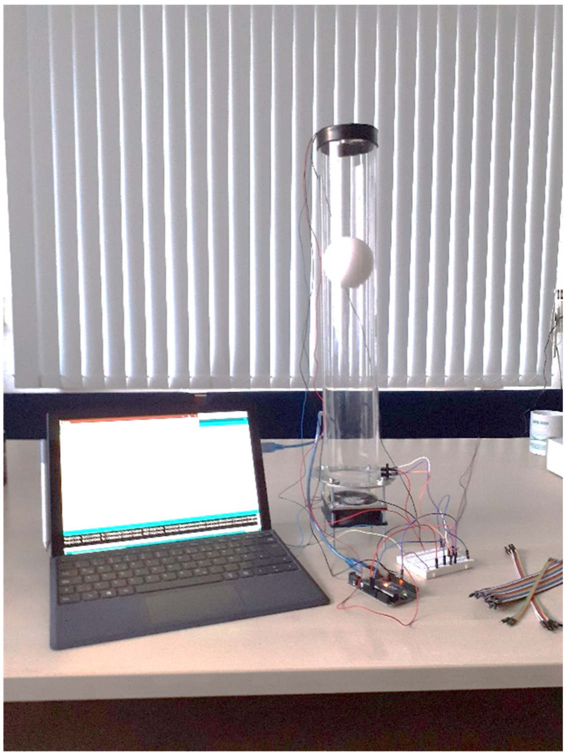

Fig. 6: Experimental set-up for the control loop with controlled system and metrological periphery.

With these experiments, two didactic aspects can be achieved. On the one hand, the normal practical tasks of MAT are implemented in real experiments to be set up by the students and, on the other hand, the students are familiarised with the use of microcontrollers using the example of the Arduino microcontroller.

From the didactic conception, the first experiment will include some experiments on the basic use of the Arduino and, on the other hand, will focus on the characterisation of a temperature sensor with regard to both its static and its dynamic properties. Apart from the components included in the experimental kit, the students actually only need a pot of boiling water and a computer from which they can control the Arduino for this experiment.

The second experiment on the control loop will address the most varied aspects of control technology using a very illustrative example of position control of a polystyrene ball (Fig. 6) in a Plexiglas tube.

For both experiments, students are provided with basic programmes for the Arduino. This is done because students who have not worked with Arduino up to this point would otherwise face the problem of first having to familiarise themselves completely with the use and programming of the Arduino. At the same time, however, students are offered the opportunity to modify these programmes and optimise them if necessary. In the latter case, the corresponding codes must be included in the protocol for the subsequent evaluation of the measurement results.

9. Lessons Learned

Previous experience with home experiments in MAT has shown that students take advantage of the opportunity to work with the experiments over several weeks to carry out extensive series of experiments and thus achieve a much deeper understanding of the content aspects. We attach great importance to the interpretation of the data and their critical reflection in the protocols of the experiments.

If one looks beyond the time of digital practicals, some changes immediately arise that can be made to a then hopefully possible presence practical. In experiments such as measurement dynamics or PLC, it is obvious that working on the practical tasks at home offers decisive advantages, as it provides more time and one can then use the time in the face-to-face consultations to clarify with the students the questions left open after working on them. In this way, both in these experiments and in the other experiments used in the MAT, it is hoped that the students' engagement with the practical material will be strengthened and thus their understanding of the relevant content will be significantly enhanced.

Acknowledgement

Many thanks go to the entire Magnetofluiddynamics team, who contributed to the success of the digital MAT practical course with ideas, help with the technical implementation, the development of the Arduino experiments, the revision of the practical course instructions and the testing of the experiments. Special thanks go to Mr. Höbold and Mr. Sturm for developing the experimental kits for the coming winter semester and Mr. Mokronowski for creating the introductory videos! Furthermore, we would like to thank the FOSTER programme of the TUD (Excellence Funding) for the financial support for the creation of the experimental kits, which will contribute significantly to the implementation of the future practical course structure.

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Lab@Home: Individualised computer-lab courses

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Abstract

Die im Jahr 2020 aufgetretene Pandemie bedingte auch an den Universitäten einen Lockdown und die Verlagerung der Lehre in den digitalen Raum. Im Bereich der Studiengänge Chemie und Lebensmittelchemie ist dies nur teilweise möglich. Insbesondere die Laborpraktika vermitteln Kernkompetenzen, die nicht anders als in Präsenz erworben werden können. Computerpraktika hingegen können mit guter Konzeption an den heimischen Computer verlagert werden. Wir stellen hier unser Konzept vor, das es möglich gemacht hat, Computerversuche aus den Bereichen der Quantenchemie und Statistischen Thermodynamik als Lab@Home-Computerpraktikum durchzuführen. Individualisierte Aufgabenstellung, kontrollierte Vorproduktion der numerischen Ergebnisse, fortlaufende Kommunikation mit den Studierenden und umfangreiche Nutzung digitaler Lehrmethoden waren dabei die entscheidenden Grundlagen für die erfolgreiche Durchführung.

The pandemic that occurred in 2020 also caused a lockdown at universities and the relocation of teaching to the digital space. In the area of the Chemistry and Food Chemistry degree programmes, this is only partially possible. The laboratory courses in particular convey core skills that cannot be acquired in any other way than in presence. Computer-lab courses, on the other hand, can be relocated to the home computer with a good underlying concept. We present our concept here, which has made it possible to conduct computer experiments from the fields of quantum chemistry and statistical thermodynamics as Lab@Home computer-lab courses. Individualised tasks, controlled pre-production of numerical results, continuous communication with the students and extensive use of digital teaching methods were the decisive foundations for successful implementation.

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1. Introduction

Part of the training in the Chemistry and Food Chemistry degree programmes deals with the subject of theoretical chemistry. This part teaches the basics of quantum mechanics, various models for calculating molecular properties as well as methods of electronic-structure calculations. Due to the interdisciplinary nature of this field, students are confronted with problems from physics, mathematics and computer applications, all of which are required to deal with chemical problems. We have made the experience that teaching these interdisciplinary subjects through practical exercises (hands-on courses) works well. Therefore, we designed, carried out, and improved corresponding computer experiments already years ago [1].

Usually, this computer lab took place under supervision at fixed time slots in a well-equipped computer pool. However, due to the pandemic that occurred in 2020 and the resulting lockdowns, attendance courses were not feasible at all or only under difficult circumstances. We therefore decided at an early stage to move this part of our courses to the digital space: as Lab@Home. We benefited from the fact that nowadays all students are equipped with computer hardware and we do not have to conduct practical experiments in the laboratory.

In this article, we present our concept of transferring these computer experiments into individualised experiments that can be conducted in the home office. The planning for the summer semester 2020 was done within two weeks after presence teaching at TU Dresden was shut down. We have constantly developed our concept ever since, which now is running successfully for the second year, and adapted it to individual circumstances of different courses.

2. Computer-lab courses

We have applied our present concept to two computer-lab courses in the Bachelor Chemistry and Food Chemistry degree programmes. Both computer labs are integrated into the physical chemistry (PC) module canon and will be described here briefly: Module PC2 ("Theory of Chemical Bonding") takes place as a compulsory module of both degree programmes in the third semester and deals with the basics of quantum mechanics (Schrödinger equation, particle in a box, harmonic oscillator, hydrogen atom, molecular-orbital theory, Hückel theory) as well as basics of electronic-structure calculations, e.g. Hartree-Fock method and density-functional theory. In addition to the lecture and a seminar series, the content is mainly taught in the PC2 computer lab, which includes five computer experiments. Their topics are: (1) atomic orbitals, (2) ionisation potential, (3) molecular-orbital theory, (4) Hückel theory, and (5) vibrational spectroscopy.

In the sixth semester, students of the Bachelor's degree programme in Chemistry also take part in the compulsory module PC3 ("Special Physical Chemistry"), which deals with photochemistry, electrochemistry, theoretical chemistry, and statistical thermodynamics. In addition to the lectures and a series of seminars, a lab course has to be attended. It consists of two equal parts: a practical laboratory course covering the areas of photochemistry and electrochemistry, and a part with computer experiments dealing with theoretical chemistry and statistical thermodynamics.

For both computer labs (PC2, PC3), the same rules apply: Each of the five (PC2) or three (PC3) experiments is introduced in advance by a topic-related seminar, in which the most important basics are revisited and special features of the experiment are discussed. Afterwards, students have the opportunity to take an electronic test over a period of four days in order to be admitted to the computer experiment. The grade achieved here is entering the final grade. There are two options of repetition for this test within the specified period. Table 1 summarises important parameters of both computer labs.

The computer experiment takes place on a fixed date in the faculty's computer pool, where 20 workstations are equipped with the necessary software. Each experiment is carried out in groups of two, the results are discussed and reported in writing, and the lab report is handed in at the end of the day. The time required for the students on site is about four hours per experiment if they are well prepared.

Tab. 1: Summary of important characteristics of the two modules in which Lab@Home computer labs were carried out. The duration refers to those semesters with Lab@Home mode.

	Module PC2	Module PC3
Module title	Theory of Chemical Bonding	Special Physical Chemistry
Study programmes	Chemistry, Food Chemistry	Chemistry
Students	approx. 90 (approx. 45 groups of two)	approx. 40
Semester	3rd (winter semester)	6th (summer semester)
Number of experiments	5 (+ pre-experiment)	3 (+ pre-experiment)
Duration	13 weeks	8 weeks

3. Challenges

The start of a lockdown of uncertain duration in spring 2020 made a decision necessary whether and how the PC3 computer lab could be carried out that was scheduled for the summer semester. In particular, the uncertainty about the lockdown duration quickly led us to the decision to move the computer lab to the digital space and the students' homes. As a consequence, the lockdown could be used already and reserved time slots were made available to colleagues that had to carry out experimental lab courses. This solution was very well received by both our students and colleagues.

Since the teaching quality had to be guaranteed even under these exceptional conditions, the relocation of the computer lab to the students' homes as a virtual Lab@Home course raised a number of questions that had to be solved in advance:

- Is the applied computational-chemistry software suitable for use by inexperienced students without direct supervision?
- How can we guarantee the correct and fast software installation on different hardware with different operating systems?
- How can we prevent disadvantages for individual students due to underperforming hardware?
- How can we guarantee asynchronous yet continuous supervision while the computer experiments are being carried out?
- How can we make all students deal with the material themselves and carry out the necessary steps independently?
- How can we construct electronic tests that are taken at home, but still monitor the students' performances in a meaningful way?

4. Approach: Lab@Home

Our approach to solving these questions was to individualise the Lab@Home computer lab. In this section we first explain the individual solutions to the questions raised in the previous section, and in the following section we give an overview of the modalities of the Lab@Home that have emerged after three semesters.

The computational-chemistry software used in the computer lab was the ADF (Amsterdam Density Functional) software package even before the pandemic [2,3]. Teaching licences can be negotiated with many computational-chemistry software companies. This programme has a graphical user interface, where molecules can be generated intuitively and all parameters of the calculation to be performed can be chosen in drop-down menus (Fig. 1). Since this software runs on the common operating systems (MS Windows, Mac OS, Linux), it was ideally suited for our approach. We accompany the installation process and operation through a messenger service channel, but also by email and, if necessary, by video conferencing. In general, no major problems arise here, as the installation process of this commercially available software is already optimised for the three common operating systems.

In addition to the Lab@Home option, however, we also keep two fully equipped desktop workstations in individual offices on the campus, so that students without the necessary hardware requirements could carry out the experiments at any time under the necessary precautions. In this way, we achieve a barrier-free computer lab.

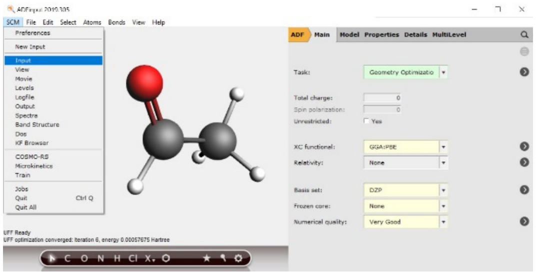

Fig. 1: Graphical user interface of the ADF programme package [2,3]. Molecules can be created intuitively and calculation parameters can be set in various drop-down menus.

The installation of the software is accompanied by a preliminary experiment, for which no report has to be handed in. In adition to the installation instructions, the students receive the numerical results of certain calculations in order to reproduce them and, thus, get familiar with the software handling. Additionally, we ask for the required computing time. This gives us an estimate of the individual hardware, and a sensible assignment of the calculation parameters can be made. Students with less powerful hardware work on data sets that are less demanding in terms of computational resources.

For asynchronous yet continuous support of the computer experiments, we use the messenger service [matrix] [4] which is well-established at TU Dresden. The respective computer-lab chat channel for questions and advice is supervised for approx. 12 hours per day, both on weekdays and weekends, so that the students do not lose time while working on the experiments. The staff of the Chair of Theoretical Chemistry is involved here and takes turns in providing support.

The biggest challenge was quality assurance: While in a computer pool the balancing between desired instructive exchange among students and undesired sharing of solutions can be monitored relatively easily, this is no longer possible in a Lab@Home situation. We were able to circumvent this problem by individualising the tasks: The students were assigned individual calculation parameters and molecules to be investigated. Thus, the same results are obtained qualitatively, but they differ quantitatively (Fig. 2).

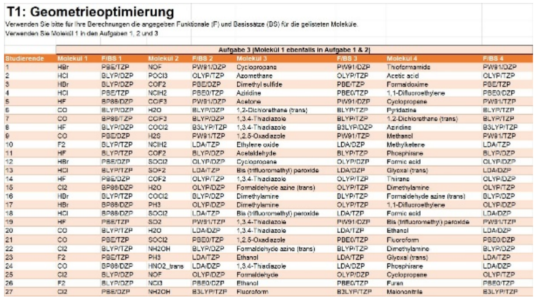

Fig. 2: Individual assignment of different molecules and calculation parameters (functionals, basis sets) to the students.

In this way, the fundaments for the didactically desired conclusions could be laid, but the corresponding calculations had to be carried out independently by all participants, i.e. individual results had to be produced. Thus, solving the tasks independently was encouraged and copying of results was made more difficult. This approach proved to be very successful. In addition, all results produced by the students were checked in advance, so that the discussion in the reports was not carried out with results that were incorrect in content.

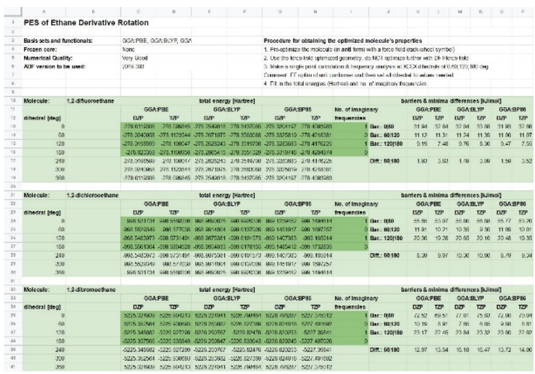

Fig. 3: Example of a shared spreadsheet filled in by the Theoretical Chemistry staff. Each calculation was carried out independently by two persons in order to avoid errors.

Of course, individualisation entails a considerable amount of extra work in advance, because all individual data sets had to be produced and checked first. This was not only necessary as a basis for report checking, but also served to filter out didactically unfavourable combinations of molecules and/or calculation parameters. In practice, this pre-production of results was implemented by the members of the Chair of Theoretical Chemistry, who compiled and checked the results in shared spreadsheets (Fig. 3) from their home offices. In total, several thousand data sets were produced in this way.

While the controlled individualisation of the computer lab led to independent engagement with the material, joint tasks initiated constructive cooperation between the students. For example, students contributed to the temperature-dependent plot of an isomer distribution in a shared spreadsheet, with each participant contributing a pair of values (Fig. 4). The resulting graph was then discussed in the reports. From the evolving solution, the students could also assess whether or not they were correct with their results.

New tasks covering current topics were developed to draw the students' interest beyond their normal occupation with the subject. This seemed particularly important in a home office situation, where also direct exchange among students is reduced. In the third semester (module PC2), the molecular basics of the greenhouse effect were included in an experiment. Thereby, the purpose was solely about teaching the physicochemical basics, i.e. scientifically understood processes. Understanding these gives all students the opportunity to form their own opinion in the political debate on the basis of scientific principles.

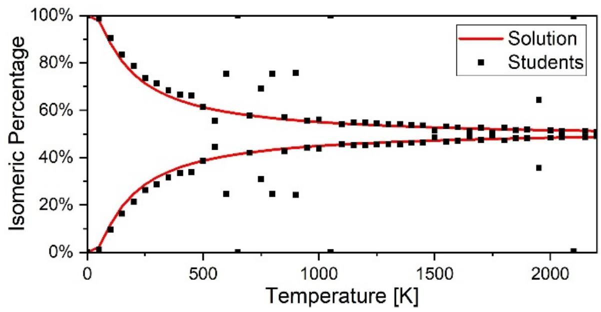

Fig. 4: Diagram created from the shared spreadsheet in which students entered their results. The two red curves show the correct result, the black dots the students' individual results with some deviations.

The communication with students was performed electronically only. The reports were written electronically and submitted via upload, either in groups of two (module PC2) or alone (module PC3).

Finally, a satisfactory solution had to be found to replace the entrance tests. Originally, they serve to reduce the teaching effort on the lab day, because only well-prepared students can learn from the computer experiments and perform them in the available time slot. By moving the experiments to the home office completely, this was no longer required. At the latest, the students learned the matter during carrying out the experiments. Students with sufficient previous knowledge were able to complete the tasks faster than unprepared participants. We therefore converted each entrance test into an exit test in order to check and reward learning success.

To summarise, the challenges of moving the computer labs to the students' homes can be addressed as follows:

- Software suitability: The ADF programme package is well suited to the demands of a Lab@Home situation. Other software may also be suitable; however, we did not test any. It is recommended to pay attention to simple installation procedures and intuitive usability. The possibility of purchasing teaching licences or free licensing is certainly an advantage.
- Correct installation: Even though commercial programmes are usually designed to be installed reliably, we have accompanied the installation procedure with a pre-experiment.
- Technical equality: The individual computing times for given tasks indicated the hardware performance. We took this into account, when assigning the individual data sets.
- Asynchronous yet continuous support: Messenger services offer optimal response times to questions.
- Independence: The individualisation of the tasks leads to independent engagement with the subject. Joint tasks provide additional motivation.
- Exit instead of entrance tests: To check and reward learning success, electronic exit

tests were carried out, that entered the grades.

5. Digital support

Use of a learning platform: The advantages of using a learning platform became apparent latest with the beginning pandemic. We had already used the local Saxonian learning platform OPAL intensively for teaching purposes before. The following features were particularly helpful:

- Student registration: e-mail communication with students was possible at any time.
- Upload/download folders: The digital reports were submitted by the students via upload. The corrected and graded reports were made available for download afterwards.
- Electronic tests: The exit tests were carried out using the test tool ONYX . No retake option was given for exit tests. In a few cases, the experiment was concluded with an oral exam.
- Forum: Initially, the learning platform's integrated forum was used to answer questions. However, the messenger service has proven to be more suitable for this purpose.
- Exams: During the pandemic, all final exams were conducted online with individualised problems and tasks.

