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Virtual² - Simulation practical course in digital space

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Abstract

Im Praktikum zur Lehrveranstaltung Simulationstechnik besteht insbesondere in der digitalen Lehre zum einen die Herausforderung der Schaffung von Voraussetzungen zur häuslichen Bearbeitung der Aufgaben. Zum anderen sind die individuellen Voraussetzungen und Fähigkeiten der Studierenden im Sinne einer nachhaltigen Lehre zu berücksichtigen. Ein Lösungsansatz hierfür ist die didaktische Methode des Flipped Classroom, bei der die Stofferarbeitung anhand von vorbereiteten Materialien wie etwa Erklärvideos in individueller Verantwortung der Studierenden liegt. Dazu wird auch die Studentenversion der Simulationssoftware Simcenter Femap genutzt, die den Studierenden am heimischen Windows-PC kostenfrei zur Verfügung steht. Die eigentliche Praktikumszeit wird in der Anwendungsphase in Form von Konsultationen und digitalen Gruppenarbeiten nach der Methode des Aktiven Plenums zur Festigung und Vertiefung der erworbenen Kenntnisse genutzt.
Diese Methode bietet eine Reihe von Vorteilen in Bezug auf die didaktischen Herausforderungen wie etwa unterschiedliche Lerntempi der Studierenden oder Aktivierung der Studierenden. Insbesondere die digitale Gruppenarbeit in Form eines Aktiven Plenums fand großen Anklang bei den Studierenden, sodass viele Elemente dieses Lehrformat auch bei der Rückkehr in verstärkte Präsenzlehre beibehalten werden.

In the practical course for the course Simulation Technology, there is the challenge of creating the conditions for working on the tasks at home, especially in digital teaching. On the other hand, the individual requirements and abilities of the students must be taken into account in the sense of sustainable teaching. One approach to solving this problem is the digital method of the flipped classroom, in which students are individually responsible for working through the material using prepared materials such as explanatory videos. For this purpose, the student version of the simulation software Simcenter Femap is used, which is available to the students free of charge on their Windows PC at home. The actual practical training time is used in the application phase in the form of consultations and digital group work according to the active plenum method to consolidate and deepen the acquired knowledge.
This method offers a number of advantages in terms of didactic challenges such as different learning paces of the students or activation of the students. In particular, the digital group work in the form of an active plenum was very well received by the students, so that many elements of this teaching format will also be retained in the return to increased presence teaching.

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1. Didactic challenge

The practical course considered here for the course ***Simulation Technology*** is located within the module "Calculation of Lightweight Structures" (MW-MB-LB-04) and is offered each summer semester by the Institute of Lightweight Engineering and Polymer Technology (ILK). It is a compulsory module for students of lightweight design in the diploma program and in the diploma postgraduate program in mechanical engineering of the Technische Universität Dresden, whereby especially the postgraduate program is mainly used by foreign students. In addition, students of industrial engineering can take "Simulation Technology" as an elective subject in their specialized studies. This results in a very heterogeneous composition of the internship group with regard to previous knowledge, semester and language competence.

In terms of content, the practical course teaches methods for simulating lightweight structures. Essentially, the finite element method is used, the practical application of which is learned by means of the established software Simcenter Femap. This software is available to students free of charge as a student version for operation on a Windows PC within the framework of academic education [1], which is why it is predestined for the teaching-learning method used here. Furthermore, the included license is unlimited in time, and the model size is also not limited, so that the software can also be used beyond this course. On the one hand, this offers the advantage that students can consolidate and deepen the knowledge and skills acquired in the course later in their studies. On the other hand, this reuse motivates the students to learn how to use the software, as their personal competencies are expanded for a later professional activity.

As a result of the different study processes and learning levels with regard to the prerequisite knowledge, the prior knowledge of the students is very heterogeneous. Accordingly, five central didactic challenges arise: ***Different learning paces, learning success controls, activation of the students, linguistic competencies and adaptation of the examination***.

