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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:

Applied biomechanics

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

Dental materials

- 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	OPAL (ONYX test)
VL 3	*Inverted Classroom*	Live consultation	Zoom
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).

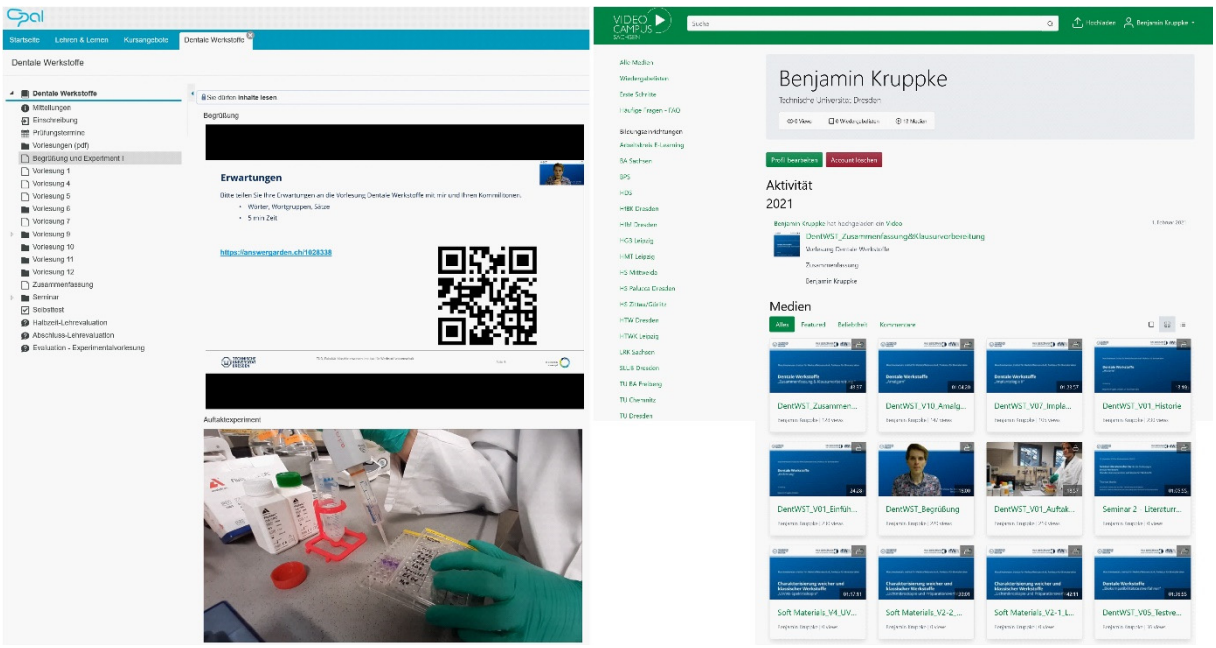

Fig. 2: Web pages: OPAL course Dental Materials with a single page and two videos embedded in it (left); the videos are hosted via Videocampus Sachsen (right) and can be accessed there after uploading and conversion in the media library.

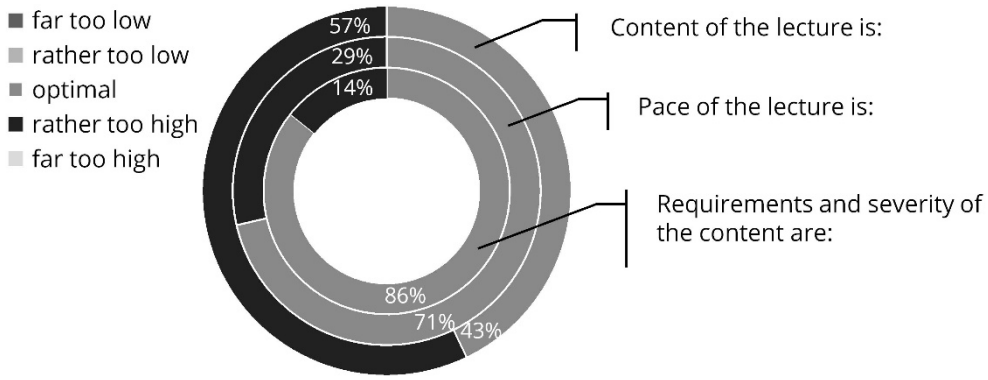

Fig. 3: Evaluation result for the predominantly asynchronous lecture in the "Applied Biomechanics" module

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 "tran-

sience" 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.