Synchronous/asynchronous digital lectures: All module lectures were recorded and could be accessed online throughout the semester via a video platform (Videocampus Sachsen [5]) of the local Saxony Education Portal [6]. It was, thus, possible to maintain the classic lecture format with 90 minutes of front-of-class teaching, because the lectures could be viewed in full or partly if required. The lectures were either recorded from the lecture hall with some students being present or from the lecturer's laptop via video streaming.

Online seminars with breakout sessions: Keeping the participants' attention during seminars was one of the biggest challenges, as these were not recorded for various reasons. This was mainly done by interrupting the lecturer's talk by breakout sessions where students could work on tasks in randomly generated small groups. Partly, the tasks were related to the computer experiments. This created variety throughout a 90 minutes course and encouraged independent engagement in the subject. The psychological barrier for asking questions was significantly reduced in small groups.

Educational videos: In addition to digital seminars, the essential contents of the computer experiments were summarised in short educational videos to provide the students with studying material in different formats. Two to three videos per experiment were produced, each of 10 to 20 minutes length. The videos were published via the local video platform Videocampus Sachsen.

Digital exam: Setting up a digital exam was certainly one of the biggest challenges. While the technical prerequisites were given by the local learning platform OPAL and the test tool ONYX, it mainly was a matter of a good conception of exam questions. We decided on an open-book exam (including internet use), since the use of unauthorised aids could not be controlled in any way under the given circumstances. The questions were adapted accordingly, so that an internet search for answers would not yield any usable results in the given time. In addition, the assignments were individualised as well and randomly distributed and sorted. Communication among the students, which could not be ruled out in general, would take too much time and could be reduced to a minimum. In summary, the grades' distribution did not differ from those of previous years, though the failure rate slightly increased.

Communication: Communication with the students proved to be a decisive point for the success of the computer lab. Here, a quick response to questions seemed to be important. As a consequence we switched from using a forum to using a messenger service, as the message notification function seemed implemented technically better.

The term communication also included giving students the feeling of being looked after: Additionally to publishing all deadlines, modalities and computer-experiment educational material well in advance, we also sent out weekly e-mails each Friday with all events, deadlines and further information for the upcoming week.

7. Lab@Home key points

For the successful implementation of a Lab@Home computer-lab course, the following points have emerged for us as being crucial:

- Individualisable tasks (quantitatively different, qualitatively analogous).
- Good and continuous electronic communication with students.
- Asynchronicity through provided educational videos and lecture recordings.
- Conducting electronic tests, also as preparation for digital exams.
- Willingness of the responsible personnel for new and unusual teaching and evaluation formats.

These points require more staff and time, both in preparation and in implementation. We have estimated that the effort per semester is around 1,000 man-hours, but probably even higher. This number does not include the time needed for conception. A well-coordinated, not too small team is therefore absolutely necessary.

In upcoming semesters, the effort will certainly decrease, but the numerical results regularly must be checked for consistency after software updates.

8. Sustainability and diversity

Computer-lab courses generally can be regarded as a sustainable form of teaching. Individual studies of the course material is performed without the use of chemicals and even independently of the available computer-pool space on campus. The individualisation entailed an increased preparation and supervision effort, as several thousand data sets had to be produced and tested in advance. This process can be at least partially automated by experienced team members using scripting languages. However, the data sets have to be checked for consistency as soon as software updates are carried out. Generally, however, the data sets are available for further years. They can also be used for future courses taught in presence. Although these will be synchronous courses, the material for each participating group still can be individually assigned.

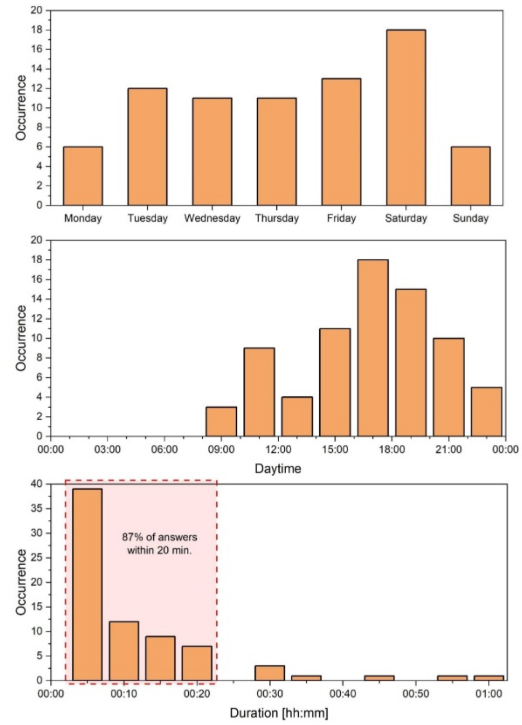

Fig. 5: Statistical evaluation of the activities of the messenger service channel for winter semester 2020/21: Question frequency by weekday (top) and time of day (middle) as well as response time by our staff (bottom).

In particular, the statistical evaluation of the computer-lab channel in the messenger service [matrix] showed that the work habits of the students strongly changed compared to a typical daily routine with on-campus teaching (Fig. 5). The Lab@Home tasks increasingly were carried out at the weekend and in the evenings. The statistics also show that our staff managed to answer about 90% of the questions within 20 minutes, regardless of day or time.

For students in exceptional circumstances, as e.g. illness or absence, the option of completing an asynchronous computer lab is certainly attractive. With the simultaneous offer of doing it on campus site (through provided, bookable hardware in the campus area), our

Lab@Home computer courses are truely barrier-free.

9. Summary and outlook

Due to the 2020 pandemic and the resulting university lockdowns, we were forced to develop a new concept for all our computer-lab courses. In the meantime, Lab@Home courses are running successfully for three semesters already. The most important challenge during the lab-course development was maintaining the teaching quality. We have achieved this by individualising the assignments. In addition, we have ensured good and continuous communication with the students. Here, a messenger service proved to be beneficial. In this way, it was possible to give the students, who were dealing with the studying material alone, a feeling of support. The possibility of asynchronous learning and barrier-free accessibility were particularly well received by the participants. In addition to the course subjects, the students had to deal with computer-technical issues (programme installation, advanced use of spreadsheet programming etc.), from which they will benefit as well.

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Virtual PC pools for computer practicals using the example of materials science

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Abstract

Computerpraktika stellen einen wichtigen Bestandteil vieler Lehrveranstaltungen dar, welche die Grundlagen und Details von computergestützten Methoden vermitteln sollen. In den Materialwissenschaften spielen solche Methoden eine zunehmend wichtige Rolle. Typischerweise setzen die Praktika eine physische Präsenz in den PC Pools voraus, u.a. da eine Vielzahl von verschiedenen Programmen lokal installiert und bereitgestellt werden muss. Um Computerpraktika auch in der Online-Lehre vollumfänglich und weitestgehend unabhängig von den Gegebenheiten der Studierenden einsetzen zu können, wurde im Wintersemester 2020/21 ein virtueller PC Pool auf Basis von virtuellen Maschinen mit Web-basiertem Zugang eingerichtet. Dieser virtuelle PC Pool wurde in verschiedenen Lehrveranstaltungen erfolgreich eingesetzt und kann auch bei hybriden Lehrformaten in verschiedenen Disziplinen verwendet werden.

Computer practicals are an important part of many courses that are designed to teach the basics and details of computer-based methods. In the materials sciences, such methods play an increasingly important role. Typically, the practical courses require a physical presence in the PC pools, among other things because a large number of different programmes have to be installed and made available locally. In order to be able to use computer practicals fully and as far as possible independently of the students' circumstances in online teaching, a virtual PC pool based on virtual machines with web-based access was set up in the winter semester 2020/21. This virtual PC pool has been successfully used in various courses and can also be used in hybrid teaching formats in various disciplines.

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1. Introduction

Most courses related to computer simulations include practicals through which students are expected to try out and apply the simulation methods. The computer practicals typically take place in PC pools, where the necessary software is available and questions can be answered by the practical instructor directly on site. Outside the pools, students can in principle install the relevant software on their own PCs, but this is sometimes very difficult due to the heterogeneity of the different hardware and operating systems. A virtual PC pool, in which the required environment is provided on the server side, offers a feasible solution for digital teaching. But here, too, various aspects must be taken into account, especially with regard to secure and low-threshold access [1-3].

In this article, the establishment and use of a virtual PC pool for materials science is described using the example of the courses *Computer Simulation in Materials Science, Computational Methods II*, *Concepts of Molecular Modelling, Computational Materials Science*: *Molecular Dynamics and Continuum Methods,* which are offered to students of *Materials Science* in the 8th and 9th semesters, as well as to students of various Master's programmes (*Computational Modelling and Simulation, Nanobiophysics*, *Organic and Molecular Electronics,* and *Physics*) at the TU Dresden. The solution presented here was developed and implemented with the help of the Centre for Information Services and High Performance Computing (ZIH) at TU Dresden.

2. Requirements

As mentioned at the beginning, the practical courses are intended to supplement the lecture material with own experiments and to deepen it with the help of projects. For this purpose, the students are given tasks which are to be processed with the software provided. The simulation results must then be evaluated and interpreted. Within the framework of the practical courses related to materials science, various (free) software is used for materials simulation under Linux. Different length scales of the materials to be examined must be covered and handled with the software used (see Fig. 1 and Tab. 1).
These programmes should also be available to all students in the virtual PC pool. Additional administration effort through installation support on different hardware platforms and operating systems should be avoided as much as possible. Ideally, students should also have full access to programmes, data and computer capacities outside of course times. In addition, care should be taken to ensure that students are provided with identical virtual desktop environments. Furthermore, data protection must be guaranteed overall.

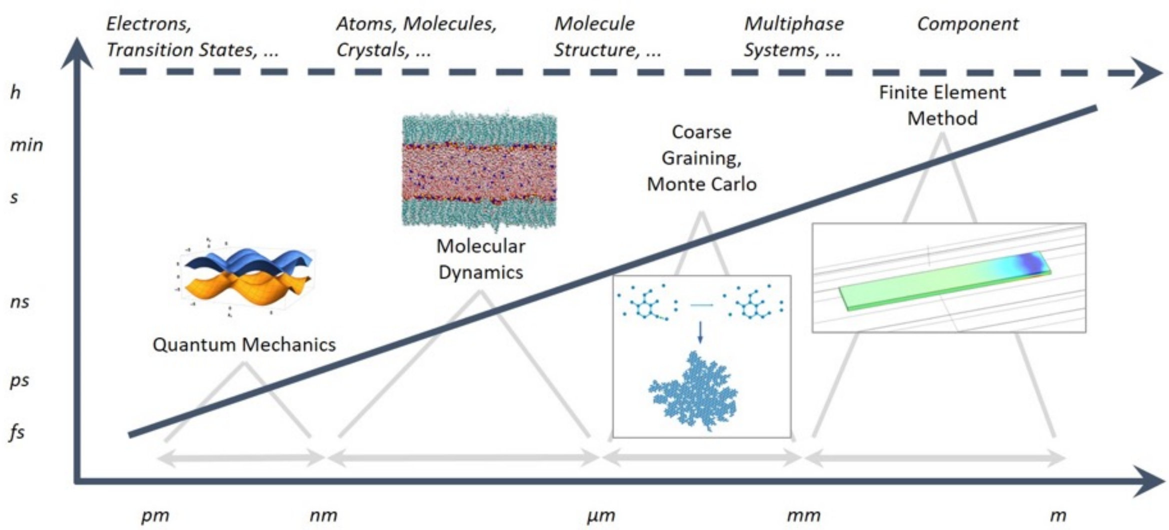


Fig. 1: Overview of methods for describing different time and length scales.

Tab. 1: Software programmes used in the computer practicals and their area of application (scale)

Software	Description	**Atomistic**	**Micro**	**Meso**	**Macro**
Jupyter Notebook [15]	Evaluation and visualisation	☑	☑	☑	☑
OVITO [12]	3D visualisation and analysis	☑	☑	☒	☒
VMD [16]	3D visualisation and analysis	☑	☑	☒	☒
LAMMPS [11]	Molecular dynamics simulations	☑	☑	☒	☒
DFTB+ [13]	Electron structure calculations	☑	☒	☒	☒
Avogadro 2 [17]	Visualisation of molecules and their manipulation	☑	☒	☒	☒
COMSOL [14]	Finite elements software	☒	☒	☑	☑

3. Implementation

For the implementation of the virtual PC pool, which comprised a capacity of 80 virtual machines, a solution was devised based on the following components:

- The virtual machines were operated in a cloud environment at ZIH. The configuration and monitoring of the virtual machines is done via a web interface, which is also provided by ZIH.
- Each virtual machine was based on a predefined installation that included all software. *Ubuntu 20.04* [4] was used as the operating system.
- *Turbo-VNC* was used as the Virtual Network Computing (VNC) server [5]. The VNC server enables remote access to the virtual machine.
- Access was realised via a web interface using the software *noVNC* [6] and secured by Transport Layer Security (TLS). *Xfce* [7] was chosen as the resource-saving desktop interface (see Fig. 2).
- The virtual machines were each assigned a fixed domain.

From the students' point of view, there are a number of advantages with this solution. Each user has their own individual virtual environment. Access is provided via the browser and is therefore largely independent of hardware and operating systems. Even those previously inexperienced with IT can easily gain access on a variety of end devices. Transmission is encrypted and access is password-protected. All software is pre-installed and tested, which means that identical software is available to all participants. Licensed programmes can also be used without local installation, as the range of IP addresses is limited. Data can be provided and accessed via a cloud solution or through network drives.

From an administrator's point of view, the solution found also offers several advantages.

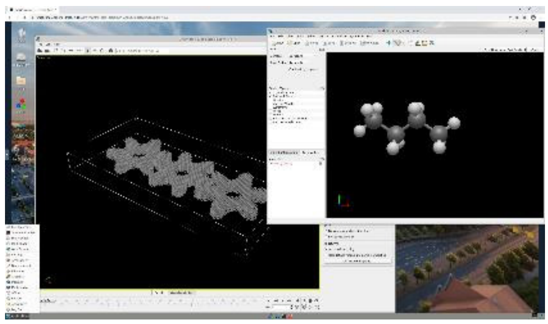


Fig. 2: Screenshot of the virtual desktop. In the foreground are visualisations with OVITO and Avogadro 2.

The software used in the internship can be managed and tested in a centralised manner as far as possible. The resources can be dynamically adapted to the demand and are in principle always available. Access and administration can be done graphically or via terminal. For central administration, the software *Cluster-SSH* [8] can be used to access all virtual machines simultaneously and execute commands. In this way, randomised passwords created for web access were assigned to the individual machines. This also makes it easy to reinstall software or store files. In addition, the virtual machines can easily be returned to their original state at the end of the semester.

4. Implementation

A total of 80 students took part in the courses *Computer Simulation in Materials Science*, *Computational Methods* and *Concepts of Molecular Modelling* in the winter semester 2020/21. Each participant was assigned their own virtual machine. In addition, the staff supervising the practical courses were each provided with a virtual machine identical to the other virtual machines. During the online practical sessions, the students were able to follow the work steps on the virtual machine's graphic interface with the help of the screen transfer function of common video conferencing systems, such as Big Blue Button or Zoom. Due to the uniform installation, any errors that occurred could be quickly narrowed down.

The OPAL learning platform [9] and the cloud service [10] provided by the TU Dresden were used to make files relevant to the practical course available. Access to these resources on the virtual machine is possible as usual via the browser.

For the *Concepts of Molecular Modelling* lecture in particular, the easy and unrestricted access was very valuable, as there were students from the international Master's programmes who were not in Germany and thus in many cases only had asynchronous access to programmes and data.

In the practicals of this course, students should learn how to use molecular dynamics programs such as *LAMMPS* [11], visualisation software such as *OVITO* [12] and the Python programming language to analyse data and perform Monte Carlo simulations (see Fig. 3). The skills learned were applied at the end of the practical in a small project on molecular dynamics or Monte Carlo carried out by the students. The focus of the *Computational Methods* course is on methods for calculating the electronic structure, which are practically tested using the example of *DFTB+* [13]. The *Density Functional Based Tight Binding* (DFTB) method is an approximation of the density functional theory, which allows the consideration of very large systems in particular. In the practical sessions of the course *Continuum Methods,* basic mass transfer phenomena as well as thermal and mechanical problems are dealt with. At the same time, the handling of the widely used (licence-required) finite element software *COMSOL* [14] is taught by means of calculations of simplified examples of such problems (see Fig. 4). Particularly when using software subject to licensing, the virtual PC pool offers a simple solution for providing access to all students. The understanding of the approach to material science problems and their processing with the help of continuum methods ultimately enables the participants to independently develop solutions to problems of a different nature that are not part of the scope of the course.

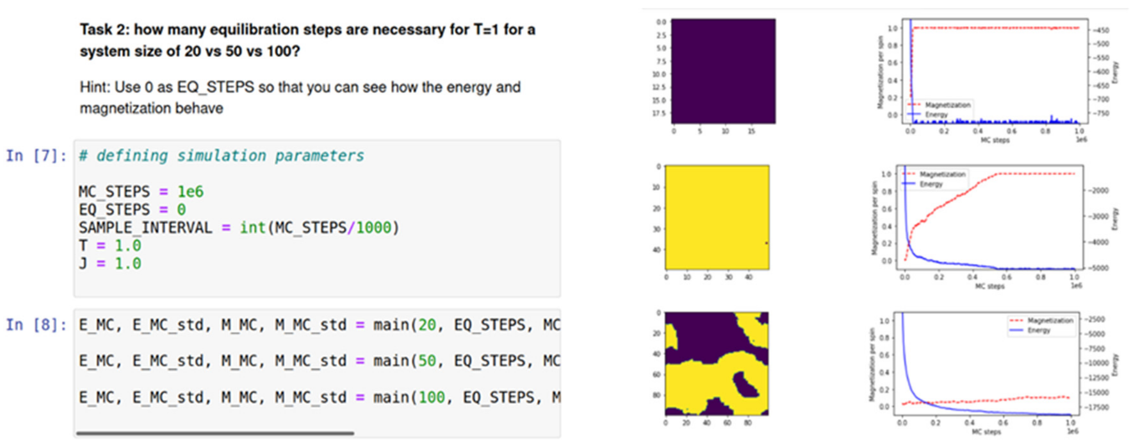


Fig. 3: Extract from a Jupyter notebook on Monte Carlo simulations.