Due to their individual previous knowledge and their respective motivation, the students have very different learning speeds. Since the use of new software can rarely be learned "overnight", students receive feedback on their individual learning status through targeted learning success checks accompanying the course of the semester. In addition, it is necessary to activate students, as there is a risk, particularly in digital teaching-learning units, that students will not engage intensively with the subject content. In addition, the language competence (German or English) of many of the international students is insufficient for an intensive scientific-technical exchange from the teacher's point of view. Finally, the examination has to be changed according to the changed teaching-learning activities and the newly formulated learning objectives according to the concept of Constructive Alignment as well as due to the digital examination.

2. Solution approach: Flipped Classroom

The comprehensive teaching-learning concept established at the ILK, which includes the four dimensions of digital teaching: ***teaching and learning, advising and mentoring, testing and assessment,*** and evaluation and ***feedback,*** serves as the basis for successfully conducting teaching against the backdrop of the challenges described (Fig. 1).

The didactic method of the ***Flipped Classroom*** (also: Inverted Classroom) offers a number of advantages, especially in the teaching-learning activity presented here, and is therefore integrated into the context of the four dimensions of digital teaching. In this context, this method primarily addresses the area of teaching and learning. In contrast to classic forms of teaching such as a lecture, in which the subject matter is taught in the presence of the learner and applied to the learner, this method offers a number of advantages.

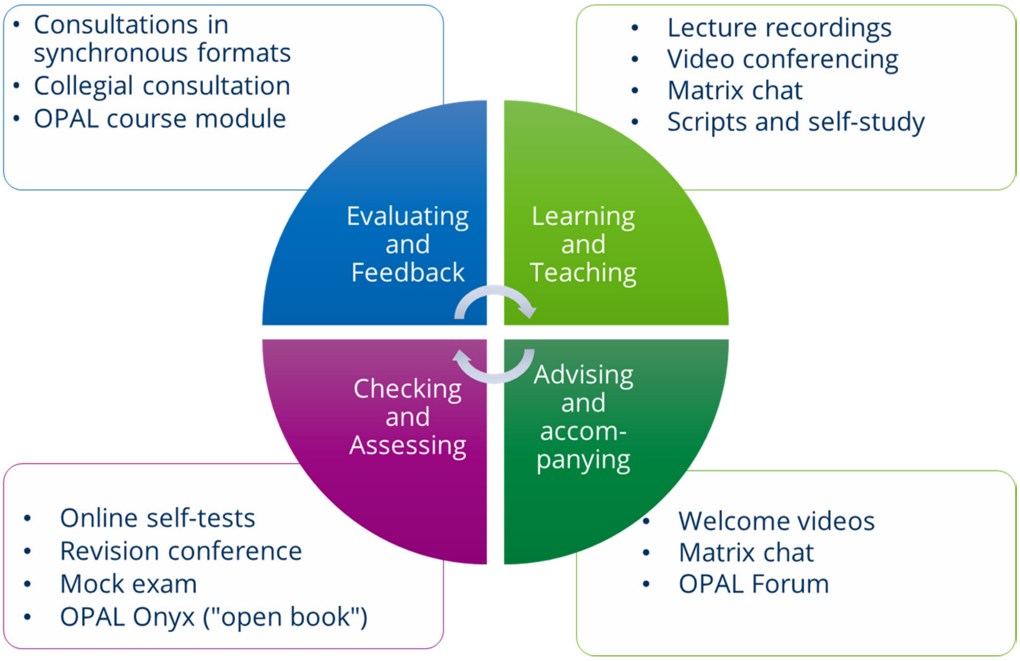

Fig. 1: Dimensions of the digital teaching-learning formats established at the ILK with exemplary fields of application [3].

This method reverses the roles of classroom and home learning [2]. Thus, in the asynchronous learning phase (development phase), the learning content is predominantly acquired by taking into account the learning objectives:

- watching the explanatory videos (tutorials),
- following the tutorials,
- the processing of the tasks and
- independent practice based on tasks without a sample solution

worked out independently by the students. In addition, the synchronous learning phase (application phase) is used to discuss, deepen and apply the learned contents. This method has already been successfully approached and implemented in many teaching-learning projects of the Faculty of Mechanical Engineering at TU Dresden [4,5] and beyond [6,7].

