



The practical in the virtual - digital teaching at the ILK

M. Kuhtz*, R. Kupfer, C. Kirvel, A. Hornig, N. Modler, M. Gude

Institute for Lightweight Construction and Plastics Technology (ILK), Faculty of Mechanical Engineering, TU Dresden

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.

*Corresponding author: moritz.kuhtz@tu-dresden.de

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 platform 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.

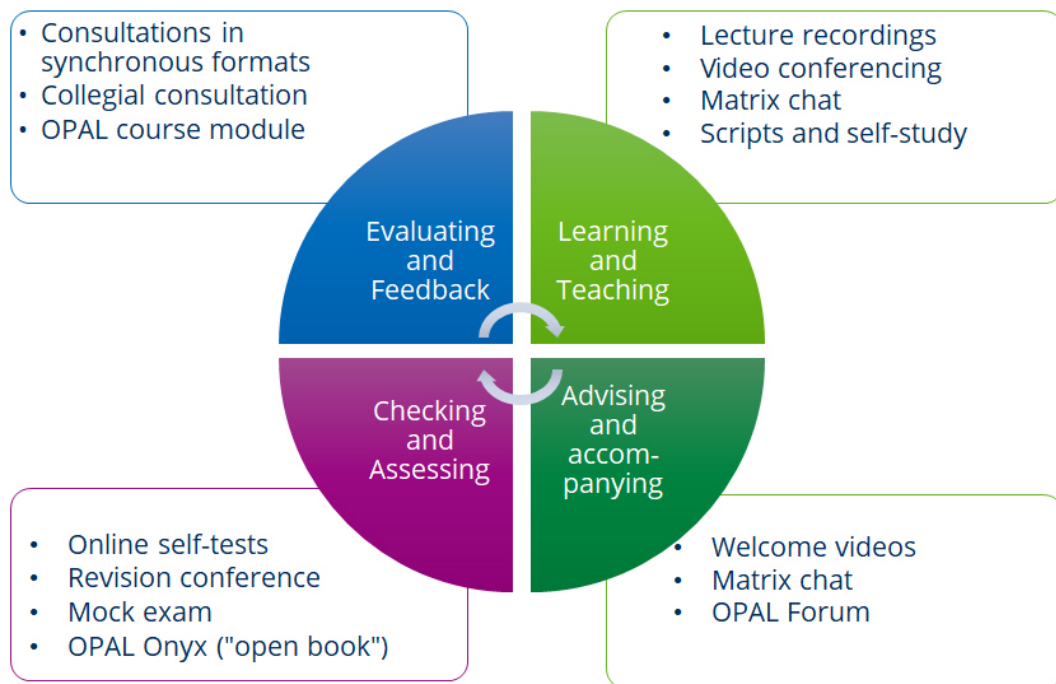


Fig. 1: Dimensions of the digital teaching-learning formats tested at the ILK with exemplary fields of application

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 there-

fore 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.

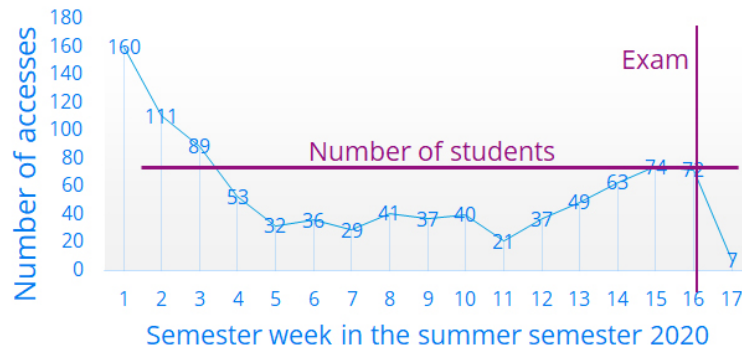


Fig. 2: Number of accesses to the Opal module "Teaching materials" in the subject BerFVS1

The virtual sessions were created in Power-Point 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.

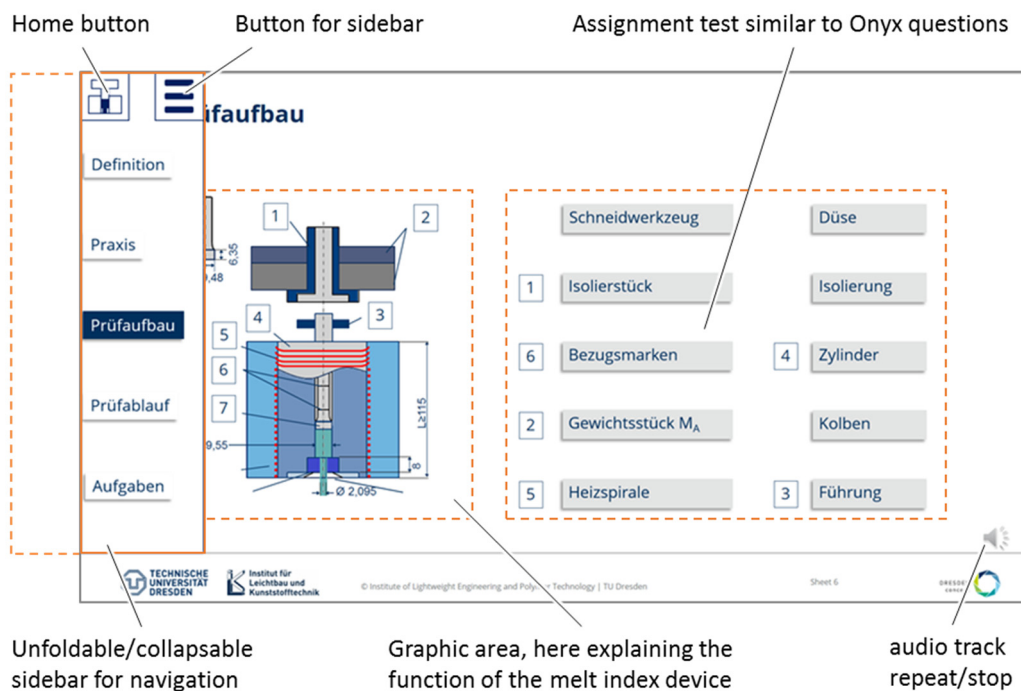


Fig. 3: Screenshot from the virtual practical "Melt index test". An intermediate test is shown in which the components are to be assigned. On the left - here folded out - is the menu area.

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 partici-

pate 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 sub-

ject 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.