The Negligible Impact of Lecture Videos on the Learning Progress in a Laboratory Course during the Covid-19 Pandemic

Anja Pfennig*
HTW Berlin, University of Applied Sciences, Wilhelminenhofstraße 75A, 12459 Berlin, Germany.

* Corresponding author. Tel.: 0049 30 5019 4231; email: anja.pfennig@htw-berlin.de
Manuscript submitted September 12, 2021; accepted November 18, 2021.
doi: 10.17706/ijeeee.2022.12.3.79-88

Abstract: During the covid-19 pandemic semesters of 2020/21 material science laboratory courses at HTW-Berlin had to be taught fully online to first year students of mechanical engineering and automotive engineering. Specially produced lecture videos are assigned and guide students through the laboratory routine prior to class. Students regard these lecture films as easy to use, supportive to individual study routines and scientifically helpful during self-study periods. They rated tasks and questions aligned with the learning outcome of the lecture videos as highly beneficial and –surprisingly- did not prefer face-to-face time. However, grades are much lower and much more students failed the class. This was directly related to the negative input of solemn studying, lack of human interaction, scientific discussions, lack of the possibility to fail and regain self-attentiveness as well as permanent online time. Otherwise highly supportive teaching material became negligible during the full online-semesters.

Key words: Covid-19, pandemic, laboratory, lecture films, inverted classroom, material science.

1. Introduction

Mechanical, automotive and economical engineering students are considered future maker of things [Ashby]. Therefore students should investigate and study with a strong practical motive and learn to match material properties in a design combined with supportive scientific education [Pfennig ICEEL 2020]. Therefore, Material Science is taught based on the "design-led" teaching approach in a blended learning course setting [1]-[6]. First students face the engineering product, then properties are introduced and later related to microstructure and atomistic structure and progressing to the physics and chemistry of materials [Ashby]. Teaching goal is the understanding of basic material science enabling students to transfer their knowledge early to engineering problems. Despite new evidence assigning success only for MINT courses that neglects progress for economic related teaching [3] the "inverted classroom" method [2]-[9] enables students to communicate and discuss early in a material science laboratory course.

Reporting on student learning challenges educators especially in practical laboratory classes. The quality of students` proficiency towards achieving well educationally benefits from standards-based assessment in contrary to the traditional score-based [10]. Standards-based assessments provide clear, meaningful, and personalized feedback for students [11] related to learning objectives and help to identify students` weaknesses in the course [12] if the course objectives are well defined beforehand [13]. Because the grading of a laboratory course has to provide quality information about student learning, it has to be

carefully planned and excellently communicated to be successful [14]. In a laboratory course a strong focus on theoretical background knowledge and verbal expression penalizes students with language difficulties and practically skilled students. Usually the lab skills count for at least 60% of the grade. However, in the Corona-online Semester of 2020 and 2021 a shift of fair-minded grading from assessing practical approaches had to be transferred into the virtual world. Therefore, the laboratory lecture video based nature of the laboratory course offered a promising alternative to practically teach online and grade practical rather than theoretical skills.

When lecture videos are considered as fundamental input during self-study periods of inverted classroom teaching scenarios [2], [7], [15]-[17] it is necessary to distinguish between audio or video recordings of lectures comprising at least 5 different techniques [18] and short lecture videos of scientifically relevant course material [19]. With providing an audio and visual stimulus covering different learning methodologies students rate lecture videos as easy to use effective learning tools [20]. Because they place significant value on the use of videos [21], [22] a positive effect on self-efficacy beliefs and intrinsic motivation is observed [23]. Use and expected outcome, however, have to be considered precisely, because only if the video included is analogous to the desired learning outcomes of the lecture [24] lecture videos are considered a reinforcement, rather than a replacement for lectures [25]. Students generally prefer online videos including self-assessing questions, as e.g. offered by H5P (https://h5p.org/). Rose et al. stated that interpolated questions increase the learner's engagement with the material [26] and help to boost actual performance [27].

Effective operation of the lecture films is based on students` experience and their special needs when preparing for specific topics in material science. Lecture videos implemented into laboratory course settings at HTW Berlin were therefore unexceptionally planned, produced and completed applying the "peer-to-peer" approach according to the 3I-model [2], [6], [16], [19]. As "peer-to-peer" [28] literally means "from students for students" involving students directly into teaching activities they are engaged in critical thinking [29], thus, producing deeper learning outcomes [30].