3. Teaching and learning

In the asynchronous learning phase (development phase), the learning content is primarily conveyed by tutorials with accompanying sheets. The videos were recorded as so-called screencasts with insertion of the teacher using the software ***OBS Studio*** and made available directly in the online platform for academic teaching and learning (OPAL) via the Video Campus Saxony. The production and provision of the teaching videos for the individual contents enables the students to work on the learning contents according to their personal prerequisites (learning speed, linguistic competence, etc.) and according to free time management. A consistent structure (introduction, main section and summary) and recurring stylistic elements in the videos provide a structure that students can use to orient themselves relatively easily. The insertion of a camera image into the screen recording makes the videos somewhat more personal and thus more enjoyable for most students, even in times of contact restrictions. The biggest challenge here is the time aspect of video production, which was significantly underestimated initially. In addition to minor technical difficulties such as noise in the home working environment, editing in particular is also very time-consuming. At the same time, the instructors are much more self-critical when re-watching a video with regard to linguistic formulations than in face-to-face events, which often leads to repeated recordings.

At the beginning and end of each semester, a synchronous online meeting takes place in the entire plenum. On the one hand, the first meeting serves to establish personal contact between teachers and students as well as to present and clarify the semester plan and organizational procedures. On the other hand, at the end of the meeting, a survey is conducted on the previous level of knowledge, organizational and content-related issues, and motivation. The answers are used to better assess the learning group with regard to its performance, so that individual teaching-learning sequences can be adapted as needed. In addition, it has been shown in previous semesters that receiving feedback from students has a positive effect on student motivation and the atmosphere within the course.

Originally, two online meetings in the form of an ***active plenum*** [7] were planned (Tab. 1). In this case, the students are given the opportunity to work together on the solution of a task. A fixed format is used: Presentation of the task and clarification of arising questions in the plenum, work in small groups as well as presentation of the group work and summary in the plenum. The ***Zoom*** conference tool, for example, is suitable for this purpose, as it is comparatively easy to send participants to work in small groups and then bring them back to the plenary session.

This format was particularly popular with the students, and the work results were also far better than expected, which is why this format was prioritized during the semester to the detriment of office hours. The other times of online presence were in the form of 30-minute study group (LG) office hours. Here, students are given the opportunity to ask professional, technical or organizational questions and to clarify misunderstandings. However, this opportunity was only used sporadically. The reason for this was, on the one hand, the partly insufficient preparation of the students and, on the other hand, the need for improvement in the reflection of the individual learning status, which was only achieved to a limited extent through the formulation of open questions. The online meetings at the end of the semester serve to clarify content-related questions and to test the content and technical aspects of the practical part of the exam (mock exam).

During the synchronous events, students are also encouraged to share the camera image in order to create a more personal and thus more pleasant learning environment and at the same time indirectly motivate students to actively participate in the course.

4. Advise and accompany

In addition to online meetings, students essentially receive advising opportunities through synchronous online meetings in individual or small groups. Individual problems can be solved by arranging individual consultation time as online meetings. Furthermore, the module "Forum" is available in the OPAL course, which serves for the exchange among the students as well as for questions to the lecturers and was mainly used with regard to the examination phase.

5. Check and asses

In addition to the summative examination at the end of the semester and the aforementioned survey at the beginning of the course, an informative learning success check based on the internship examples is also carried out in Active Plenary with and without sample solutions. This format provides an opportunity for students to compare their respective learning levels with their peer group of fellow students.

For the preparation of the examination, the established methods of the development and application phase are used. Thus, two ***mock exams*** are offered for parts of the course within the module or subject examination. While the first one primarily addresses the content structure of the questions, the second one is mainly intended to clarify the technical functionality of the online examination. So far, this worked smoothly, and the students were able to cope very well with the tasks, which were very similar to the exercises.