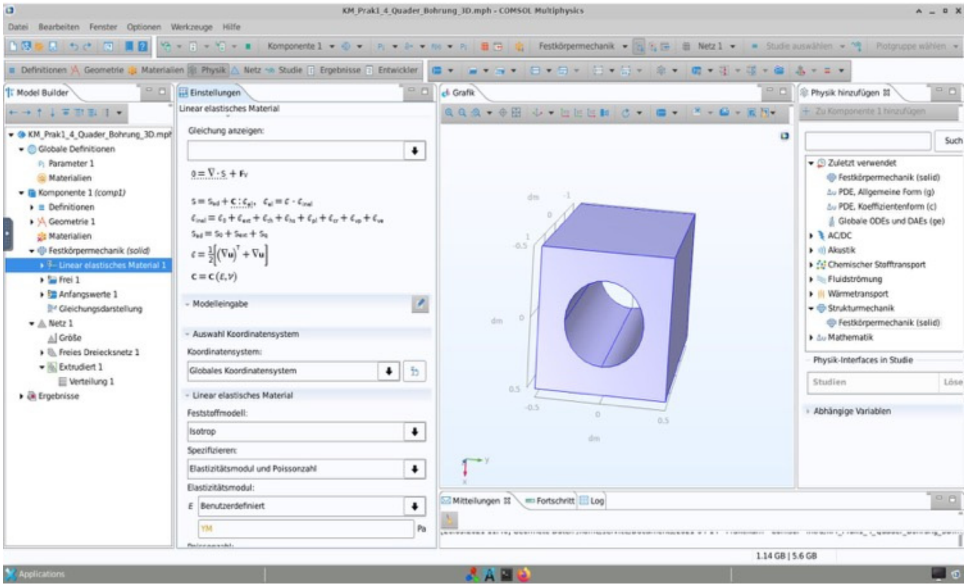


Fig. 4: Screenshot of a calculation example in the finite element software COMSOL [14] from the practical session *of the Continuum Methods course.*

In the following two subchapters, the structure and procedure of a practical unit are presented as examples. First, the use of Python will be discussed and then a question related to molecular dynamics will be described.

4.1 Practical 1: Python

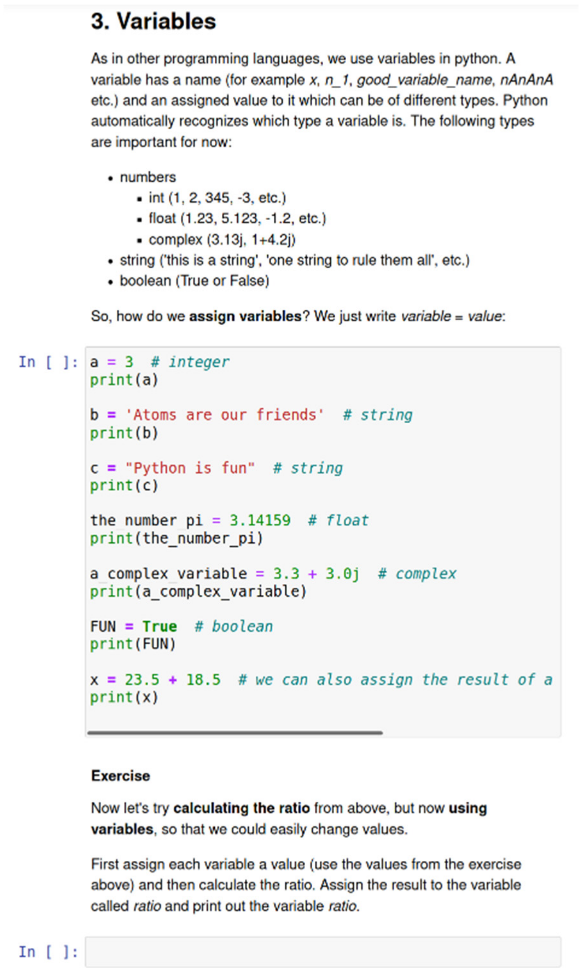
At the beginning of the semester, an introduction to Python was given in order to make it easy for students without any previous knowledge of programming to get started. The aim was for the students to understand simple Python code and also to be able to create scripts independently, for example for data analysis. Therefore, the courses focused on the greatest possible participation and personal work of the students in order to guarantee the greatest possible learning success.

The tutorials were held online via the Zoom platform. The students had to solve programming tasks independently during the tutorial, which were then discussed. Surveys were regularly conducted to check the current progress of the students in completing the tasks in order to determine when the tasks should be discussed. Furthermore, the tutorials were recorded so that asynchronous learning was possible without any problems if, for example, students were in a different time zone or had other commitments.

The programming tasks were created in so-called *Jupyter notebooks* [15]. This is an environment in which parts of code can be executed section by section and text modules can also be inserted (see Fig. 5). These Jupyter notebooks were designed in such a way that precise instructions and explanations were already included and small programming tasks were to be solved. The students were then expected to solve the tasks in the notebooks on their own during the course, while tutors were available to answer questions in the Zoom conference. The notebooks could be downloaded and worked on in the virtual machines via OPAL.

In addition to the introductory courses on Python, there was also a Python-based tutorial on Monte Carlo simulations (see Fig. 3). This tutorial was held with Jupyter notebooks by also including explanations and tasks that were worked on by the students.

At the end of the semester, the students worked on their own small project, on which they prepared a report. Since the virtual machines could be used at any time from home via the browser, all students were able to carry out this project independently from home.



3. Variables

As in other programming languages, we use variables in python. A variable has a name (for example *x*, *n_1*, *good_variable_name*, *nAnAnA* etc.) and an assigned value to it which can be of different types. Python automatically recognizes which type a variable is. The following types are important for now:

- numbers
  - int (1, 2, 345, -3, etc.)
  - float (1.23, 5.123, -1.2, etc.)
  - complex (3.13j, 1+4.2j)
- string ('this is a string', 'one string to rule them all', etc.)
- boolean (True or False)

So, how do we **assign variables**? We just write *variable = value*:

```
In [ ]: a = 3  # integer
        print(a)

        b = 'Atoms are our friends'  # string
        print(b)

        c = "Python is fun"  # string
        print(c)

        the_number_pi = 3.14159  # float
        print(the_number_pi)

        a_complex_variable = 3.3 + 3.0j  # complex
        print(a_complex_variable)

        FUN = True  # boolean
        print(FUN)

        x = 23.5 + 18.5  # we can also assign the result of a
        print(x)
```

Exercise

Now let's try **calculating the ratio** from above, but now **using variables**, so that we could easily change values.

First assign each variable a value (use the values from the exercise above) and then calculate the ratio. Assign the result to the variable called *ratio* and print out the variable *ratio*.

```
In [ ]:
```

Fig. 5: Extract from a Jupyter notebook introducing programming with Python.

4.2 Practical 2: Molecular Dynamics

Molecular dynamics simulations are an important pillar of computational materials science. During the practicals, the students solved given tasks using annotated input scripts. One such task is e.g.

1) Generate an ideal gold nanowire (kfz, L = 8 nm, R = 1.2 nm).
2) Calculate the dependence of the pressure on the strain in the z-direction.
3) Calculate the dependence of the potential energy on the strain during the elongation process and calculate the elongation at break for the nanowire.

The execution of the corresponding script takes only a few minutes. Afterwards, the behaviour of the Nanowire can be visualised with the help of *OVITO* and thus the critical strain can be found (see Fig. 6). The evaluation of the compression-strain and energy-strain curves can then be done, for example, in a Jupyter notebook or by separate software. A total of four practical courses took place, in each of which a task was worked on as described by way of example. Thematically, the following topics were dealt with, among others: Generation and deformation of carbon structures; heating and cooling processes of nanostructures.

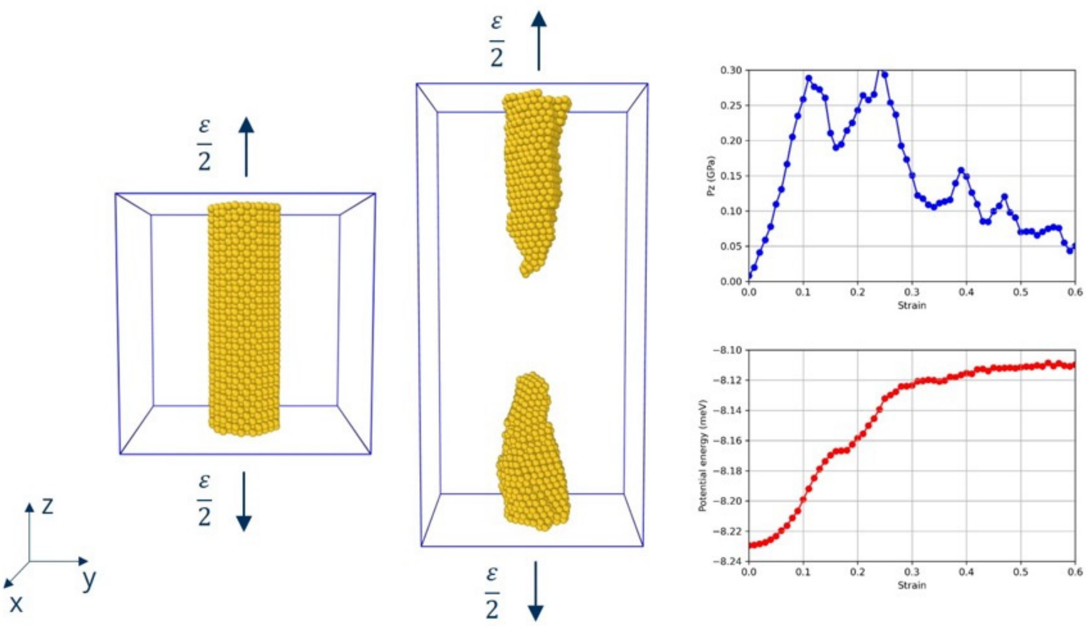


Fig. 6: Visualisation of a gold nanowire in OVITO a) without strain, and b) with 60 percent strain. c) Mechanical stress (top) and potential energy (bottom) as a function of elongation.

5. Conclusion and outlook

All in all, the solution presented here is a convenient and feasible option for conducting computer practicals in the field of hybrid teaching as well. Through access via the virtual machines, the practical courses could be carried out without restrictions. The standardised provision of software and the secure, unproblematic access at any time via the web interface should be emphasised. In future, it will therefore be possible to make the students' tasks and solution progress available in parallel in the computer pools and the virtual machines. In this way, flexible access for students to the practical resources can be guaranteed and individual teaching support strengthened at the same time.

Acknowledgements

We would especially like to thank Mr. Holger Mickler, Mr. Christopher Mosch and Mr. Mathias Jurenz from the ZIH of the TU Dresden for their very helpful support during the concept finding, installation and error analysis.

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[6] https://novnc.com/

[7] https://www.xfce.org/

[8] https://github.com/duncs/clusterssh

[9] https://bildungsportal.sachsen.de/opal

[10] https://tu-dresden.de/zih/dienste/service-katalog/zusammenarbeiten-und-forschen/datenaustausch/cloudstore

[11] https://lammps.sandia.gov/

[12] https://www.ovito.org/

[13] https://dftbplus.org/

[14] https://www.comsol.de/

[15] https://jupyter.org/

[16] http://www.ks.uiuc.edu/Research/vmd/

[17] https://www.openchemistry.org/projects/avogadro2/

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Experiences with EXAM/ONYX exams

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Abstract

Ein Jahr digitale Lehre bedeutet auch ein Jahr digitale Prüfungen. In diesem Paper sollen dazu einige praktische Erfahrungen aus Sicht der Professur Formgebende Fertigungsverfahren (FF) zusammenfassend vorgestellt werden. Dabei ist der Einsatz der an der TU Dresden zur Verfügung stehenden Softwareplattform EXAM@TUD Schwerpunkt der Betrachtungen. Bei deren Nutzung gibt es neben vieler positiver Ansätze auch einige Schwachpunkte, die noch einer Verbesserung bedürfen. Diese sollen als Erfahrungsbericht aus ca. 60 Online-Klausuren (Probe- und Abschluss) hier näher vorgestellt werden.

One year of digital teaching also means one year of digital exams. This paper will summarise some practical experiences from the perspective of the Chair of Forming and Machining Processes (FF). The main focus is on the use of the EXAM@TUD software platform available at the TU Dresden. In addition to many positive approaches, there are also some weak points in its use that still require improvement. These are to be presented here in more detail as a report of experience from approx. 60 online examinations (trial and final).

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This article was originally submitted in German.

1. Introduction

One year of digital teaching also means one year of digital exams. This paper will summarise some practical experiences from the perspective of the Chair of Forming and Machining Processes (FF).

1	Klausurarbeit Umformtechnische Verfahrensgestaltung
2	Umformtechnik, Zerspan- und Abtragtechnik, Oberflächen und Schichttechnik - alte DPO
3	Umformtechnik, Zerspan- und Abtragtechnik, Oberflächen und Schichttechnik - neue DPO
4	Klausurarbeit Werkstoffherstellung und Fertigungstechnik
5	Klausurarbeit 1 Fertigungstechnik
6	Fertigungstechnik RES MECH
7	Klausurarbeit Abtragetechnik und Werkzeugkonstruktion
8	Produktionstechnik - Produktion und Planung MW-MB-PT-02
9	Produktionsautomatisierung und Logistik
10	Klausurarbeit Fertigungsplanung - Teilefertigung
11	Klausurarbeit Präzisions-, Ultrapräzisions- und Mikrozerspanung
12	Fertigungsplanung WING
13	Verfahren der Urform- und Umform- und Zerteiltechnik - Werkstück- und Verfahrensgestaltung
14	Klausurarbeit Fertigungsplanung 1
15	Klausurarbeit Fertigungstechnik und Produktion & Logistik
16	Klausurarbeit 2 Fertigungstechnik
17	Fertigungstechnik MW-MB-06
18	Klausurarbeit Werkzeuge der Umform- und Zerteiltechnik
19	Klausurarbeit Produktionstechnik - Werkzeugmaschinen und Produktionsautomatisierung
20	Klausurarbeit Rapid Product Development
21	Klausurarbeit Mehrachstechnologien

Fig. 1: Online examinations in the 2020/21 winter semester (trial and final examinations in each case)

In teaching, the Chair focuses on the subject areas of casting and forming technology, cutting and abrasive technology as well as production automation and production planning in the area of parts manufacturing. The current teaching programme is correspondingly extensive and has been implemented digitally to a large extent since the summer semester 2020, as is the case at the entire TU. Digital teaching also includes the matching range of examinations as proof of teaching and learning success.

Due to the large teaching volume, there were a total of 16 test and final exams at the end of the summer semester 2020 and a total of 41 at the end of the winter semester 2020/21, all of which were carried out digitally online either on the students' own responsibility or in cooperation with other departments. (Fig. 1).

The various examinations were realised with the help of the EXAM@TUD system (Fig. 2). This software was set up by the company BPS Bildungsportal Sachsen GmbH specifically for the TU Dresden. The examinations had between 4 and 400 participants. The duration of the examinations was between 80 and 180 minutes, with a share of 20 to 90 minutes for the FF professorship.

The reason for this high number of examinations is also due to the transitional phase between different diploma examination regulations (DPO) in the field of mechanical engineering as well as the desire of the university and faculty management to allow students to take all examinations in every semester.

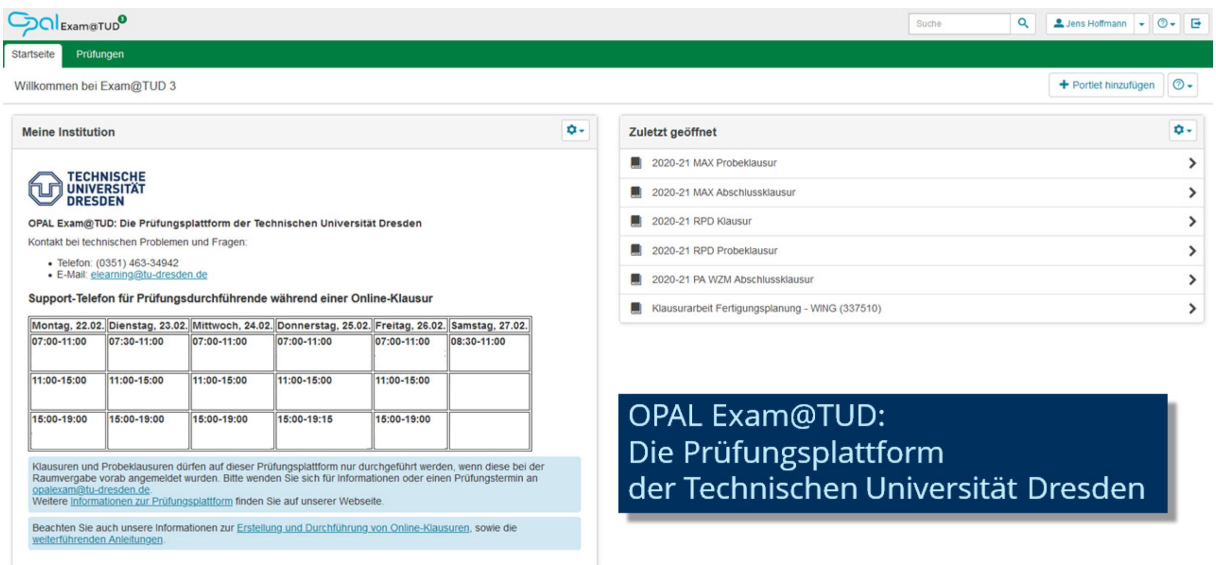


Fig. 2: Start view of the EXAM3 examination platform

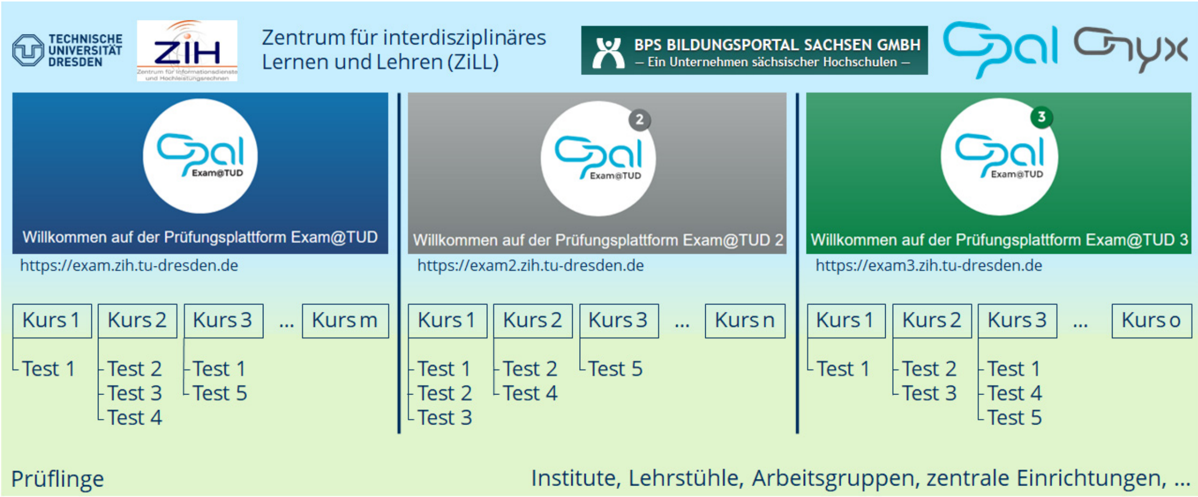


Fig. 3: Structure of the EXAM examination platform in the examination period after the 2020/21 winter semester

2. Software used

As mentioned before, the examination platform EXAM@TUD [1] with the software ONYX from BPS GmbH [2] is used at the TU Dresden. After only the EXAM platform could be used in summer of 2020, EXAM2 and EXAM3 are now also available (Fig. 3). According to information from ZILL (Centre for Interdisciplinary Learning and Teaching) [3], up to 500 participants can be active at any of them at the same time. From previous experience, these platforms under the responsibility of the ZIH can be attested to be highly stable and reliable.