This study describes the teaching experience and learning outcome when a blended learning course concept is transferred to a fully online laboratory course. Experiences, success, failure and impact on future course design are considered and concluded

2. Course Setting

The material science laboratory course basically addresses first year students in mechanical engineering, economical engineering, and automotive engineering. Students enrolling into the second semester material science laboratory course come from multiple different educational backgrounds. Only 40-60% of the students enroll after from high school, 40-60% were educated on the job and then got work experience between 2 to 6 years [6]. Generally students with job training are doing better in laboratory courses because they do well in groups and quickly organize themselves. They also relate science quickly to engineering problems and have a practical conception. Students without practical training are often overstrained and confused what to expect in a practical course setting. Also since the refugee crisis in 2015 a large percentage of students with migration background enroll in mechanical engineering mostly lacking German language skills [6].

The concept of the material science laboratory courses follows a blended learning scenario where scientific backgrounds are self-studied via online-lectures and especially during the pandemic 2020 via lecture videos providing full lab-tours. Face-to-face time of the first year material science course is 4 hours/week which was rerouted into online-sessions with only 4-6 students per working group. It is necessary to study the scientific background of material properties to understand the material test results

that then have to be analyzed and discussed at home. Discussions during online-time are encouraged in breakout-rooms, but each student is responsible for her/his own progression and of the group results. To provide a good scientific base without letting students wonder around in the orbit of material in the web a great variety of teaching material is specifically chosen, produced and provided via moodle [2], [16], [17], [19]. Moodle provides an excellent basis to establish graded activities [2], [4], [5] that are followed each lab activity or theme. In alignment with the learning objective of the course the assessment of the lab course focuses on different skills and the learning progress rather that a one-time result. The decentralized course assessment cumulatively added the results of lab exercises and results from compulsory theoretical work (appropriately weighted activities: tests, glossary entries, single homework and group assignments) over the 12 to 16 weeks of the semester summing to 40 possible points in total. Before final grading students needed to sign the cumulative assessment and a non-disclosure agreement for the teaching materials throughout the course.

5 basic "how-to" motion picture lecture videos (11:42 min, https://www.youtube.com/playlist?list=PLUOlZMSZYz5wHGs9vEu-5DWqmsktUvtx7) on materials testing and introduction to the laboratory course as well as 12 animated scientific lecture videos [5], [6], [17] and 3 extended lecture videos on ultrasonic testing (ca. 27 min, https://www.youtube.com/playlist?list=PLUOlZMSZYz5wLXOL12hlWOrL1MIbXfZeS) (Fig. 1) were produced to make the materials science laboratory come to life. These are integrated into micro lectures on Moodle and various teaching material [2]. Student project teams [6], [17] during SS 2020 and WS 2020/21 are currently working on lecture films covering: tensile testing, crystallography, microscopy, micro structure, heat treatment).

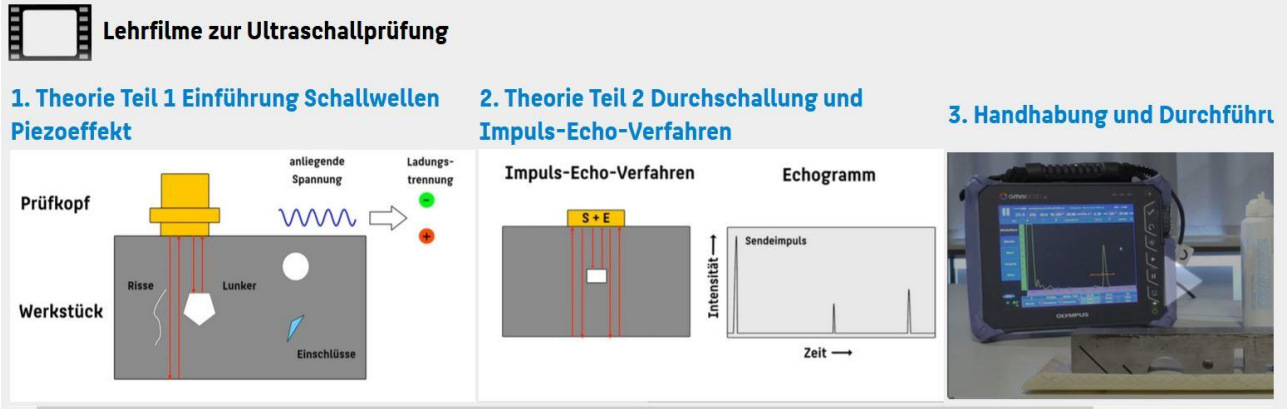

Fig. 1. 3 "how-to" animated and motion picture lecture videos (27min) on ultrasonic testing and introduction to the laboratory course. Scientific lecture films are openly available at HTW-Berlin: https://www.youtube.com/user/cutsandtalks