The exam at the end of the semester is a module exam and was conducted this semester as an online exam in the form of an "open book exam". The tasks for the practical part of the simulation technology with Simcenter Femap were set.

Based on the audit results, two main conclusions can be drawn: First, it can be seen that students who actively participated in office hours and active plenaries performed well to very well. Second, students with low participation

Tab. 1: Semester schedule

	Preparation phase			**Application phase**		
	Learning content	Method	Material	Application	Method	Media/ material
1	Enrolment and Overview OPAL Course	Self-study	OPAL	Introduction	Online-meeting	Zoom
2	EET, Graphical User Interface, First Aid	Tutorial	Videos and accompanying sheets (AS)	LG1, LG2, LG3, LG4	Consultation	Zoom, Forum questions Begleitblätter
3	Create or import geometry, meshing, mid-surface modelling	Tutorial	Videos and AS	LG5, LG6, LG7, LG8	Consultation	Zoom, Forum questions AS
4	Task 2.1 Beam elements with constant pipe cross-section: Dead load	Self-study	Task sheet (TS)	LG9, LG10, LG11, LG12	Consultation	Zoom, Forum questions AS
5	Task 2.2 Shaft with variable pipe cross-section: dead load and shear force	Self-study	TS	LG1, LG2, LG3, LG4	Consultation	Zoom, Forum questions AS
6	Task 2.3 Troubleshooting	Self-study	TS	Task 2.2	Active plenary	Zoom
7	Task 2.4 Shell meshing and 1D connections	Self-study	TS	LG5, LG6, LG7, LG8	Consultation	Zoom, Forum questions AS
8	Task 2.5 Mid-surface modelling and parameter study	Self-study	TS	LG9, LG10, LG11, LG12	Consultation	Zoom, Forum questions AS
9	Laminate-Modeller, Solid-Laminate	Tutorial	Videos und AS	LG1, LG2, LG3, LG4	Consultation	Zoom, Forum questions AS
10	Task 2.6 Laminate modelling	Self-study	TS	LG5, LG6, LG7, LG8	Consultation	Zoom, Forum questions AS
11	Task 2.7 Volume modelling	Self-study	TS	Task 2.6	Active plenary	Zoom
12	Task 2.8 Solid laminate modelling	Self-study	TS	LG9, LG10, LG11, LG12	Consultation	Zoom, Forum questions AS
13	Free practice	Self-study	OPAL	Conclusion	Online-Meeting	Zoom
14	Free practice	Self-study	OPAL	Mock exam	Mock exam	Evaluation

have achieved at most satisfactory performance. This group consists mainly of postgraduate students whose native language is not German. Here, it is suspected that students' lack of language skills inhibits their active participation in interactive formats of the application phase, resulting in professional deficits. Although language requirements were taken into account in the teaching videos, only very few students in this group took advantage of the opportunities offered by the consultation hour or the active plenum. The better activation of students with German as a foreign language remains as a didactic challenge.

6. Evaluate and feedback

In addition to the evaluation by the faculty, there was also a continuous evaluation in the application phase. For example, there are always opportunities for queries in the online meetings. The office hours give students opportunities to give feedback to each other and to the instructors. In addition, students were able to compare their learning status by comparing their exercise results with the sample solution or through discussion in the forum.

In addition, student feedback regarding the course was elusive. In the face-to-face discussions of the office hours, methods and materials were rated as "good" or "very good". However, few students actively participated in more structured feedback sessions, such as informal surveys at the beginning or end of a synchronous course. The feedback received was exclusively neutral or positive. Obviously, there is a certain feedback fatigue on the part of the students, because also the survey of the Center for Quality Analysis of the TU Dresden on the course contents specifically on the internship unit could not be statistically evaluated, because less than ten answer sheets were handed in among 80 students enrolled in the OPAL-course.

7. Conclusion

The didactic method of Flipped Classroom offers a number of advantages in the context of digital teaching, such as consideration of different learning paces, and fits well into the dimensions of digital teaching-learning formats. Therefore, it is planned to retain many elements of this teaching format when returning to intensified face-to-face teaching.

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