However, the use of three parallel platforms without a software junction quickly makes it difficult for the examiner to keep track of everything, and the effort required for data transfer is relatively high. Currently, a course must be downloaded from one platform as a packed archive and then uploaded to one of the other two platforms. This should be improved in order to be able to use the platforms as parallel drives, as is usual in Windows, and also to enable links between elements (courses, tests) of different platforms.

3. Delimitation

The examinations are conducted on the basis of the valid examination regulations of the respective area. The procedure shown in Fig. 4 is carried out in advance.

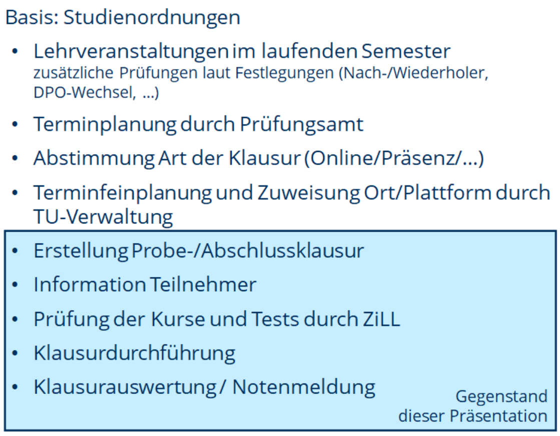


Fig. 4: Delimitation of the area of examination preparation, implementation and evaluation considered in this paper

The steps marked accordingly in the illustration will be examined in more detail below. They differ significantly from the usual procedure for classroom examinations.

4. Exam preparation

Digital examinations require a different, usually more labour-intensive technical and information preparation than typical face-to-face examinations.

Generally, an ONYX-based digital examination consists of an OPAL course and one or more test modules, each containing an ONYX test. A test containing the respective tasks can be used in different courses if required.

Within the courses, the control of the examination as well as the administration of the participants takes place. For this purpose, various pre-settings and links have to be set up.

The individual tasks are created and integrated in ONYX. These can be grouped into sections according to certain criteria for instance for different scientific areas.

The administration of the participants and their results is done within the course.

In summary, it can be said that the preparation effort for a digital exam is usually much higher than for a face-to-face exam.

5. Course

The basis for creating an online exam is an OPAL course (Fig. 5). This can be created or reused as a new course or as a copy. In case of a reuse, the user data has to be updated. Old data will be lost. From the point of view of preserving the results of previous online examinations in accordance with the applicable regulations, it is advisable to work with a newly created copy of the course. In the case of sample examinations, this may well be deviated from, as the aspect of retaining user data does not play a role here.

In connection with this, there is a major problem with the use of ONYX as with OPAL as a whole: The file management (Fig. 6). It is not possible for the user to work with folders or directories on the course level and thus to structure the existing data in a meaningful way. Up to now, a meaningful structuring can only be done via the name of the course (e.g. prefixing the relevant examination period to the course name). With approx. 60 courses, it quickly becomes confusing. There is an urgent need for action here on the part of BPS GmbH.

For our exams, as already mentioned, we use new or copied courses. However, these have to be set up each time, because unfortunately the default settings of the EXAM/ONYX system do not meet the requirements of the TU Dresden or the ZILL (Fig. 7). An adjustment is required especially for the visibility of the evaluation of the tests carried out. Here, too, there is a need for improvement in the further development of the software for the future.

Fig. 5: Start view of an online examination course

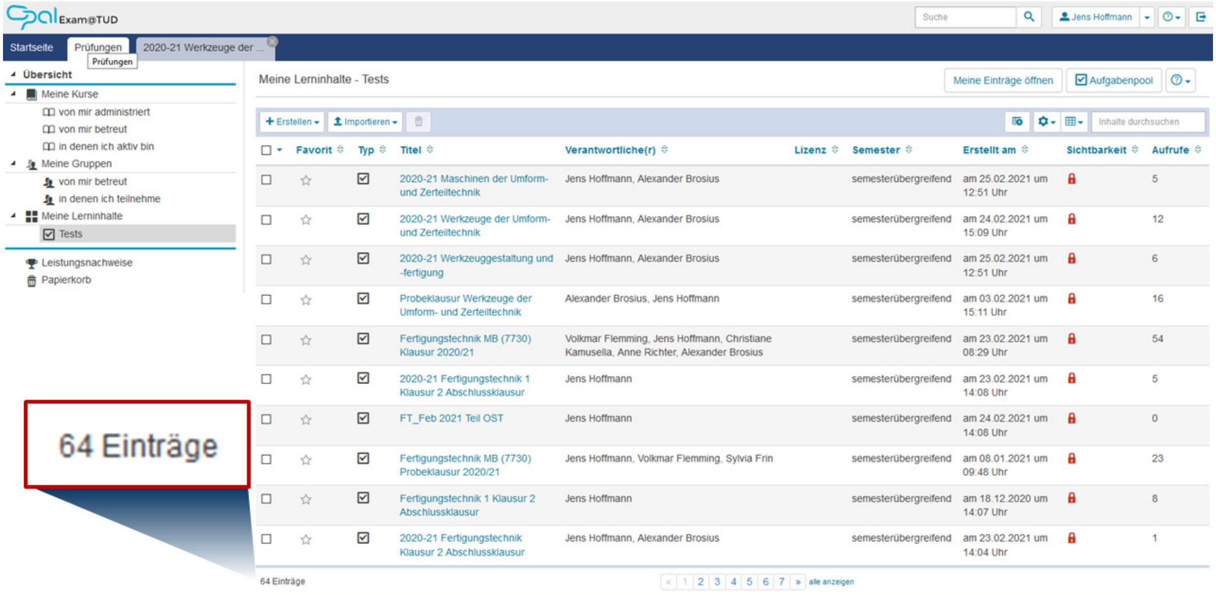


Fig. 6: "Course management" in EXAM/ONYX

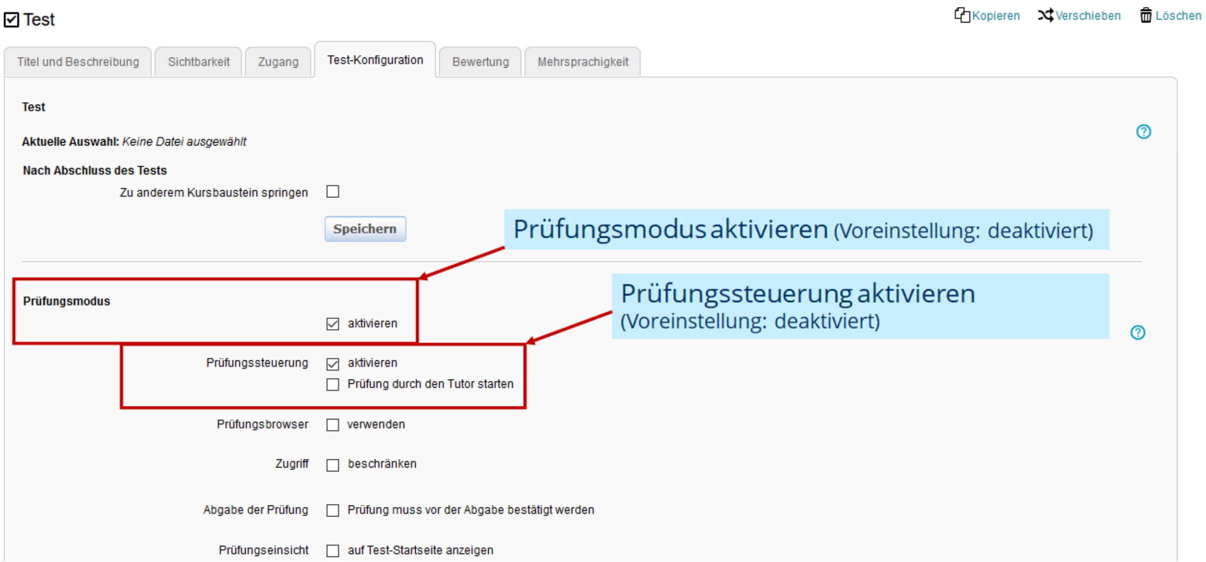


Fig. 7: Settings in the test configuration (example)

Participants of the examinations can be invited according to the specifications of the system or enrol independently. At the chair, the latter variant is generally preferred in conjunction with a confirmation of the conditions of participation for the examination. It should be noted that participants cannot unsubscribe independently (unfortunately no default setting in the system, must be set up manually, Fig. 8).

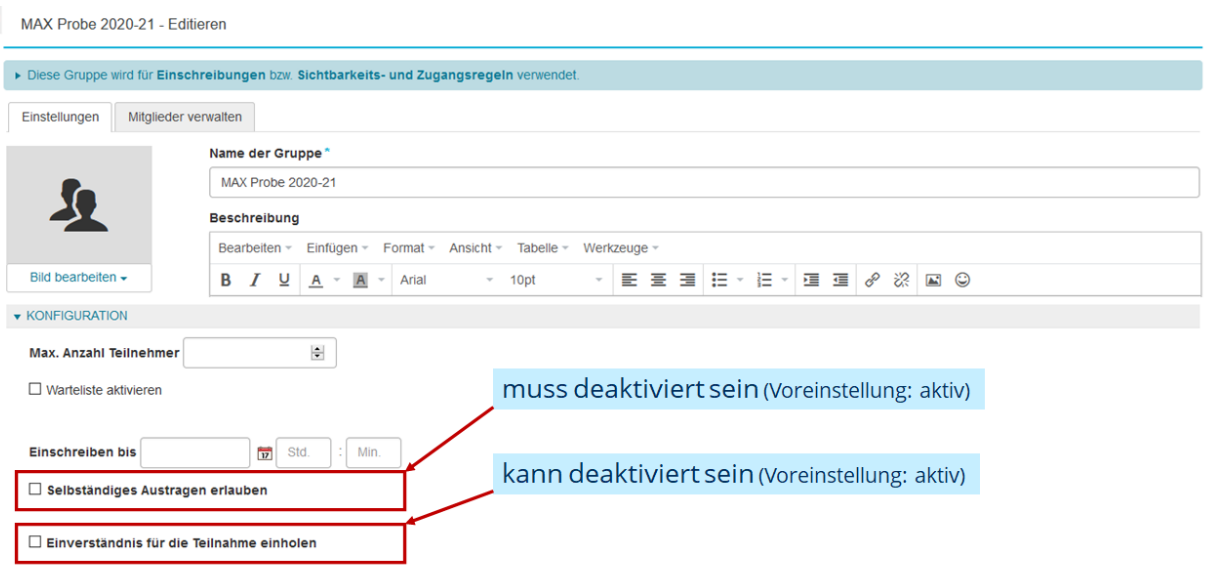


Fig. 8: Settings for member administration

Please note that certain settings for exam control have to be realised in the OPAL course (e.g. number of solution attempts in the test module) or in the ONYX test (e.g. exam duration). In the case of the number of solution attempts, it is also possible to specify a setting in both places, but the setting in the ONYX test has no influence on the exam procedure. At this point a synchronisation of the settings between OPAL and ONYX is absolutely necessary.

6. Test

The ONYX test contains the various tasks of a written exam. As already mentioned, one or more tests can be used for an examination. Each individual ONYX test must be integrated in the course via a test module. The use of an ONYX test in different test modules or OPAL courses is possible and can reduce the workload.

Within an ONYX test, tasks can be grouped into sections (Fig. 9). Here, a separate determination of the achieved points is possible. Unfortunately, so far these are only displayed in the test evaluation, but cannot be saved for further processing, e.g. as an Excel file. The only option is to export the data manually - the lack of this functionality is not comprehensible for the user.

In the test, as already mentioned, various specifications can be made for exam control. These include, for example, the selection of tasks, their sequence and the way in which the examinee works through them (linear/free).

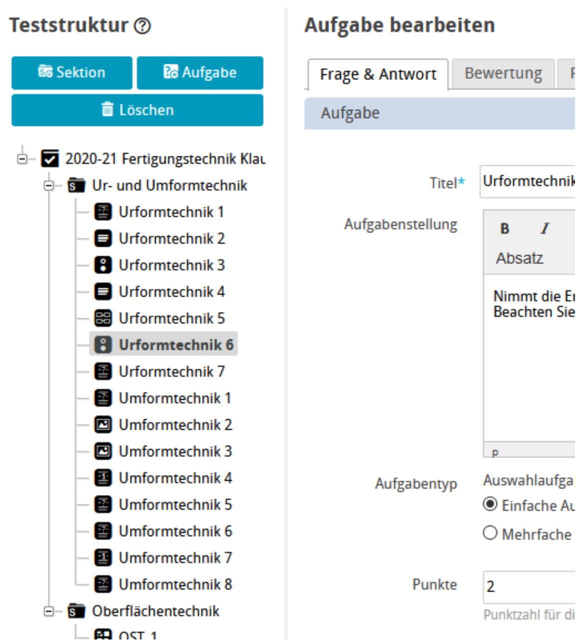


Fig. 9: Structure of a test with sections

These definitions require sound knowledge of the effect of and content of the parameters, experience and concentration when setting them. It would be desirable to have a better pre-setting of the parameters specifically according to the TU's specifications as well as a better description of the functionalities.

7. Task types and associated difficulties

Various types of tasks are available for use (Fig. 10). These are naturally different from those known from face-to-face examinations. The exception is the so-called free text. The other task types are easy to use. A corresponding explanation is stored in the ONYX editor and available via ZILL. Our department has some special experience in this area, which we will now discuss.

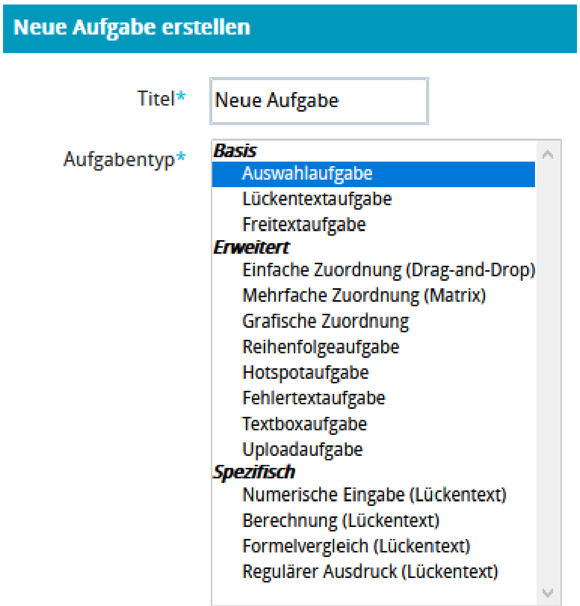


Fig. 10: Available task types

Questions can be copied or moved between different tests. This can be done using the "extract" function and subsequent import. If this is to be done between different EXAM@TUD platforms, a down- and upload is also required, as already described for the courses. This can certainly be done more easily and in a more modern way, and is thus another wish for future developments.

7.1 Problematic selection task "Multiple Choice"

For choice tasks, the variants single and multiple choice are available. While there are no major problems in creating a correct solution (single choice), the situation is different with multiple choice. Here, the specifications of the MC guideline of the TU Dresden must be observed [4]. This requires a number of settings in the assessment that do not necessarily seem logical at first. The question is why these university-specific requirements are not better addressed by default settings in the ONYX system. In our view, there is a need for improvement here.

7.2 Problematic "Cloze Text"

One possible form of task is the cloze text. In this case, a word or a group of words or a number is replaced by a gap in a text. The examinee has to enter the corresponding solution in this gap. This input is compared by the system with a default and possibly defined alternatives. Despite the possibility of programming a "fuzziness" (letter deviation, upper/lower case), it is difficult to record all possible correct answer options. This leads to frequently necessary manual corrections and thus increases the effort. The gap is useful for exact values (e.g. numbers), otherwise rather impractical.

7.3 Problems with "Free Text"

The question type "free text" is very similar to the familiar question type in presence exams. Here, the participant can enter corresponding explanations to a question in a text field. These must be assessed manually by the examiner after the examination. Automating the assessment is almost impossible with this type of task.

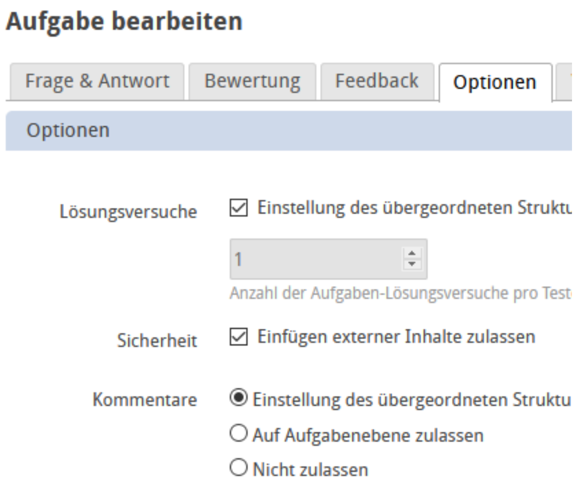


Fig. 11: Display of the section results

When creating a task of this type, the examiner should prevent the participant from simply copying texts from other applications (pdf files, internet, ...) by means of copy & paste, which is not allowed and constitutes an attempt to cheat. This can be done by setting an appropriate option. However, this is also a little hidden ("Allow insertion of external content", Fig. 11).

In contrast to the other task types, the preparation effort for free-text tasks is very low, but more time has to be invested in the evaluation. Especially with a number of participants of more than 20 ... 50, this effort has to be questioned individually.

7.4 Uploading files

In addition to free-text tasks, it is currently also possible to upload files as part of an examination. In this way, for example, solution paths or sketches can be recorded by the examinees and made available for assessment. This makes it possible to better understand the processing path and to take subsequent errors into account.

Depending on the file size and the available internet connection, however, this method can become problematic. The assessment effort is similar to that of free-text tasks.

8. Preparation for implementation

First of all, before the examination date, do not forget to make the created OPAL courses (not ONYX tests) public (setting in EXAM@TUD) and to set the visibility and access rules for the course correctly. Especially the time and the affiliation to certain participant groups have to be considered.

After the creation of the courses and tests, the problem arises of passing on information to potential participants about modalities and the link to the course. Unfortunately, there is no active support from the examinations office and the study office for online examinations with regard to informing participants.

The ZILL staff will kindly check prepared examinations before the examination date. Necessary corrections should be made before the exam. The fact that there is sometimes not much time available for this is something that the people responsible for the courses generally have to criticise themselves for, as the completion of the required courses and tests is sometimes done very "promptly", leaving hardly any time for checking by the ZiLL.