Even in regular semester students generally did not find it appealing to pick suiting lectures and study properly on their own when preparing for the lab course. Hence, most lab courses have already been very challenging, a lot of time is consumed by repeated explanations making the lab course disappointing for lecturers. The joy of hands-on courses could not be felt [19] during present time and the pandemic threatened to lower the empathetic skills of lecturer even more. This paper now provides a first resume on the efficiency of lecture videos in a first year material science laboratory course during the covid-19 pandemic. And although dividing classes into groups of only 4-6 students tremendously increased teaching time of the lecturer -besides correcting, feedback and coaching of individual students after the assignments- small group teaching with lecture videos as scientific input during self-study periods proved to be an

adequate solution (not replacement!) for laboratory courses.

3. Laboratory Course Results

Laboratory course results are compared from WS2014/15 until WS2020/21 demonstrating the outstanding results of the mechanical engineering students in winter semester 2014/15 (red dots) that raised the grade point average of this semester and has to be rated exceptional, but goal to reach in future. The concept of implementing lecture films prior to the laboratory course applied first in spring semester [19]. Lower grades in WS2015 (1,99) are due to large differences of the results obtained from mechanical engineering (1,80) and automotive engineering students [2,17]. From SS 2016 on grades for both, students of mechanical and automotive engineering, showed a good average for all experiments. Separate assessment of the single laboratory experiments show a slight shift towards better grades with students intensively working on lecture films for the most difficult themes: ultrasonic testing and microstructural analysis. Still, there is no significant increase in grades.

Although there is a shift towards lower grades since establishing lecture films as means of self-taught learning prior to laboratory classes, the number of students failing the class is very low (Fig. 2). Winter semester 2017/18 and 2018/19 displayed the worst results since data collection. Here, the special situation of German higher education has to be taken into account with refugees entering the system [6]. Students with migration background of approximately 65% coming from Maghreb countries showed severe lack of language skills and therefore averagely scored significantly lower.

However, most of these students passed the course! On the contrary during SS2020 and WS2020/21 (the so called corona-semesters) where lab courses were taught fully online, 12%-17% of the students failed the course (Fig. 2).