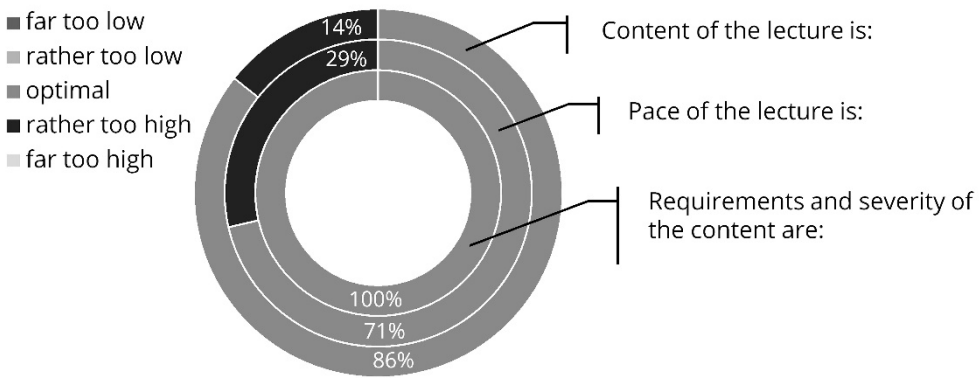

Fig. 4: Evaluation result after combination of different lecture methods in the module "Dental Materials"

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].

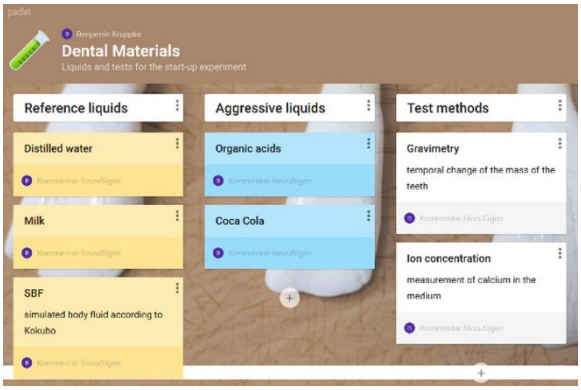

Fig. 5: Exemplary collection of notes on a digital pinboard - web-based asynchronous possibility to collect suggestions via padlet.com (according to [7])

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).

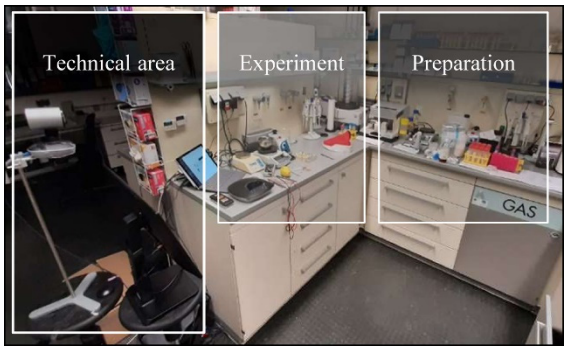

Fig. 6: Photograph of the laboratory with division of the three work areas (according to [7]).

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).

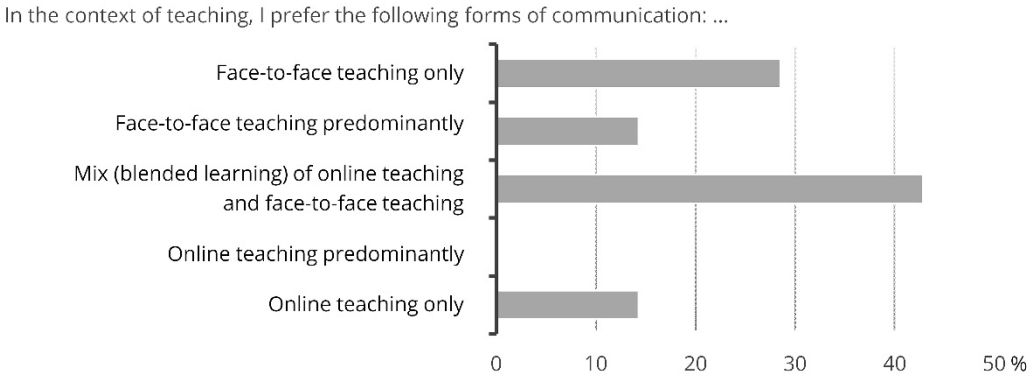

Fig. 7 : Evaluation result for online teaching versus face-to-face teaching in the dental materials module after implementation of the three-part lecture concept

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