9. Participant management

One point in the implementation of online examinations that has not yet been looked at in detail is the changing topicality of the participants. First of all, the already mentioned settings in the user administration must be ensured.

There are two possibilities for recording the active participants.

a) If the complete current participant lists are available in advance via Hisqis or Selma (administration systems for student services at the TU Dresden), these can be used for an invitation and the subsequent participation in the examination. This data is to be recorded in the participant administration and only these participants are to be granted access. Unfortunately, this is not always possible due to the variety of participants from other areas and the resulting incompleteness and confusion of the data.

b) Alternatively, automatic enrolment can be defined when accessing the course. This allows anyone who has the access data (link and password) to take the test. It is possible to link the automatic enrolment with an agreement to the current examination conditions (module "Enrolment for the examination"). However, there is a risk that unauthorised persons may also gain access.

After the examination, the results of the participants have to be assigned to the various Hisqis and Selma data sets, which is sometimes very labour-intensive.

10. Performance of the online exam

The implementation of the online exams proved to be largely problem-free in the winter semester 2020/21. Unless human errors (wrong test included, wrong settings, ...) lead to problems, the three platforms have run stably.

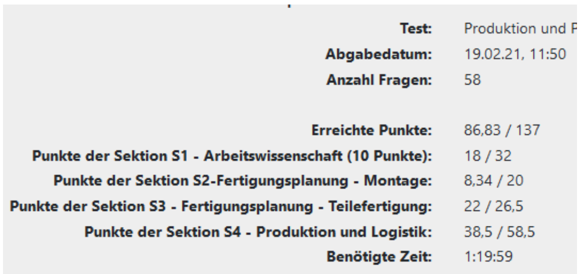
The person in charge has few possibilities to intervene (restart test, end test, add time), but none at all in case of disturbances of the internet connection. It is also almost impossible to monitor the way the participants work (attempts at cheating).

In rare cases, the number of examination attempts (which normally should not exceed one) had to be reset manually via the assessment tool when the examination was cancelled.

The timing of the exam is currently unclear. There is a time-defined access to the OPAL course as well as a limitation of the processing time of the ONYX test. Does the access period only mean the limitation of the start time of the exam by the student or does it also limit the processing time to the total time window? How is this to be reconciled with the allocated time slot for the online exam? This requires clarification on the part of the examination board.

11. Evaluation of the online examinations

After the online examinations have been completed, the evaluation is required. Various tools are available for this. First, the manual evaluations (free text, cloze text, file upload) should be carried out. These are administered in the system together with all others after manual entry. Then the result data is available for evaluation in the system. In the case of a continuous test (e.g. without using sections for separate sub-tests), the result export can be done via the download in the evaluation tool. If different sub-tests are to be evaluated separately and sections were used in a test, the file archiving function must be used. This creates a very extensive file with all information. However, this is currently only available in csv format and must first be transformed into Excel. The partial results are displayed on the screen (Fig. 12), but unfortunately not saved. Here, too, an improvement in user-friendliness would be desirable.



Test:	Produktion und P
Abgabedatum:	19.02.21, 11:50
Anzahl Fragen:	58
Erreichte Punkte:	86,83 / 137
Punkte der Sektion S1 - Arbeitswissenschaft (10 Punkte):	18 / 32
Punkte der Sektion S2-Fertigungsplanung - Montage:	8,34 / 20
Punkte der Sektion S3 - Fertigungsplanung - Teilefertigung:	22 / 26,5
Punkte der Sektion S4 - Produktion und Logistik:	38,5 / 58,5
Benötigte Zeit:	1:19:59

Fig. 12: Display of the section results

12. Conflict DPO - ONYX

In addition to other essential specifications, the DPO assigns the individual courses to modules. The criteria for the corresponding examinations are defined for these. One or more courses can belong to a module. One example is production technology in the 1st semester (Fig. 13).

The module MW-MB-PT-03 contains the two courses Machine Tools and Production Automation, whose time scope is identical. The total examination time is 180 min. The two parts are provided by different professors. It makes sense to conduct two partial examinations with separate content and then offset the partial grades. How would it be possible to implement this in EXAM@TUD?

Variant 1 would be the use of two separate tests and correspondingly two test modules. The examination results are then also determined separately. However, an overall examination time cannot be defined, but only the times for each sub-area, which is not legal according to the DPO.

Variant 2 would be a test with two corresponding sections. A total test time is defined and the examinee divides it up himself. The problem here is that no separate results can be determined for the two sections. Only a very large, unclear file can be generated for manual evaluation via file archiving.

As already mentioned, section results are displayed but not saved.

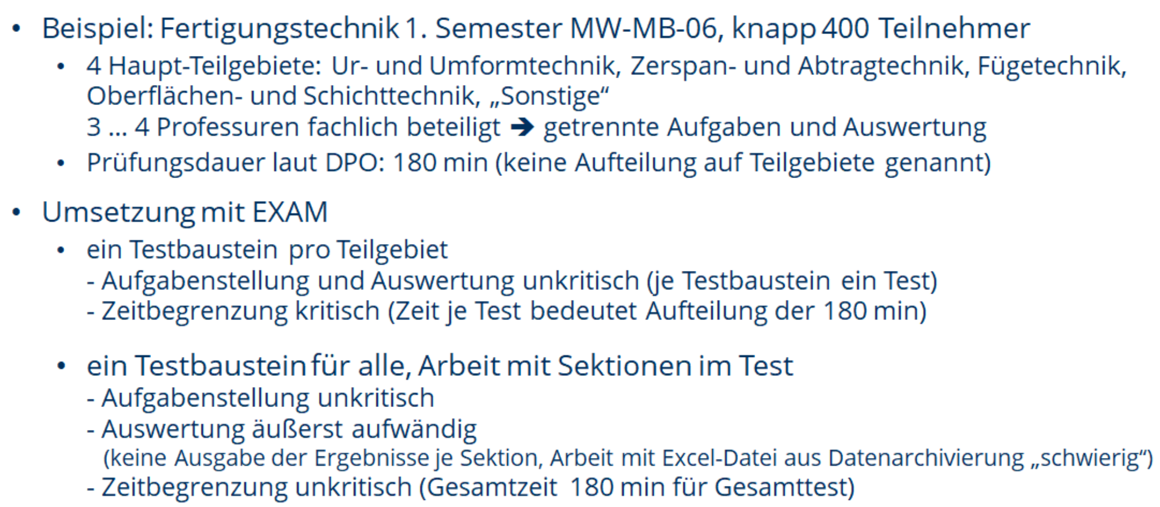


Fig. 13: Problematic different sub-areas in one test

13. Problem cases Hisqis / Selma

A major problem is the lack of interfaces to the software platforms Hisqis and Selma used in the examination office and the study office. All systems work with the input and output of data in Excel format, but unfortunately that is where the similarities end. The structure and content differ considerably, which means that a more or less large amount of manual work is required for the corresponding data transformation.

14. Summary

Overall, the results of the current examination period show that the online examinations are secure and stable. More time has to be spent on preparing the exams compared to face-to-face exams, and the questions have to be adapted to the possibilities of the software. Whether this is positive or negative for the students depends on the subject and the subject matter.

The effort required for the evaluation of the examinations can vary from very small to extensive. The reasons for this were explained in detail in the previous sections. The question of the legally secure detection of attempted cheating remains open. These can be limited by appropriate measures in the design of the examinations, but not completely excluded. It must be assumed that all documents (scripts, books, internet, ...) are available to the participants during the examination. This must be taken into account when designing the tasks and exam management.

For the EXAM@TUD platform used, here is a summary of what we consider to be the most important changes and development requests:

User systems EXAM / EXAM2 / EXAM3

- Use of the courses / test across platform boundaries or use of a uniform platform
- Simplify transfer of courses / tests between platforms (no longer via download/upload with local storage).
- Creation of a folder structure for courses to increase clarity (analogous to task pool)

OPAL Courses / ONYX Tests

- Customise default settings
  - User management with blocking of independent unsubscribing and deactivating the sending of information about enrolment
  - Limit examination attempts
  - Deactivate test evaluation display
  - Activate examination control
- Coordinate settings between course and test (time for access, number of accesses, ...)
- End of access time means end of processing time of the test
- MC tasks: Adapt default settings to TU Dresden MC guideline

- Enable direct output of section results to file
- Adapt assessment tool to reality / make it more flexible
- Enable output of task/part/section results to file
- Coordination / implementation of study regulations with the corresponding software options
- Simplify transfer of tasks between tests

Examination organisation, administration

- Information for students also via examination office (link, deadline)
- Provision of contact details from Hisqis / Selma
- Uniform data formats or direct interfaces Hisqis - Selma - ONYX

These wishes should be collected by the faculty and transmitted via the TU or directly to BPS GmbH.

Finally, we would like to thank our colleagues at the Examinations Office for Mechanical Engineering for their flexible support in clarifying a wide range of problems in the organisation and administration of the examinations, the staff at ZILL for their active support in preparing and conducting the online examinations by providing training, documents and a critical look at the courses, and also the ZIH for the stable computing technology.

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Possibilities of OpalExam to improve exam assessment and viewing

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Abstract

Durch die Umstellung von Präsenz- auf Onlineklausuren stehen Lehrende vor neuen Herausforderungen. Dabei geht es nicht alleine nur um die technische Herausforderung, sondern auch um den eigenen Anspruch, Klausuren online so zu modellieren, dass Betrugsversuche entweder verhindert werden können oder dem Betrügenden keine Vor- sondern Nachteile bieten. Lehrenden stehen dabei während der Klausurmodellierung in OpalExam verschiedene Möglichkeiten zur Verfügung: Definition von Zufallswerten durch Verwendung von Variablen in der Aufgabenstellung, Erstellung mehrerer Varianten einer Aufgabe, die den Studierenden zufällig zugewiesen werden oder auch Änderung der Aufgabenreihenfolge für die Studierenden und Definition eines linearen Durchlaufs durch die Klausur. Die einzelnen Optionen können dabei natürlich auch kombiniert werden.
Wird ein nichtlinearer Verlauf (Studierende können zwischen den Aufgaben beliebig hin- und herspringen) durch die Klausur angestrebt, so werden die Klausuren durch die Wahl der ersten beiden Optionen komplexer. Für Studierende wird dadurch zwar die Zusammenarbeit erschwert, die Bewertung der Antworten des Studierenden durch den Prüfenden allerdings auch. Innerhalb dieses Aufsatzes werden deshalb Möglichkeiten aufgezeigt, wie der Bewertungsaufwand gesenkt und dabei gleichzeitig die Klausureinsicht erleichtert werden kann.

The switch from offline to online exams presents teachers with new challenges. Not all challenges are technically, a challenge is also the own demand to model online exams so that cheating attempts can either be prevented or do not offer advantages but disadvantages to the cheater. Teachers have various options at their disposal when modelling exams in OpalExam: Definition of random values by using variables in the assignment, creation of several variants of an assignment that are randomly assigned to the students or also change of the assignment order for the students and definition of a linear run through the exam. Of course the individual options can also be combined.
If a non-linear progression (students can jump back and forth between tasks at will) through the exam is the goal, the exams become more complex by choosing the first two options. While this makes it more difficult for students to collaborate, it also makes it more difficult for the examiner to evaluate the student's answers. In this paper, it will be shown how the assessment effort can be reduced while at the same time making it easier for the students to review the exam results.

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1. introduction

Switching from face-to-face to online examinations presents teachers with new problems and challenges. In addition to the restructuring of assignments and technical problems and challenges that arise, see e.g. [1, 2], attempted cheating is a serious problem, cf. [3, 4, 5]. In order to prevent cheating through collaboration without online proctoring, assignments can be individually tailored to students, but this can significantly increase the effort required for assignment creation, assessment and viewing. In this regard, Onyx in OpalExam includes several features that can simplify exam marking and review. Section 2 gives an overview of current possibilities to avoid cheating during exam creation in OpalExam. Section 3 discusses the advantages and disadvantages of the resulting more complex modelling. The documentation of the achieved points per answer for tasks with multiple task fields is not yet available as a setting in Opal. Nevertheless, this can be realised is described in section 4. Awarding partial points to answers that do not correspond to the correct solution, e.g. because a term was forgotten in the calculation, is only possible in Opal when using question type “formula comparison”. A documentation of the necessary programming is given in section 5. The consideration of consequential errors in longer calculation tasks is also possible with question type “formula comparison”, described in section 6. Finally, a summary of the possibilities described here follows in section 7.

2. Ways to avoid fraud attempts

When using the test function in Opal or OpalExam, assignments and tests can be modelled in Onyx and made available to students online. If examinations are conducted online, collaboration between students cannot be ruled out. This could take the form of several students theoretically sitting next to each other with their laptops or even being connected via video chat. Control by the teacher is difficult or even impossible, especially in the latter scenario.

The only option is to model exams so that the result of collaboration between students leads to large time losses and thus becomes less attractive to students.

There are several ways to do this:

- The use of random values in the task by defining variables,
- the creation of several task variants,
- changes in the order of tasks and setting a linear progression through the exam.

If only the task order of an exam is changed, students cannot work on the task together via video chat, but they are still able to exchange results with each other if they all have the same numerical values, questions or pictures. A simple screenshot can be exchanged very easily. In addition, a big difference to presence is that students can no longer switch back and forth between individual tasks at will by setting the linear progression. If a non-linear progression is set instead, so that students can switch between tasks at will, the effect of changing the sequence of tasks is almost cosmetic.

An improvement can be achieved by using random values in the task. For this, the given variables, e.g. length *a*, are assigned a random number. This is done by introducing variables that are automatically assigned when the task is called up by the students and integrated into the task text, see Fig. 1. These variables are referred to in the following as pre-submission variables, since their values are already fixed for the students before the task is submitted and can no longer be changed.

For these pre-submission variables, e.g. number intervals with step widths to be defined can be set in the "Variables" tab of the task, Fig. 2.

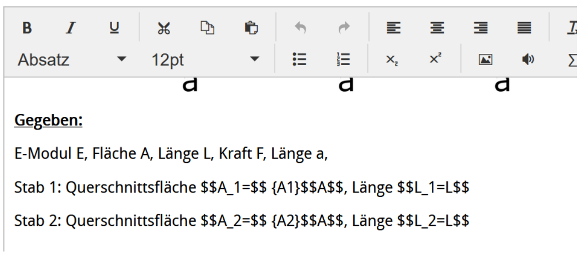

Fig. 1: Inclusion of pre-submission variables in the task text

The students get automatically assigned numerical values that differ from those of their fellow students when the task is called up. In this way, at least the copying of numerical values can be avoided.

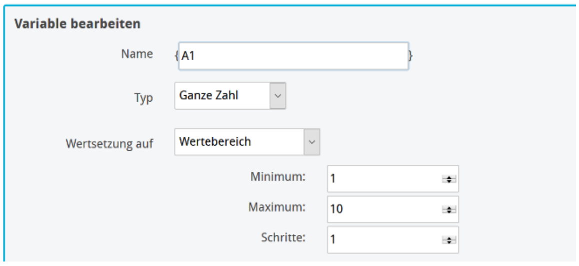

Fig. 2: Definition of an interval of random values for a pre-submission variable

What is still possible, of course, is sharing the solution path among several students. To prevent this, different versions of a task can be developed, see Fig. 3. This option is comparable to the output of A and B exam versions in offline exams, if the necessary space between two students could not be maintained in the past.

Due to minor changes in the assignment, a 1:1 adoption of the fellow students' solution is no longer easily possible. Instead, orientation on another students solving for a different exam version can lead to loss of time and points if the student has to find the differences or overlooks them.

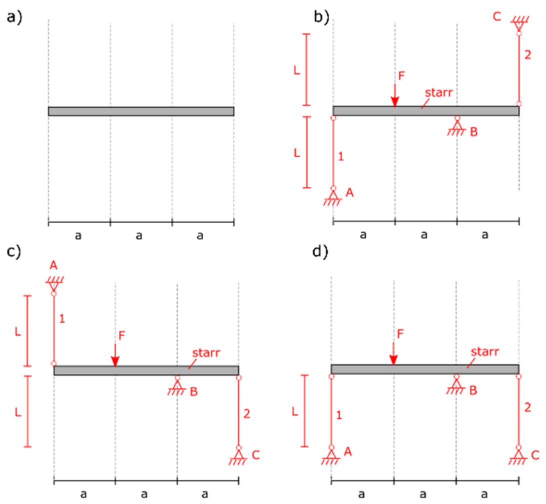

Fig. 3: Representation of different variants for an assignment: a) Examination template for the students, b)-d) Variants of the assignment.

3. Advantages and disadvantages of complex modelling

A combination of random values and task variants thus makes copying and collaboration less attractive for students. However, for the modeller of the exam, this also increases the modelling effort and thus the complexity significantly. In addition, there may be time differences in the assessment of the exam when the automatic evaluation is checked. In contrast to an attendance exam, correctors are no longer able to recognise the error in the solution at first glance based on the result alone, since each student receives their own numerical values and have different task variants.

Modellers therefore have two options: Either to model the exam tasks and their result queries so closely that a re-assessment or awarding of partial points by correctors is not necessary. However, with a close-meshed result query, there is quickly the danger of already having to specify a solution path, which lowers the degree of difficulty of the exam.

Or to have the examination assessment in mind already during the modelling of the examination and create the tasks so that an allocation of partial points, a consideration of consequential errors and a documentation of achieved points per answer and not only per question is automatically possible. The second variant leads to a faster, because clearer post-assessment and fewer questions from students during the subsequent examination.

4. Display of achieved points per answer for tasks with several answer fields

Within the exam modelling, tasks can be created where students have to give more than one answer, e.g. “numerical input interaction” with several gaps or a “choice interaction” with several choices. However, the Opal evaluation only shows the total score of the task and the information right/wrong for each answer. The information on how many points were scored per answer is missing.

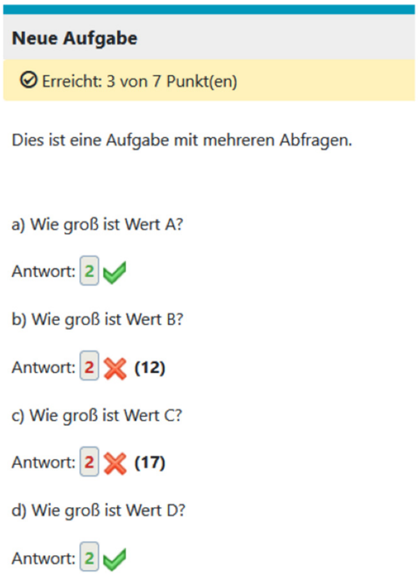

Fig. 4: Display of the evaluation of a task with several gaps. Only the total score is displayed at the top, [6].

If all answers have the same level of difficulty and each gap is assigned the same number of points, this is not a problem in the evaluation. If, on the other hand, the individual answers are to be weighted differently, there is no indication of the points achieved for each answer. This leads to unnecessary difficulties when correcting the automatic evaluation and viewing the exam, see Fig. 4. Therefor it makes sense to display the number of points achieved after each answer.