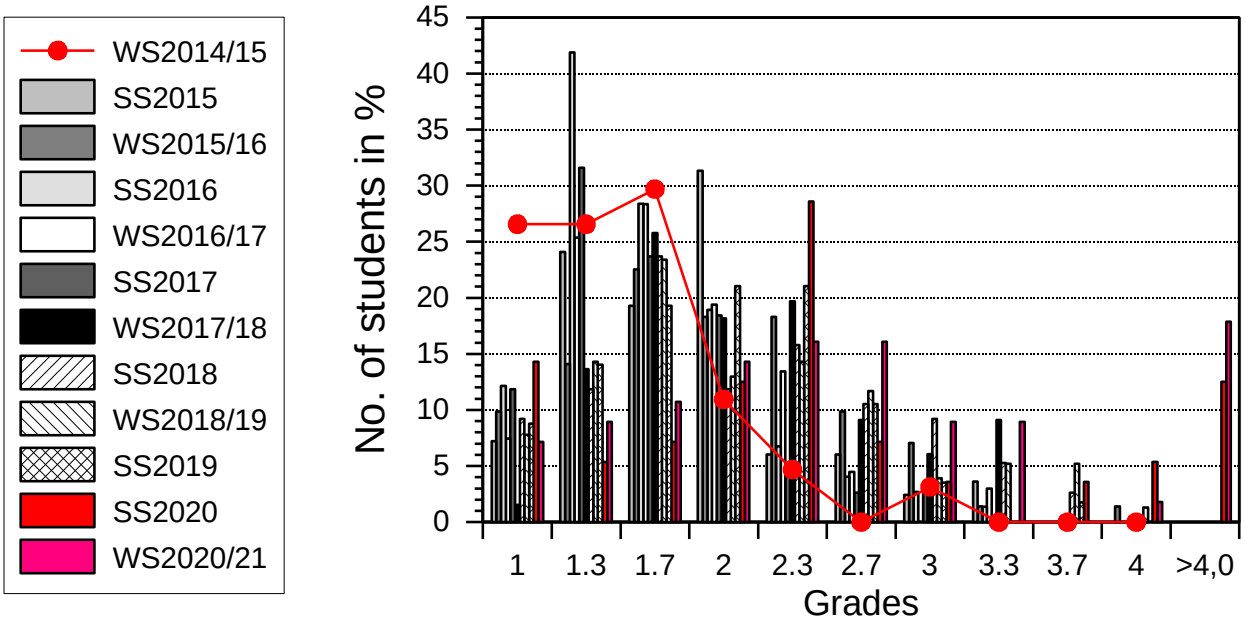

Fig. 2. Accumulated grades for 5 different experiments of students taking a lab course at HTW comparing fall semester 2014 without lecture films (red line) and all semesters from winter semester 2014/15 until winter semester 2020/21 with lecture films (histogram) The red columns indicate the results obtained within the two Corona semesters.

A test on heat treatment accompanied the laboratory exercise. This test could be taken before or after the online session (lab talk) and feedback on practical group work. Students generally were prepared for the lab

talk and new about the process and workflow. The group work comprised of transferring problems in alignment with heat treatment of steels. These arise independent of outer circumstances, such as present or online teaching, and are focus of the discussion on this particular lab exercise.

Similar to the overall lab exercise results more students failed the test during the pandemic online semesters that the previous semesters (Fig. 3). In general, grades were significantly lower. Students had access to exactly the same teaching material, had clearly described tasks and comparable workloads. The workload of the lecturer, however, was much higher, because groups were smaller during online teaching and more one-to-one coaching, course organization, Moodle organization and rewriting of chapters and problems were necessary to teach the same content. Still, summative assessment showed decreasing learning progress resulting in lower grades (Fig. 3).

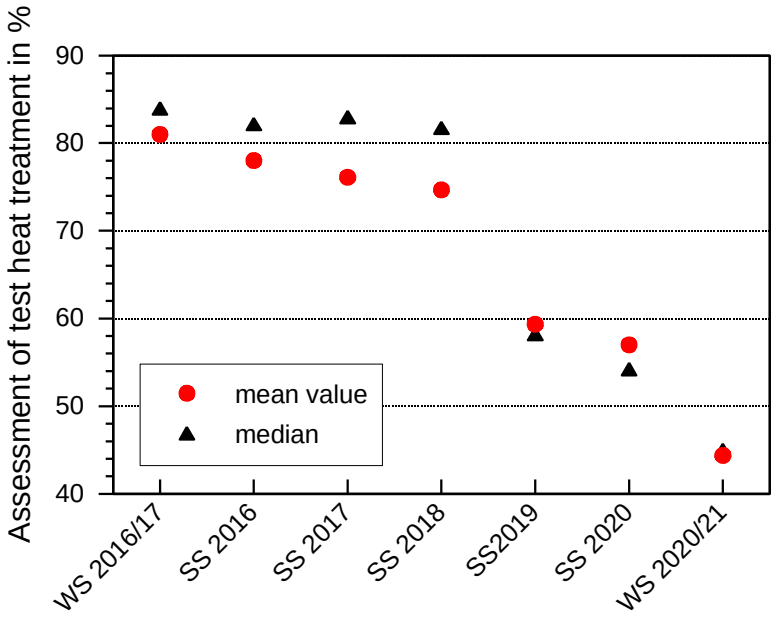

Fig. 3. Test results (median and mean value) on "heat treatment" taken from material science lab courses spring semester SS2016 until winter semester 2020/21. Lower scores are relate to students with insufficient language skills (SS2019) and the covid-19 pandemic (SS2020 and WS2021).

The decreasing median in Fig. 3 relates to decreasing scores and lower overall grades. From WS2016/17 to SS2018 there were few students failing or getting poor grades (median higher than mean value). Starting SS2019 median and mean value decrease indicating many students getting low grades.

4. Evaluation and Discussion

Lecture films as means of teaching material during a fully online semester still appeals to many students, because they are easily accessible, repeatable and independent of time and place (Fig. 4). They offer the possibility to dive deeply into scientific backgrounds which otherwise cannot be understood by first year students. Without the chance of asking questions during present hours the majority of students feels lost. However, carefully prepared lab- and theoretical background videos that are aligned with the course outcome [6], [24] clearly supported understanding. YouTube statistics show that once the students started to watch the films they completed at least 75% [5]. Nearly 50% of the students watched lecture films before the face-to-face laboratory lecture, and preferred films over books or online lectures because the explanation is given directly (Fig. 4) [5]. It is interesting to note, that most students watch the videos after online lectures, possibly because they now had a better insight of practical use (Fig. 5) and used the videos

for post-processing of the laboratory course content.