Post-submission variables can be used to display points achieved per answer, cf. [6]. These are integrated into the task text in the same way as pre-submission variables, but only assigned values after the task has been submitted. Post-submission variables do not appear for students during the exam and only become visible when the exam results are viewed. In addition to displaying the points achieved per answer, post-submission variables can also be used to display explicit information for the scorers or for exam review.

The post-submission variable is defined in the "Variables" tab below the pre-submission variable. Post-submission variables can also be assigned text, fixed values or variable values. Unlike pre-submission variables, post-submission variables can also access the programme-internal variables SCORE, MAXSCORE, MINSCORE, LEARNERRESPONSE, etc.

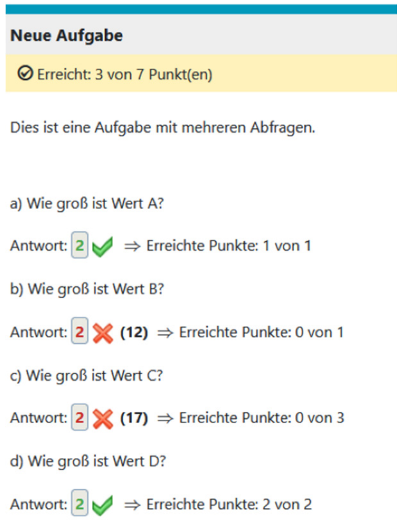

Fig. 5: Extension of the task by post-submission variables to display the achieved points per gap, [6].

If, for example, the post-submission variable "{1Score}" is defined and set equal to the internal programme variable "SCORE_GAP_1", this variable contains the score achieved by the student after answering gap 1. If this variable is included in the task text, the score achieved by the student appears in the task text after submission, see Fig. 5.

In [6] a step-by-step guide on how to use the post-submission variable to display achieved points per gap is documented.

5. Award of partial points

An extension of the scoring for correct and incorrect answers by partial points can also be realised during the examination modelling. The basis for this is question type “formula comparison”, cf. [7]. The maximum number of points for the gap is still defined via the setting option "Points" of the gap. The correct answer is also still defined via the "Solution" field.

In order to award partial points, the gap type "Formula" must be used in expert mode, which enables the possibility of programming an if-else condition. The evaluation criterion must be changed from "True/False" to "Points", see Fig. 6.

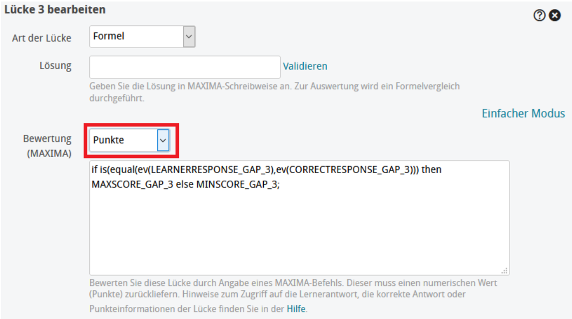

Fig. 6: Captions in Open Sans, 9pt, italic, left-aligned. 4pt spacing before caption text, [7].

The default is an if-else condition that checks whether the student answer (LEARNERRESPONSE) corresponds to the correct answer (CORRECTRESPONSE). If this is the case, the student receives the maximum score (MAXSCORE), otherwise the minimum score (MINSCORE), i.e. 0.

In order to be able to award partial points in addition to the maximum and minimum scores, the if-else condition must be extended by an additional condition. For this purpose, another if-else condition is modelled, which checks whether the student has, for example, a deviation of 1 from the correct answer. If this is the case, the student still receives 1/3 of the maximum score, see Figure 7.

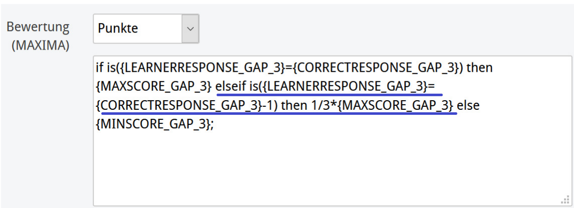

Fig. 7: Extension of the programming by another if-condition(marked blue)

If the full number of points for the task is no longer awarded to the student, Opal indicates this in the evaluation by awarding a yellow tick, see Figure 8.

Since 30.03.2021, the green and yellow ticks as well as the red crosses are also displayed in the assessment PDF when exporting via data archiving, [8]. The display can thus also be used for exam assessment and viewing.

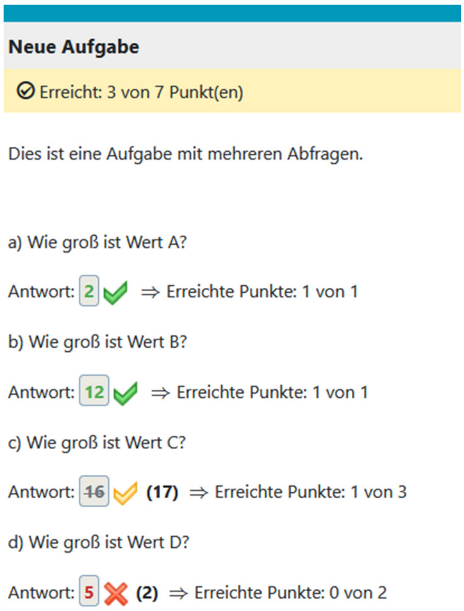

Fig. 8: Representation of the evaluation of correct, incorrect and partial points, [7].

6. Consideration of consequential errors

In the evaluation of presence examinations, the evaluation of consequential errors accounts for a large proportion of the examination evaluation time. In order to reduce this proportion, the automatic examination evaluation can be used. This makes sense especially for exams with a large number of participants.

If it is to be possible to evaluate consequential errors within a task, there are various ways how this can be realised. A discussion of this can be found in [9].

For a non-linear examination modelling, the question type “formula comparison” is used here. Within the expert mode, the option "Points" is still selected.

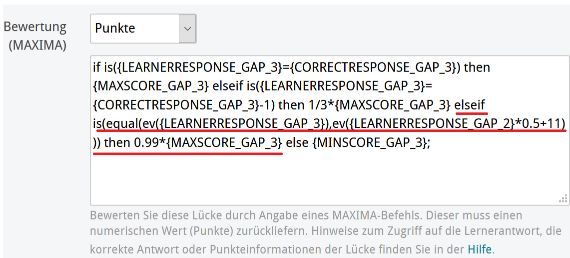

Fig. 9: Addition of another if-condition to the Maxima programming (underlined in red)

The extended if-else condition defined in section 5 is extended by another if-else condition to take into account a consequential error from gap 2. In the case of a wrong solution, this condition asks whether the wrong solution has arisen as a consequential error. If yes, points can also be given based on this, if no, the student receives 0 points.

Fig. 10: Automatic evaluation with consideration of consequential errors

In Fig. 10, 1% of the achievable score of the gap was deducted for a subsequent error. Due to the small deduction, the gap was evaluated as partial points, cf. section 4, and marked for the corrector. The size of the deduction can be freely chosen when modelling the task.

Fig. 11: Automatic evaluation with assessment and separate indication of subsequent errors

If it should become even clearer that a subsequent error was evaluated here, a post-submission variable {3FF} can be defined, which in the case of a subsequent error takes the text value "Subsequent error!" and otherwise the value "", Fig. 11.

To do this, an if-condition must be created for the post-submission variable, see Fig. 12. Afterwards, the post-submission variable can be included in the task text in the same way as the other post-submission variables.

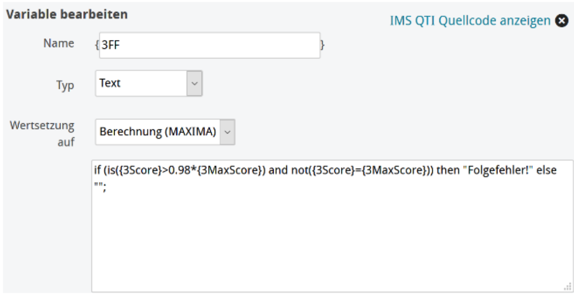

Fig. 12: Creation of the consequential error text variables for gap 3

7. Summary

The conversion from offline to online exams holds some hurdles. To minimise cheating attempts, transcription and collaboration must be made unattractive. This goes hand in hand with an increase in the complexity of task modelling. In order not to cause an increase in the assessment effort, post-submission variables can already be used during the task modelling or formal gaps can be programmed.

It should be mentioned that this increases the time needed for modelling and checking the tasks. However, if the use of digital exams is still planned in the future, e.g. in combination with an offline examination [9], the modelling effort can be worthwhile if similar tasks can be generated from the existing ones in the subsequent examination period through minor adjustments. Therefore, this can create a pool of tasks that specifically and permanently minimises the examination assessment time.

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Online examination with OPAL, ONYX and MAXIMA – opportunities and limitations

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Abstract

Der Transfer klassischer Präsenzklausuren in digitale Formate ist perspektivisch wohl unumgänglich, um als Teil einer zeitgemäßen und qualitativ hochwertigen Ausbildung auch zielorientierte sowie anspruchsvolle Leistungsüberprüfungen durchzuführen. Im Rahmen dieser Veröffentlichung skizzieren wir an konkreten Beispielen die Chancen und Grenzen der Testplattform ONYX in Zusammenspiel mit dem Computeralgebrasystem MAXIMA unter Nutzung des Lernmanagementsystems OPAL bei der Umsetzung zweier Online-Prüfungen mit bis zu 500 Studierenden. Interessant sind dabei insbesondere die beobachteten Verlagerungen der Arbeitsanteile hinsichtlich Konzeption, Klausurbetreuung und Korrektur, die wir vorstellen und deren Auswirkungen wir diskutieren.

The transfer of classical classroom examinations into digital formats is probably inevitable in the future in order to carry out goal-oriented and demanding performance examinations as part of a modern and high-quality education. In this publication, we outline the opportunities and limitations of the ONYX testing platform in conjunction with the computer algebra system MAXIMA using the learning management system OPAL in the implementation of two online examinations with up to 500 students. Of particular interest are the observed shifts in the proportion of work with regard to conception, examination supervision and correction, which we present and whose effects we discuss.

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1. Introduction

In the summer semester 2020 as well as in the following winter semester, both semester-accompanying learning level self-evaluations for the students and the semester-end examinations were successfully implemented digitally at the Chair of Magnetofluiddynamics, Measuring and Automation Technology as part of the course "Measuring and Automation Technology".

The lecture series "Measuring and Automation Technology" is divided into summer and winter semesters and is completed with one examination each. Both examinations were previously divided into a basic part with 10 individual questions and a calculation part with 4 complex calculation questions. Experience has shown that the number of participants in this course drops from over 500 students to about 400 from the first semester to the following semester. Regardless of the conception of the examinations, the correction of the entire question part required about 1 person-month each semester and about 0.5 person-months for each of the arithmetic problems. This means that the correction of examinations requires about 6 person-months of personnel per year.

Based on the positive feedback of the past years on supporting asynchronous and individualisable learning offers such as lecture recordings, scripts, literature and feedback channels, the planning of a supplementary online mock examination in the teaching management system (LMS) OPAL [1] was already started in 2019 in order to analyse the advantages and disadvantages of an online examination on the one hand and to provide students with a comprehensive asynchronous possibility for individual knowledge verification and examination preparation on the other.

The LMS OPAL used and the test suite ONYX [2] integrated in it are technically developed by the e-learning service provider BPS Bildungsportal Sachsen GmbH (BPS). "*BPS Bildungsportal Sachsen GmbH was founded at the end of 2004 by 11 Saxon universities to support them in the introduction and sustainable use of new media in academic education and training. Its core task is the best possible promotion of the broad use of Internet-supported teaching/learning scenarios in Saxony's higher education institutions and their associated institutions*" [3]. The "E-Learning" *working group* of the State Rectors' Conference of Saxony *"supports the universities in continuing the path successfully taken with the "Saxony Education Portal" initiative to bundle and jointly develop their potential in the field of e-learning [...]*" [4]. The open-source computer algebra system MAXIMA is integrated into ONYX.

With the beginning of the Corona Pandemic in spring 2020, the online mock examination, which was intended as a supplementary offer, turned into an alternativeless necessity for a purely digital guarantee of teaching. In this publication, we would like to take a critical look at the potential of online examinations implemented with OPAL, ONYX and MAXIMA. For this purpose, we provide insights into our approach, present selected examples of our implementations, present problems encountered, workarounds as well as solutions and estimate the time required in order to finally initiate a discussion on the opportunities and limitations of online tests compared to classical face-to-face implementations with our experiences. This also leads to further questions: What accuracy is achieved in relation to the overarching teaching/learning objectives? What complexity can be mapped? How time-consuming is an online test?

In addition, we will discuss the Element [5] communication platform used (based on the open-source Matrix protocol), with which the accompanying communication was successfully implemented.

In this publication we will address the above points chronologically from audit conception to audit evaluation and then formulate a conclusion.

2. Concept development

The central requirement for the implementation of an online examination concept on the basis of an existing, classical face-to-face examination concept is, on the one hand, the precise redefinition of learning objectives, if necessary by extracting them from existing examinations, and, on the other hand, the derivation of new questions that can be implemented, adapted to the possibilities of OPAL, ONYX and MAXIMA, with a focus on these learning objectives. In addition to knowledge of possible types of questions (e. g. in the ONYX test environment) for examinations in STEM subjects and a technical background knowledge, the authors consider a profound technical knowledge (in the sense of programming knowledge) for the parameterisation of ONYX ***questions***[1] by means of variables and for the implementation of mathematical questions with the computer algebra system MAXIMA to be essential.

Unfortunately, a central point of contact was still missing for the concept creation in the summer semester 2020 at the TU Dresden, which could clarify didactic, legal and technical questions in addition to organisational questions, actively accompany the creation of the examinations and/or arrange appropriate contacts.

With great commitment, the team of the "Centre for Interdisciplinary Learning and Teaching" (ZiLL) [6] was available in the following winter semester as a central contact point for these very questions and even provided accompanying support in the creation of tests. In addition, the "Digital Examination Task Force" was put together at the Faculty of Mechanical Engineering from voluntary experts who could advise colleagues with extensive experience on engineering-specific examination solutions.

3. Authors

In the course of the concept development, the question of the circle of authors for the generation of corresponding exams also arises, because subject-specific prior knowledge paired with the necessary specialised prior knowledge has - in the best case - only a very limited circle of people. A non-specialist eScout (a student with previous experience with the LMS OPAL used) supported us very successfully, but her and our expectations had to be adapted, because without the corresponding specialised knowledge, of course, no ONYX ***questions*** can be generated independently and only adapted to a very limited extent. As a result, the eScouts' tasks were limited to additional work in the areas of creating illustrations and entering prepared ***questions*** into ONYX on the basis of detailed instructions.

eScouts should therefore be selected according to the concrete requirements and their qualifications, whereby a combination of very different qualifications (e. g. psychology and physics) would be particularly helpful, but could probably only be represented in reality by interdisciplinary eScout teams.

While the main hurdle in the summer semester 2020 was still the rapid implementation of an online examination concept from the existing classroom concept and the associated familiarisation and empowerment of (co-)authors, in the winter semester it was possible to build on the developed basis with very good technical knowledge, for example in parameterisation of ***questions***, variable definitions, random values or MAXIMA functions.

In the winter semester 2020/2021, the energetic support of an eScout by the Media Centre of the TU Dresden was unfortunately no longer available to us, as they wanted to reach as many chairs as possible with the eScout programme. Considering the professional and technical skills imparted, we perceived this as a very unfavourable conception in the eScout project, as the effective benefit for our chair was very low overall. From our point of view, eScouts are very effective nuclei for personnel support and the dissemination of knowledge for the implementation of online content. Essential for this is a good to very good qualification of students as eScouts and, due to the training period, longer-term contracts of the eScouts to ensure a knowledge transfer as well as a real benefit for the educational institution. It would also be conceivable to empower student assistants from the chair.

4. Exam preparation

During the preparation of the exam, special features and bugs came to light in MAXIMA as

[1] Terms highlighted in ***bold italics*** indicate fixed terms or technical terms from OPAL or ONYX. The marking serves to differentiate from terms from general language usage. Example: A complex question was implemented as an ONYX ***TEST*** and each sub-question (of this complex question) was implemented as an ONYX ***QUESTION***.

well as in ONYX and OPAL, which we would now like to present together with our solutions or workarounds in the sense of a knowledge transfer.

When using the MAXIMA algebra system, some special features must be taken into account. For example, MAXIMA does not consider the commutative law for logical expressions, i.e. "a AND b" is not necessarily the same as "b AND a" and "c OR d" is not the same as "d OR c" either. In ***questions*** on Boolean algebra and logic***,*** this is of course quite a problem! However, this is not a bug in the true sense of the word, because the MAXIMA user manual clearly states that "AND is not commutative, because the expressions a AND b and b AND a can have a different result due to operands that have not been evaluated.

Care must also be taken when using the imaginary number i (defined in MAXIMA as %i). The expression 1/i is not directly interpreted as equivalent to -i in MAXIMA, but must first be "simplified" by using the function expand(1/%i) in order to be recognised as equivalent to -i. There are more examples here based on features of MAXIMA. The power of this open source computer algebra system is enormous, but for effective and reliable use, one must first become familiar with the "technology" here.

When planning the exam, nomenclatures for indices, for example, should be discussed in detail and checked for their suitability. The formula character ai, for example, would be entered as a[i] in MAXIMA, but as a_i in the LaTeX text typesetting system. For numerical indices, such as a1, the notation a1 would also be permissible in MAXIMA. In the preview function in ONYX, both MAXIMA and LaTeX expressions are interpreted, which is why an identical preview image is produced (Fig. 1) and the input thus appears equivalent to the students. However, since MAXIMA would only interpret the notation a[i] as an index, only this answer would be evaluated as correct. When querying a variable, this behaviour can be intercepted by storing alternative solutions in ONYX, which would, however, only be more time-consuming to solve for formula comparisons. In order to be equitable to the students and not to include the teaching objective MAXIMA in the syllabus, indices can also be prevented by using notations such as ai or AI - in any case, however, a consistent and uniform concept should be pursued here in assignments and solutions.

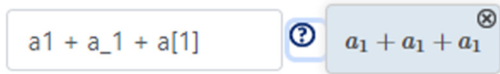


Fig. 1: Caution with indices. Different inputs by the students lead to seemingly identical results, which, however, are not interpreted in the same way by ONYX and MAXIMA.

And if one or all ***questions*** in ONYX suddenly stop working, it is advisable to check whether there may have just been a server update in which the ONYX or MAXIMA versions were updated (as happened during the examination phase of the 2020 summer semester, as a result of which some MAXIMA calculations became non-functional). It would be desirable to send all OPAL or ONYX users automated information about updates in advance.

But even real bugs sometimes lead to functional problems, e. g. ***questions*** of the type ***match interaction*** only worked with a maximum of four lines until July 2020, although you could insert more lines. Or with ***questions*** of the type ***matrix interaction,*** you could drag several elements on top of each other or lose elements in digital nirvana due to a programming error - here BPS reacted very quickly and was able to fix the bug in July with our advice. It is particularly annoying when ***questions*** can suddenly no longer be saved or the supposedly saved changes are not saved (Fig. 2).

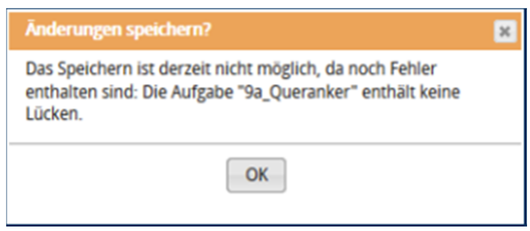


Fig. 2: Nerve-racking, because non *comprehensible ONYX errors (there were several gaps implemented in the task), which can only be circumvented by recreating the task.*

In our experience, copying the ***question*** helps in the best case or, unfortunately, more often only a complete recreation. And sometimes the only thing that helps with ONYX is logging off, going to sleep and logging on, so that ***questions*** suddenly work overnight. We could not always clarify why some of these problems occur and due to what circumstances. According to BPS, the system is regularly cleaned up automatically at around 2:00 a.m., which would at least be an explanation for the sometimes miraculous problem solving overnight.

A frequently recurring request from our team of authors was an offline tool for test creation, from which ***questions*** or even entire ***tests*** can be exported in order to import them into the ONYX ***question bank,*** for example. The background to this wish is that the nested structure, cumbersome creation of several variables, long loading times for pages and instability (presumably due to high server load) are an enormous time eater and put nerves to the test.

An exam is understood as a course element ***test*** in OPAL. The TU Dresden has decided to create a separate OPAL instance called OPAL Exam@TUD for exams, especially for stability and data protection reasons. The course element is usually linked to an ONYX ***test***, which consists of several ***questions.*** In addition, ***sections*** can be added as a structuring aid. The navigation type of a ***test*** to be defined as linear or non-linear has a significant effect. With a linear navigation of ***questions,*** students must therefore go through the exam step by step in the given pattern. A non-linear navigation would therefore be desirable, allowing students to choose an individual sequence of ***questions*** according to their strengths and weaknesses. However, this is not possible if only one ***question*** depends on another or if the solution to a previous ***question*** is given away with a following ***question.*** From the point of view of an author who is not so experienced in programming, the simple solution of defining a linear navigation within individual ***sections*** while being able to freely select between these ***sections*** in a non-linear manner seems obvious - unfortunately, this is not possible at present. In order to create a satisfactory workaround here, the MAT2 exam was therefore divided into 12 ***tests*** within a course element of the type ***structure***, of which each ***test*** represents a classic complex task or a topic block. In addition, a ***test*** for the declaration of independence was initially inserted. In order not to fix the time for each ***test*** rigidly and thus to allow an individual time allocation, the access to the course element ***structure*** was limited to the time for completion. However, another challenge comes into play - the consideration of different processing times for students with disadvantage compensation. Unfortunately, until the beginning of 2021, it was not possible to allocate students an additional time quota without interrupting the processing (mostly due to technical problems). For this reason, the ***structure*** module was duplicated in order to distinguish between students with disadvantage compensation and students with HISQIS registration (Fig. 3).

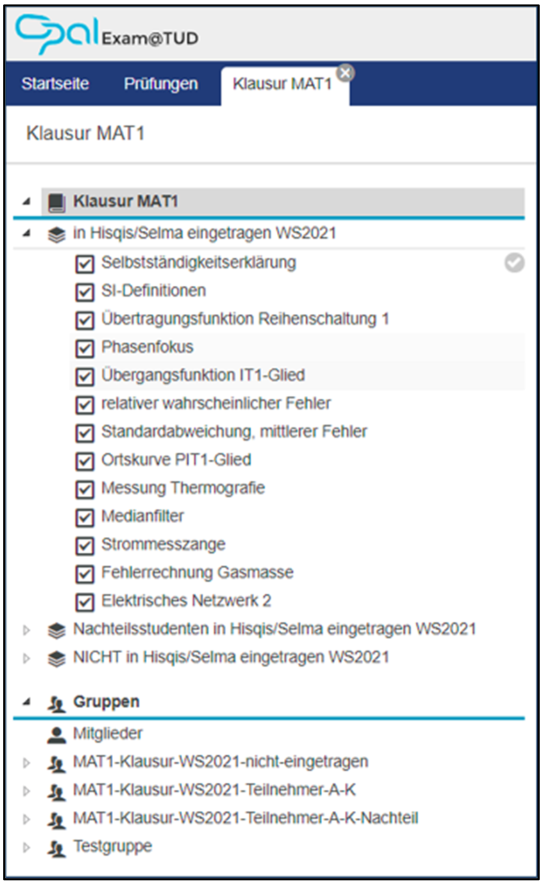


Fig. 3: OPAL "Structure" course elements as a container for a written exam with the questions as separate linear tests for combining linear and non-linear navigation.

However, the presented workaround also has its downsides, because when running the exam in exam mode, if a student has technical problems, it is first necessary to know in which test he or she was currently working in order to be able to e. g. continuation of processing.

In addition, it is necessary to repeatedly jump between tests in order to identify possible problems by means of the examination view. Furthermore, there is the aggravating side effect that when exporting the exam results, not one file but, in our case, 4 x 12, i. e. 48 individual files, have to be exported and harmonised with each other again. Consequently, it would be desirable to have an extended test structure that allows a combination of linear and non-linear contents.

In the summer semester of 2020, the work in ONYX and OPAL still surprised many special features or even bugs that were reported to BPS as the developer. In addition, wishes were expressed for the implementation of some missing functionalities. Essential points for us here were, on the one hand, the possibility to individually extend the processing time, for example, for students with disadvantage compensation (without there being any technical problems) and, on the other hand, the possibility to combine linear and non-linear test structures. This last point in particular is essential for acceptance and equivalence of online examinations. Students must have the possibility, according to their personal strengths, to individually divide up the processing time as well as the processing contents via a non-linear structure of a test. This is in contrast to the fact that more demanding, complex questions in particular can only be implemented as purely online variants with sub-questions that build on each other and have a linear navigation (without providing solutions to sub-questions on a silver platter).

It is pleasing that the individual time requirement of BPS was implemented shortly before the examination period in spring 2021. However, only in the context of one ***test***. This is not possible for OPAL course components of the type ***structure***, in which several ***tests*** are combined, see Fig. 3. Again, and therefore extremely annoying, is that the missing combination of linear and non-linear test structures affects the work of the item creators so massively! For us, this is the central weakness of the current ONYX test suite.

Unfortunately, this also resulted in the fact that the implemented individual time limit could not be used and the known, clear additional effort was created again, because a purely linear navigation does not represent a fair examination solution in our perception. In order to be able to provide a non-linear exam that also contains linear complex questions, all questions were therefore again defined as independent ***tests*** within a superordinate OPAL course element ***structure.*** Thus, an individual time increase within an ONYX ***test*** unfortunately had no effect on another ***test*** in the same OPAL structure element, which means that the newly implemented function for our case unfortunately completely missed its actual task. Instead of an ONYX ***test*** with 13 ***questions***, we had an OPAL course element ***structure*** as an exam with 13 linear ONYX ***tests*** as questions, as in the previous semester (cf. fig. 3). Since we also had to implement an increased processing time for students with disadvantage compensation, this exam structure had to be duplicated again in OPAL and in addition we needed another **structure** for students without HISQIS or SELMA entry, so that in the end there were a total of 39 ONYX tests.

In order to offer students supplementary security and to have a further basis for decision-making in the case of unclear errors, an ***upload interaction*** was integrated after computationally intensive sub-questions, in which students can upload handwritten notes or sketches (Fig. 4). Unfortunately, the file uploads sometimes led to significant delays under examination conditions.

Fig. 4: Questions integrated into a test for uploading handwritten notes after computationally intensive sub-questions.

5. Empowerment of students

As already explained, the syntax of MAXIMA must be learned - naturally also by the students. Therefore, it is essential to offer tests early in the semester to practise entering formulas in MAXIMA-compliant expressions, but also to practise using OPAL, ONYX, MAXIMA and feedback systems as well as your own hardware.

We also tried to alleviate this syntax problem by specifying a simple notation for variables with indices (e. g. DT = D_T), which was included in the respective ***questions*** as accompanying text via a global variable in the ***test.*** Nevertheless, questions arose several times during the exam, which is why tests accompanying the semester should not be dispensed with.

Uploading files, capturing (scanning, photographing) and compressing files or a realistic assessment of the stability of the home internet connection are also relevant.

Accordingly, uniform rules for OPAL, ONYX and MAXIMA across faculties would be desirable. Perhaps introductory courses for these tools could be offered to students with tips and suggestions for homework and online examination situations. In this way, students and teachers could build on a foundation that would be essentially identical for all courses and chairs.

6. Audit supervision

The support and supervision of students during an examination is of enormous importance in digital formats and, in our view, seems absolutely necessary for a fair and successful online examination. Questions or problems of the students can thus be clarified or possible errors in exam questions can be quickly identified. The students' feedback confirms that just being able to address problems or questions to the supervisors would give them security and have a calming effect - they would not be alone during the exam. This is a value that should not be underestimated and a positive psychological effect.

The preparation phase until the finished online exam is long and intensive - all data is revised umpteen times, checked for comprehensibility and correctness of content. Then comes the exam and (of course) students find an error in the assignment! What to do? All students must now be informed as quickly as possible about the procedure, but how?

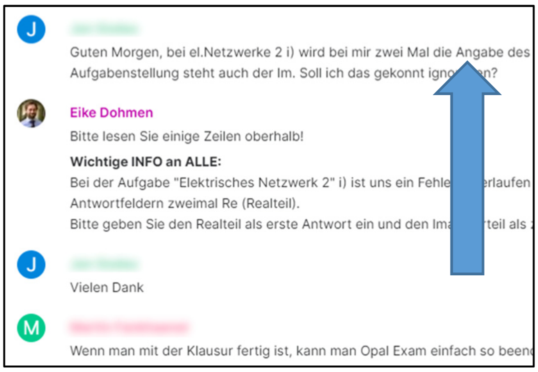


Fig. 5: Excerpt from an exam-related chat room: What to do if mistakes are discovered during an online exam?

Accompanying the OPALexam servers, we moderate individual chat rooms with about 80 people each at the Element instance of the TU Dresden (matrix.tu-dresden.de), which is based on the open-source messenger protocol Matrix. Over two semesters and several exams as well as internships, the platform has proven to be very reliable, fast and efficient for internal communication as well as exam supervision. The chats are predestined to distribute essential information almost instantaneously to all students. However, due to the chat structure, essential information also "wanders" quickly out of sight and must therefore be posted again regularly so as not to disadvantage anyone (Fig. 5).

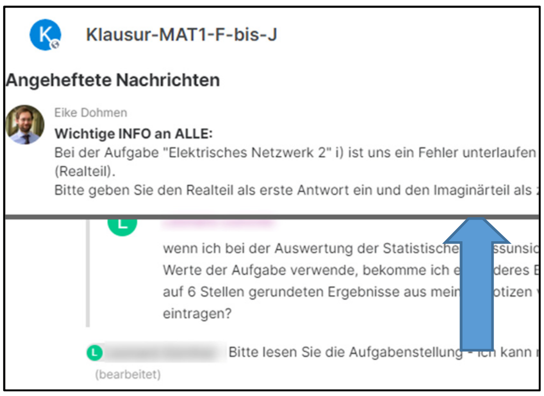


Fig. 6: Looking into the future: with the lab function "Pin", important messages can remain permanently in view for all members of a room.

During the MAT 1 exam in this winter semester, 99% of all students were successfully informed of an error in the assignment using the Matrix chat. In order to enable the permanent provision of essential information in the chat, there is currently a functionality in Matrix in the laboratory stage, whereby messages are permanently pinned directly below the room name (Fig. 6). In the future, this feature will also be available for all other users.

Protection through file upload

In addition to active support, the possibility of uploading handwritten notes or sketches, for example, is a helpful instrument to offer students additional security and to create a basis for decision-making in the case of unclear errors during correction. Accordingly, an ***upload interaction*** was integrated into the ***tests*** after computationally intensive sub-questions. Unfortunately, file uploads are a major reason for increased server load and sometimes require a relatively large amount of time, which students may then lack under examination conditions. An upload after the exam would remedy this, but it would increase the likelihood of inconsistent answers and attempted cheating.

Multi-tasking for the examiners

At the beginning of the examination period of the summer semester 2020, there were some clear performance bottlenecks in OPAL, which led to long waiting times and in one case even to a server crash during an ongoing examination, especially in the case of large examinations with a lot of "simultaneity" of user actions (such as uploads of results). Accordingly, a quick and easy solution was implemented during the exam period in summer 2020 by setting up three independent instances of OPAL exclusively for exams with the name OPALexam on servers at the TU Dresden. Unfortunately, this emergency solution remained in place for the examination period in spring 2021. As a result, the supervisors had to be logged on to three separate servers at the same time, in addition to any existing communication platforms, in order to be able to supervise the students during the exams (Fig. 7). In addition, connection problems, missing registrations or other technical problems with students could only be solved with exact knowledge of the first and last name (otherwise ambiguous), knowledge of a possible disadvantage compensation and knowledge of the most recently completed task.

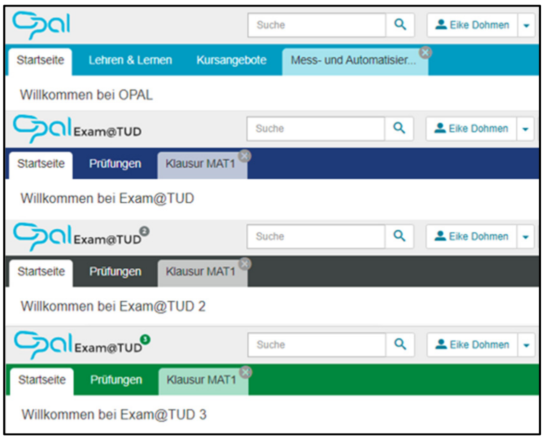


Fig. 7: OPAL, OPALexam, OPALexam2 and OPALexam3 - here multitasking of the examiners is required.

Due to these parallel structures, the supervisors had to be active simultaneously on three servers, each with three of the OPAL course elements of the type ***structure*** (with/without disadvantage compensation, with/without HISQIS/SELMA registration), each with 13 ONYX ***tests,*** and at the same time serve two communication channels (supervisors with each other, supervisors with students). If students wanted to be able to continue their work "quickly", they first had to know - as already described - the complete name, the server, the respective course element ***structure*** and the last ***questions*** worked on.

7. Examination control

Under the term ***examination control,*** a very helpful tool for controlling the examination and solving problems has been integrated into OPAL. Here BPS has implemented many improvements in 2020 and 2021, such as the display of the individual remaining time of students, the display of connection problems or an automatic continuation of the examination after disconnections. Nevertheless, improvements are still possible here as well. We present some selected special features or curiosities in the following.

Unfortunately, in some cases it did not seem possible to manually end the exam for a few students who were still working on it (Fig. 8). We suspect that this is a display error and hope that BPS will clarify or remedy this.

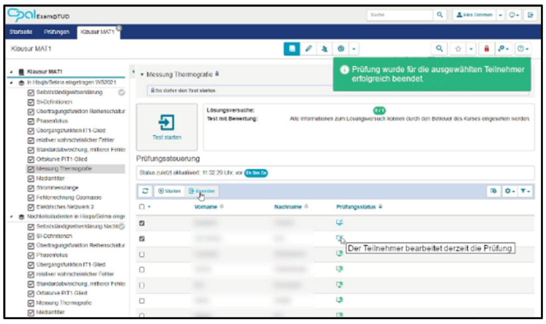


Fig. 8: Screenshot of the end of the exam - after expiry of the processing time (incl. any time buffer granted), some students continued to be displayed as "processing"; curious - even with the exam control, this status could not be changed.

A few students in our sample examination with a processing time of 1 h still had more than 1 h remaining for processing after 1 h, which should be impossible according to our understanding (Fig. 9). In these individual cases, the mock examination had to (and could) be ended manually.

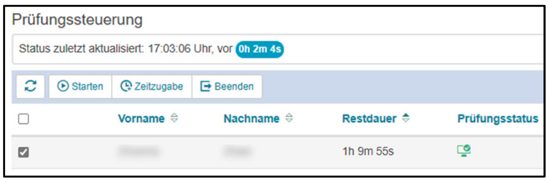


Fig. 9: Screenshot of the end of the mock exam - a student still has 1h 10m remaining time for processing, although the mock exam only had 1h processing time.

Examination period variable?

A student who started the exam just before the end of processing at 10:30 am reacted very angrily to the hard, manual end of the exam at 11:15 am and posted a screenshot revealing the reason for his indignation: at SELMA (the online portal for exam administration), the exam period was incorrectly listed from 00:05 am to 23:59 pm (Fig. 10).

Fig. 10: Screenshot of a student from SELMA - the whole day is shown as the examination time window.

8. Data export

The examination team was extremely relieved when the exam was successfully completed with over 500 students without any major incidents. Traditionally, our chair then publishes the first overview statistics on the distribution of points for the question section common in presence examinations on the same evening.

The very unfavourable fragmentation of the exam over several servers and substructures unfortunately drags particularly noticeably into the phase of data export and exam correction. Now all results from 13 ***tests*** in 3 course modules ***structure*** on 3 independent servers - consequently 117 individual tests - had to be downloaded, checked and, if necessary, re-evaluated.

Just for the corresponding data archiving from OPAL including the download of the 3.8 GB ZIP archives it took (with a good internet connection) almost an hour! After that, the Excel files with the test results had to be extracted from the archives, which unfortunately was still faster than downloading the Excel files alone in OPAL (because there is only one option for displaying the PDF file, i. e. each PDF file has to be displayed first in order to be able to save it afterwards. Now one of the authors had the honourable task of copying all 117 Excel files together in order to achieve an efficient correction at least afterwards. Basically, this was relatively quick, 2-3 working hours, ...

Presets and character sets

...if it were not for the fact that on all three OPALexam instances (OPALexam, OPALexam2 and OPALexam3) the export settings would have had to be set to his personal settings BEFORE the export, in order to always receive Excel files with the appropriate character encoding (Fig. 11).

Fig. 11: System settings for export format and character set.

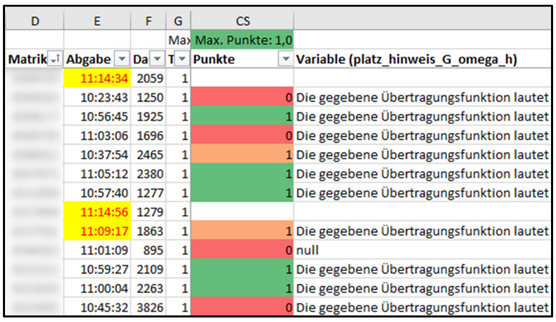
Specifically, three different basic settings for the export format were defined on the three OPALexam instances - apparently these basic settings are neither taken over by the existing OPAL account nor are they set uniformly. This may cause problems with data archiving (sometimes CSV, sometimes XLS) and especially with the recognition of numbers, which are interpreted as text depending on the character set!