The combination of carefully preparing the films during self-study periods and answering knowledge and transferring questions usually prepares students well for lab courses. After watching lecture films more download activity was noticed assumedly accompanied by studying of the lectures that were provided to prepare the experiments. During online lectures most students preferred group work (break-out sessions) over scientific input allowing for hands-on work and presenting results rather than listening passively. Note, that it is very important to NOT repeat the content of the lecture films during an online-lecture! Students need to get used to prepare themselves well before adding to group work and engineering solutions. Lecture films are therefore a probate media to encourage students to self-study and prepare for a laboratory course [5]. In inverted classroom scenarios lecture videos provide excellent requirements as shown by various authors [6], [15], [16], [23].

Despite the good feedback from many students regarding lecture videos covering the scientific background of the lab experiments as well as lecture videos on the experiments themselves as highly supportive, easy to use and helpful for understanding theoretical backgrounds the laboratory courses did not deliver sufficiently satisfying results during the covid-19 pandemic.

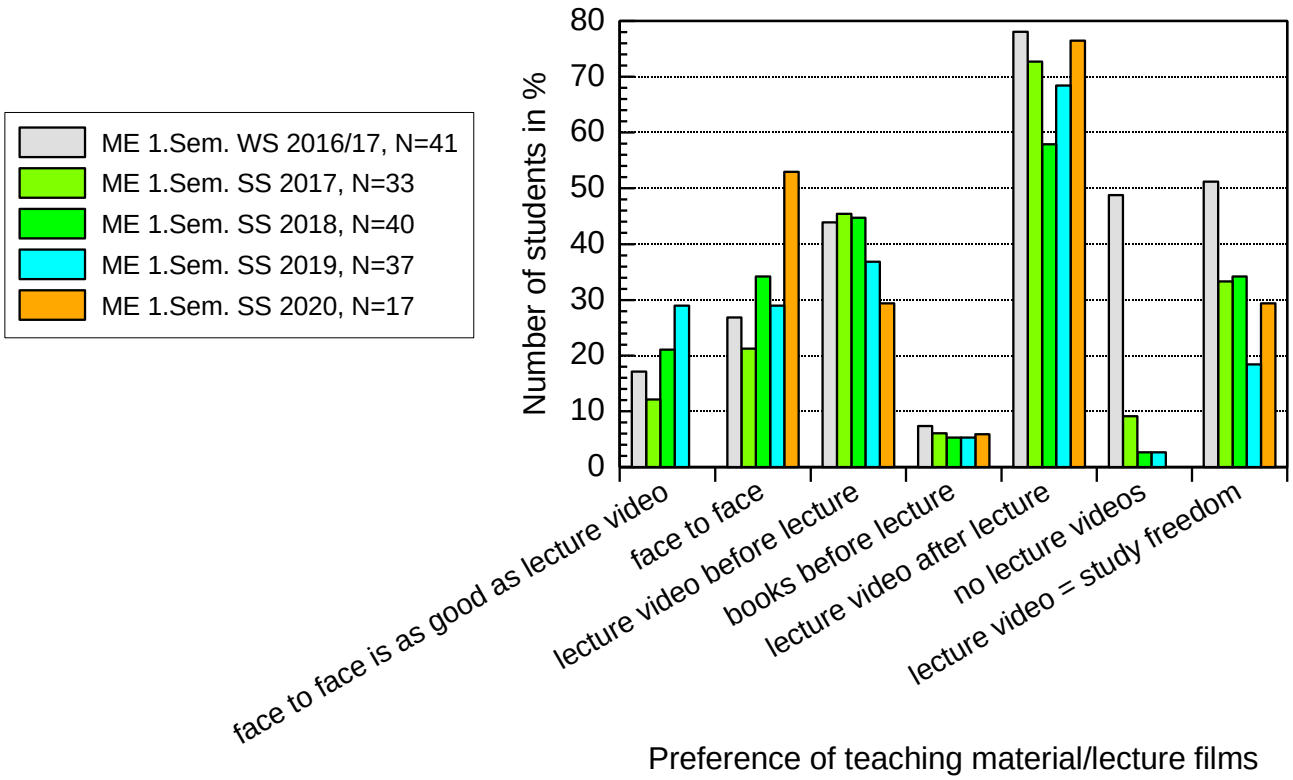

Fig. 4. Preference of lecture material in first year material science course. (multiple choices were possible) [31].