All numbers were read in as text, which meant that all columns with numbers had to be converted into numbers (text in columns). But that was not enough, because when exporting the results of the questions with MAXIMA calculations, the ***learner response*** were exported with "." as the decimal separator, contrary to the other settings. Here are some pitfalls hidden in the data export that would vanish into thin air if only one OPAL instance with one ONYX test (for one exam) and one globally valid, simple default setting, whose effects are understandable even to the layman, were sufficient. The effort to adapt the software through BPS should therefore always be compared to the fact that many users have to wrestle with the additional expenses described.

Data loss?

With the merged table, an essential step for control and re-evaluation is made. In some cases, however, there were no variable values in the Excel table from the data archiving or these were declared as "null" (Fig. 12).

On the positive side, on the one hand the scores are correctly exported to the Excel file and on the other hand the examination view in the web interface fully documents the students' view of the examination in addition to their entries and makes it available as a PDF.



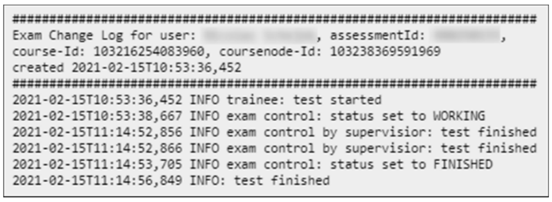
D	E	F	G	CS	
			Max	Max. Punkte: 1,0	
Matrik	Abgabe	Da	T	Punkte	Variable (platz_hinweis_G_omega_h)
	11:14:34	2059	1		
	10:23:43	1250	1	0	Die gegebene Übertragungsfunktion lautet
	10:56:45	1925	1	1	Die gegebene Übertragungsfunktion lautet
	11:03:06	1696	1	0	Die gegebene Übertragungsfunktion lautet
	10:37:54	2465	1	1	Die gegebene Übertragungsfunktion lautet
	11:05:12	2380	1	1	Die gegebene Übertragungsfunktion lautet
	10:57:40	1277	1	1	Die gegebene Übertragungsfunktion lautet
	11:14:56	1279	1		
	11:09:17	1863	1	1	Die gegebene Übertragungsfunktion lautet
	11:01:09	895	1	0	null
	10:59:27	2109	1	1	Die gegebene Übertragungsfunktion lautet
	11:00:04	2263	1	1	Die gegebene Übertragungsfunktion lautet
	10:45:32	3826	1	0	Die gegebene Übertragungsfunktion lautet

Fig. 12: Extract from the Excel evaluation table created with missing variable values (right).

A similar problem occurs when exporting floating point variables (float) from questions with MAXIMA calculations, where only 2 decimal places are exported. In an error calculation task, the variable delta_p_global_e was not exported with 1.140762589549 as specified, but ended up in Excel as 1.14. Since further calculations are made on the basis of this variable, which must be specified correctly with 6 decimal places, only an analysis in the web interface helps. This is particularly problematic if an evaluation formula was specified incorrectly and a recalculation of the results is to be carried out for all students - the corresponding input data is then missing. Since it is not yet possible to intercept such errors by the examiners through an automated re-evaluation in the web interface, each variable would have to be exported manually in order to be able to re-evaluate.

Fig. 13: Progress log as a new, powerful feature in OPAL for examination assessment

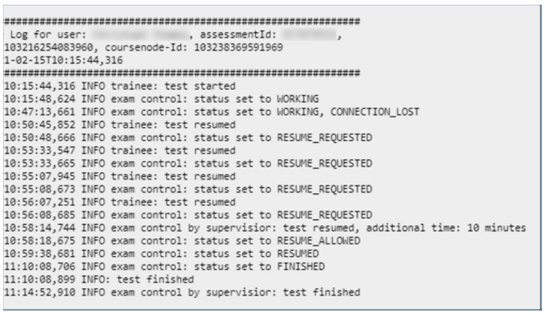
With the history log, BPS has implemented a powerful tool to track down problems based on the server logs (Fig. 13).



```
##############################################################################
Exam Change Log for user: [redacted], assessmentId: [redacted],
course-Id: 103216254083960, coursenode-Id: 103238369591969
created 2021-02-15T10:53:36,452
##############################################################################
2021-02-15T10:53:36,452 INFO trainee: test started
2021-02-15T10:53:38,667 INFO exam control: status set to WORKING
2021-02-15T11:14:52,856 INFO exam control by supervisior: test finished
2021-02-15T11:14:52,866 INFO exam control by supervisior: test finished
2021-02-15T11:14:53,705 INFO exam control: status set to FINISHED
2021-02-15T11:14:56,849 INFO: test finished
```

Fig. 14: Problem analysis with the progress log - exam termination by examiner (end of exam 11:00 a.m. - termination by examiner in the superordinate OPAL course element structure for all remaining participants 11:14:52 a.m.).

With regard to the above-mentioned problem with missing variables in the export file, it was thus possible to establish that the empty cells always occurred when examiners or students cancelled an examination (Fig. 14).



```
############################################################
 Log for user: [redacted], assessmentId: [redacted],
103216254083960, coursenode-Id: 103238369591969
1-02-15T10:15:44,316
############################################################
10:15:44,316 INFO trainee: test started
10:15:48,624 INFO exam control: status set to WORKING
10:47:13,661 INFO exam control: status set to WORKING, CONNECTION_LOST
10:50:45,852 INFO trainee: test resumed
10:50:48,666 INFO exam control: status set to RESUME_REQUESTED
10:53:33,547 INFO trainee: test resumed
10:53:33,665 INFO exam control: status set to RESUME_REQUESTED
10:55:07,945 INFO trainee: test resumed
10:55:08,673 INFO exam control: status set to RESUME_REQUESTED
10:56:07,251 INFO trainee: test resumed
10:56:08,685 INFO exam control: status set to RESUME_REQUESTED
10:58:14,744 INFO exam control by supervisior: test resumed, additional time: 10 minutes
10:58:18,675 INFO exam control: status set to RESUME_ALLOWED
10:59:38,681 INFO exam control: status set to RESUMED
11:10:08,706 INFO exam control: status set to FINISHED
11:10:08,899 INFO: test finished
11:14:52,910 INFO exam control by supervisior: test finished
```

Fig. 15: Problem analysis with the progress log - time expired (end of the exam with 10 minutes extra time 11:10 am).

For lines with only "none" as a variable value an expiry of the examination time during processing could be identified as the cause (Fig. 15).

9. Audit correction

In the course of redesigning our exams, we always tried to take the students' perspective into account. When correcting the exam, it then became clear that it is also necessary to look at the questions from the corrector's perspective. Which questions are efficient to correct and assess? Where do we run into decision-making problems? An example of this is the classic cloze test called ***text entry interaction*** in ONYX, in which students' vocabulary knowledge, sentence formation, dialect, existing keyboard and, last but not least, spelling must be taken into account in addition to their subject knowledge. For example, the following answers were given for a gap with the correct answer "additive", which would have to be re-evaluated as correct or at least discussed.

- additive Y+Z=Y2
- added
- adding
- additional
- per addition
- summary
- unites
- linked
- coupled
- together
- merged
- combining
- subjunctive
- positive

This multitude of correct answers for a simple ***text entry interaction*** is hardly predictable or interceptable. With a change from a ***text entry interaction*** to ***inline choice,*** these problems could be eliminated without significantly affecting the demand or value of the task. In another task, a student informed us that he had a Swiss keyboard and therefore no "ß", which is why he used "ss" for the answers in question. This "mistake" could be caught relatively well by alternative solutions, but here, too, the use of an inline choice is a reliable alternative.

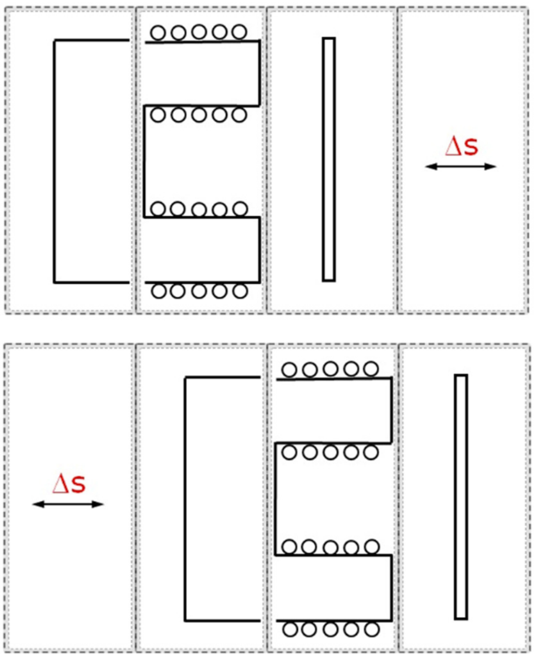


Fig. 16: Sample solution (top) and correct alternative solution (bottom) for the task: "Sketch the measuring principle of an inductive cross-armature displacement transducer".

Similarly unpredictable is the creative intelligence of the students that generates another correct solution in a supposedly clear ***match***

interaction (Fig. 16). Therefore, when assessing assignments, a manual check or correction of the answers must still take place in addition to the automated evaluation.

If a test is aborted during the processing of the last ***question*** (e. g. due to technical problems), it can happen that the automated assessment fails because randomly generated variables for task control are not saved. In our exam, this happened with several students in a complex task (realised via a ***test*** with several ***questions***) for control, in which the variable {task type} was randomly assigned "Taktstrasse" or "Mischer" at the beginning of the ***test.*** In the case described, however, the variable {task type} was empty, although some students had already answered all questions based on this variable. The students thus received zero points on their answers, regardless of whether they were correct or incorrect. This error can only be identified by a follow-up check of the answers. The data export to an Excel file proved to be helpful here, in which incorrect solutions could be highlighted in colour using conditional formatting and complex post-assessments based on formulas were also possible. Formula-based re-assessments were particularly helpful in the case of systematic errors, e. g. IF (task type = "Taktstrasse") AND (points = 0) THEN (additional points = +0.5). Regarding the data export it should be noted that the export format (especially the character set) can be defined in the personal settings of OPAL (Fig. 11).

One drawback of the Excel export is that online post-assessments including the reasons are not exported, which is why a combined online and offline assessment is currently only possible to a limited extent. However, this issue has already been communicated to BPS and will hopefully be taken into account in the next revisions.

Online correction is advantageous for an intensive examination of each individual answer of all students, as here the correctors are given clear, concise visual feedback with all relevant information (Fig. 17). However, the response speed of OPAL for loading the pages and the nested navigation are disadvantages. Unfortunately, the visual feedback is not exported with the PDF export (e. g. with the function Archive). The PDFs exported centrally into an archive can be opened and viewed much faster, but unfortunately this very helpful feature is missing. On the positive side, it should be noted that BPS is constantly developing the interfaces and that some new features have already been added here since the exam.

Errors happen and can only be identified through intensive, critical checks. Especially because of the complex structure of OPAL and ONYX, which is only partially transparent for the users, careless errors can hardly be avoided. Errors in content can only be identified efficiently by colleagues. However, in order to identify technical errors or problems in exams, a stochastic exam testbot (a programme that randomly generates results for a defined number of fictitious users) would be a conceivable suggestion from our point of view. This could be a programme that, for example, answers questions with random values for 100 virtual examinees, cancels tests or skips questions, etc. and then exports the resulting data as a validation data set.

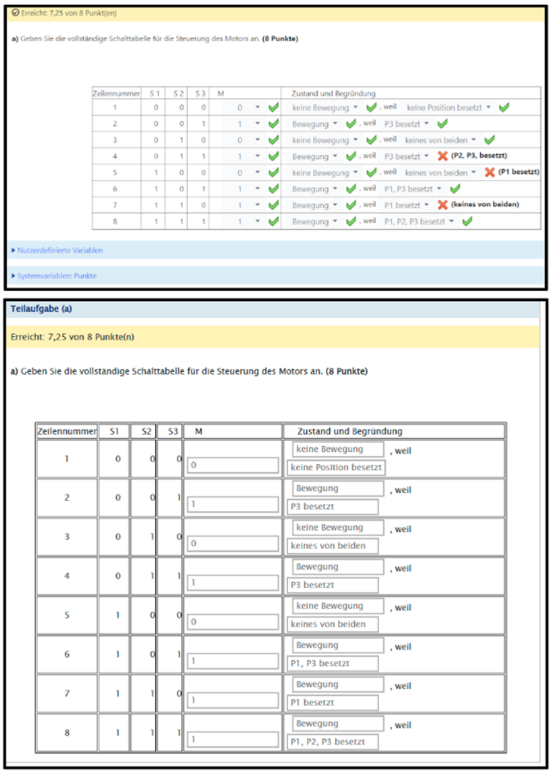


Fig. 17: Online assessment tool with visual feedback on the answers incl. the sample answer and variables (top) compared with the corresponding exported offline PDF (bottom).

Attempts to deceive

A closer look at the file names of the file uploads is interesting. On the one hand, there are indications of dubious recording sources (e. g. WhatsApp_Image_xyz) and, on the other hand, astonishing matches (e. g. "IMG20200728_081613_4.jpg"). Attempts at cheating could not be ruled out, but our perception was that very few students tried to cheat and that, especially in the summer semester 2020, the majority of students were actually rather happy to be able to take an exam at all.

In the following winter semester, however, it was claimed much more frequently that one had just mistyped or misclicked, but had evidence in the subsequently uploaded handwritten notes that one had wanted to submit something completely different. In this case, it is essential to have an unambiguous procedure that is clearly communicated before the exam in the form of framework conditions - in this specific case, that only the online entry counts and the uploads only serve as a supplement in the event of technical problems or in exceptional cases.

10. Potential assessment

In order to be able to present opportunities and limits, we would like to estimate the workload. A first (well-founded) examination statistic could already be generated a few hours after the examination. The correction of the entire question section took a total of about three person-days compared to about one person-month for the classic paper examination. Correcting the arithmetic problems took only two to three person-days per problem compared to half a person-month each. In total, the assessment effort was 12 person-days compared to the previous three person-months (approx. 60 person-days) per semester. This already includes the data export and data consolidation on a pro-rata basis. Irrespective of the enormous training and preparation effort, the pure correction time for the MAT2 exam could thus be reduced to 20%. The preparation time, on the other hand, was estimated at 6 person-months during the initial implementation and about 1-2 person-months in the following semester. This means that there was a significant additional time expenditure of up to 100% for the preparation. The cost estimate illustrates the particular potential of online examinations, especially by shifting the time spent from correction to the preparation of current questions adapted to the learning objectives, as well as making learning more flexible with increased accessibility. For teachers, the correction effort decreases dramatically, especially for exams with many participants (> 30 people). But the effort can also be worthwhile for smaller courses, since especially semester-accompanying learning status checks can be implemented in a similar way with OPAL, ONYX and MAXIMA and can then serve as the basis for an exam in a slightly modified form. In addition, the effort required to familiarise oneself with the technology and possibilities is significantly less after the first exam generation, which again reduces the time required for the preparation and implementation of exams.

OPAL & ONYX

The tools OPAL and ONYX used by the TU Dresden are developed by BPS. These tools play an important role in teaching and online examinations for our department, but also for the TU Dresden and the Free State of Saxony. On a positive note, the reliable, quick and consistently competent answers to problems, questions or suggestions should be noted. Although some of the suggestions (e. g. combination of linear and non-linear structures) are unfortunately waiting to be implemented due to the programming and associated financial effort. Here, the wishes and comments should be bundled and prioritised in a centrally coordinated manner (university-wide or state-wide). Our greatest wish regarding the functionality of ONYX would be to realise a combination of linear and non-linear ONYX tests.

Framework conditions

It would be essential to define the framework conditions at the TU Dresden for online examinations in a practical and concrete way, especially in the area of conflict between examination value, data protection, identity verification, examination regulations, but also with regard to adapted further training offers for teachers and students. After one year, there is still no solution at the TU Dresden to the issue of identity verification for online examinations that conforms to data protection regulations, which inevitably leads to a devaluation of examinations in terms of their actual informative value about the performance of an examinee and significantly reduces the value of the efforts of all those involved. It would be conceivable to create an eAssessment centre for online examinations with (several) central premises.

Central coordination office

In order to be able to offer a sustainable, competitive and attractive range of courses with online examinations across all chairs, a permanent central institution at a university with the appropriate personnel, space and technical equipment is required. This should not only be available on demand, but should proactively encourage the chairs to implement new teaching and examination concepts in the sense of excellent university development.

In this context, the "Centre for Interdisciplinary Learning and Teaching" ZiLL should be highlighted, which has taken on this task at the TU Dresden and provides competences, information, further education offers and contact persons for the implementation of online offers. It is to be hoped that the ZiLL will become an integral part of the university structure and thus be maintained in the long term.

But the commitment of the team of the TU's own messaging platform matrix.tu-dresden.de as well as the Task Force Digital Examinations, in which voluntary lecturers of the Faculty of Mechanical Engineering advise other lecturers on questions regarding the creation of examinations with their experience, should also be emphasised.

eScouts

eScouts are an excellent concept and for us represent nuclei for the transfer of knowledge about and implementation of online content. Interdisciplinary eScout teams and regular meetings of the eScouts could, in our view, help to really exploit the underlying interdisciplinary potential. At the same time, longer contracts for eScouts would make sense in order to provide financial security and ensure a transfer of know-how. It should be considered whether a corresponding financial incentive should be created for eScouts by classifying them higher in terms of salary than a student assistant - after all, further training and additional qualifications should be required to qualify as an eScout, and these should also be rewarded accordingly. Securing the basic eScout qualification, for example through an eScout Summer School or an eScout certificate, could achieve this and thus open up lucrative student jobs.

Conclusion

Regardless of the current, pandemic-related restrictions in face-to-face teaching, online examinations are thus a powerful and contemporary examination format for the authors.

11. Suggestions

In the course of the turbulent semesters, a number of ideas and suggestions have emerged with which we would like to stimulate or whose implementation would be desirable from our point of view and could lead to increases in efficiency. These are listed below in summary form:

- Combination of linear and non-linear navigation in ONYX tests
- Offline creation of ONYX tests
- Inter-faculty standards for platforms and nomenclature (MAXIMA)
- Introductory webinars in OPAL, ONYX, MAXIMA for students
- Server updates only with announcement
- a powerful OPAL instance
- Stochastic test bot
- Standardised eScout qualification
- interdisciplinary eScout teams
- Longer-term eScout employment

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We would like to thank Ms G. Haase, who successfully supported us in the implementation of the online content in the summer semester 2020 and was funded as an eScout from the project "Flexible Design of Study Programmes" (SFG) of the Media Centre of the TU Dresden to contribute to a more flexible study environment.

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