During the covid-19 semesters online semesters hardly any students were well prepared for class or brought notes or handwritten summaries etc. to an online-class. This finding contradicts blended learning teaching where students generally were prepared well [5], [6]. Although the teaching material (lecture films) was meant to explain the science behind the results usually produced in the lab was regarded helpful, student groups did not work homogenously with lack of inspiration. They seldom asked questions or initiated discussions. Only few were eager to dispose their knowledge and learn more of the details – most of the time these were students with their cameras turned on during the entire online lecture time. For the

lecturer it was very hard to discover whether complicated correlations were understood correctly or not or even understood at all. Only if students were encouraged directly to engage in thinking and write their thoughts into the chat, adequate response was achieved. Here, even otherwise quiet students participated. Therefore, chats play a significant role during online-teaching!

It is noteworthy that even in the fully online semester of SS2020 and WS2020/21 the students did not agree on face-to-face time over remote online teaching and the use of lecture videos. Especially during online-teaching students need to account lecture videos as useful and fully accept these as probate teaching media. Guidance by the lecturer, guiding tasks and questions during lecture video studying is highly advised in a higher education context especially in lab courses.

In general, students achieved much lower grades during the covid-19 pandemic and much more students failed the course or single tests. This may be due to mistaking the input of lecture films or providing a certain security of expertise after watching the difficult content only once. However, this explanations seems too easy. Deriving from the activity during online lectures the grades achieved in the laboratory course could directly be attributed to the students` learning ability and motivation before the course. The question arouses why were students badly prepared although the course was structured, the assignments clear and aligned with the course learning outcome, lecturers were available for support, group work was directed and lecture films beautifully explained the contents (as on student stated)? The most likely answer to these questions is the lack of human interaction which directly relates to study progress and learning success. Being forced to remain separated and only study alone does not evoke the joy of learning und understanding. The negative input of solemn studying, lack of human interaction, scientific discussions, possibility to fail and regain self-attentiveness as well as permanent online time count profoundly. Students are tired, fed up, disappointed, bored, without energy and feel left behind. This basic human reaction to online teaching cannot be overcome by teaching method or teaching material, support and care for well-being by the lecturer. Supportive lecture videos (not online lectures!) turned into a mass of diffusive teaching material not providing enough emotional support and encouragement for scientific input.

5. Conclusion

In general students rate lecture videos as beneficial and entertaining when preparing for laboratory courses. When students prepared well, they improved their learning skills, scored better during tests or questionnaires prior to the experimental online lecture and were able to discuss lively. However, even with a highly positive rating of the use of lecture videos and good feedback on the course alignment their implementation did not show a great benefit in terms of students` grades. More students got low grades and 12-17% of the students even failed. Therefore, lecture videos do not automatically enhance the students` learning outcome, but are attributed to the students learning ability and motivation before the course which are directly related to the learning environment, interaction with other student fellows and learning success during self-study periods. When lecture videos are rated beneficial in terms of concentration and attentiveness as well as scientific level of communication during lab classes, these advantages could be neglected during the online semester of the covid-19 pandemic in SS2020 and WS2021.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The author conducted the research, analyzed the data and wrote the paper. The author had approved the final version.

Acknowledgment

The author likes to thank all students from the "Fachübergreifendes Projekt SS2015-WS2020/21" for the making of the lecture films. Part of the work was funded by the programs Lehrefonds, QIO of HTW-Berlin and „excelLuS" HTW-Berlin: "Studieren an der HTW Berlin – exzellente Lehre und hervorragender Service", Förderprogramm "Bund-Länder-Programm für bessere Studienbedingungen und mehr Qualität in der Lehre" des Bundesministeriums für Bildung und Forschung (BMBF) mit Förderkennzeichen: 01 PL 11034 und Förderzeitraum vom 01.11.2011 - 30.06.2016

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Anja Pfennig was born in Büdelsdorf, Germany in 1970. She studied minerology at the University Bonn, Germany, where she graduated in 1997. Her Ph.-D. is in the field of ceramic moulds for liquid metal casting was earned in 2001 from the University of Erlangen, Germany. She then worked for Siemens Energy in charge of ceramic shields and transferred to Berlin in 2008 where she currently teaches material science at the Applied University Berlin, HTW. A. Pfennig research expertise is corrosion fatigue. Her interest in teaching is new teaching methods and e-learning to enhance learning output and cope in future positions.