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"MAKING IT WORK" – PRACTICE EXAMPLES OF PREPARATION AND EMBEDDING PEER-TO-PEER LECTURE FILMS IN SUCCESSFUL INVERTED CLASSROOM SCENARIOS

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Abstract

Embedding lecture videos in "inverted classroom" teaching scenarios has been proven successful in teaching material science to first year mechanical and automotive engineering students at HTW Berlin. These videos covering difficult scientific background knowledge such as precipitation hardening, duplex steels, materials testing and heat treatment as well as lattice defects, composits and corrosion were initiated from students needs and learning experiments. Therefore a student project was defined for production of lecture films each semester supervised closely by the lecturer and film expert. This peer-to-peer approach is essential because the students immediately include their own learning experience and strategy into the set of films and therefore directly implement their perspective and scientific needs within the digital teaching material. Along with recording of lectures the lecture films provide for excellent self-study material suitable for inverted classroom scenarios. Because students already use videos as learning source they appreciated the possibility work independently, appeared active, well prepared and motivated given the self-study period was facilitated well and the contents were in alignment with the overall learning outcome of the course. Also, the quality of the lecture videos *influences the learning behavior. Here, sequences of the teaching method are qualitatively evaluated by practice examples encouraging lecturers to get started with digital learning material and the inverted classroom teaching method.*

Keywords

Inverted Classroom, Lecture Videos, Peer to Peer Approach

1. Introduction

Lately the interest in embedding various types of media in connection with or even in place of traditional lecturing methods. One well known form of media provides for video or audio recordings or establishes concise lecture videos of pertinent course material. Videos as means of learning source have been well established in the curricula of young adults and students in higher education. A teaching video that covers different learning methodologies allocates audio and visual incentive. Generally, a high percentage of male as well as female students appraised the embedding of films in the lectures to be beneficial to their learning progress. Still, more male students agreed about the benefit of videos compared female students (Al-Jandan, Farooq and Khan, 2015). Still, there is a difference between lecture videos where certain topics are summarized, animated and tailored to a diverting teaching source and video lectures covering the contents of an entire lecture using at least five different techniques, such as interviews or commented slides (Crooka and Shofield, 2017). When developing network-based resources for teaching and learning it is important for the practitioner who is accreted in digital learning material to always take into account these differences between male and female students.

Among lecturers and pedagogues there is apprehension if lecture videos and video lectures might outgrow more traditional teaching methods. However, Havergal, 2015 states that McGowan`s study proved that lecture videos definitely reinforce, rather than replace lectures. Therefore, lecture videos support modern teaching in higher education and should be included in the lectures, provided any film included agrees to the desired learning outcomes of the particular lecture (Al-Jandan et al., 2015). The affordances of particular videos and assignments need to be considered in light of the backgrounds and experience as well as the discussion arrangements of participants (Hatch, Shuttlewort, Jaffee and Marri, 2016).

Alghough Gulley and Jackson, 2016 found unfruitful evidence of either short term or long term benefits to students in terms of improvement of understanding, retention of course material and course material itself and effective use of time in class, students significantly value using videos. (Gulley and Jackson, 2016; Kon, Botelho, Bridges, Chiu Man Leung, 2015). They assessed videos as effective and appreciated learning tools and considered them easy to use during self-study periods (Kay and Kletskin, 2012). With no regards of the technique chosen for lecturing (frontal teaching or film support (Saun et al., 2017)) lectures including or explaining practical work improve the overall learning outcome (Sarıhan et al., 2016).

Students prefer questions directly interpolated within online videos increasing the learner's employment with the teaching material (Rose et al., 2016). However, it is very important that lecturers keep in mind that students tend to be overconfident when learning from lecture films. Embedding repeated tests within a lecture helped to improve students` actual performance to the outcome of performance predicted beforehand, while single tests assigned after the lecture resulted in lower judgments of learning that are even unrealistic (Szpunar, Jing, Schacter, 2014). Still, testing after a lecture topic with different teaching materials required gives students time to repeat contents and "get the whole picture".

1.1 Implementing the Inverted Classroom Approach

The "design-led" teaching approach (Ashby, Shercliff, Cebon, 2013; Pfennig, 2012; Pfennig, 2016) following the "inverted classroom" teaching scenario (Fischer and Spannnagel, 2012; Braun et al. 2012; Berret, 2012); Brame, 2015; Pfennig, 2016, Pfennig, 2017-1/2/3) was chosen to teach Material Science to first year mechanical engineering students at HTW Berlin. Inverted classroom teaching scenarios have positive effects on intrinsic motivation and self-efficacy beliefs (Thai, de Wever, Valcke, 2017). Blended Learning was found to provide best teaching environment with a blended learning setting revealing a higher learning performance compared to the e-learning setting (Thai et al., 2017).

Class results improve when students are directly involved in the planning and conception of teaching activities, such as preparing lecture videos, indicating a positive effect on students` critical thinking (Colorado State University, 2015), Lord, 2012). Moreover, involving students learning history and experiences, e.g.: *think pair share* and *peer instruction* (Whitman and Fife, 1988), *reciprocal peer tutoring* (Simon, Kofanhars, Lee, Tamayo, Cutts, 2010) or *undergraduate teaching assistance* (Fingerson and Culley, 2001) produces deeper learning outcomes (Cuseo, 1992), Goto and Schneider, 2010). Therefore, lecture videos produced following the peer-to-peer approach are successfully embedded in teaching scenarios at HTW-Berlin.

With practical examples and evaluation of the own teaching method the author wants to encourage lecturers to start a more cooperative and collaborate teaching method including digital material. Peer-to-peer lecture videos *are* demonstrated to be successfully included in inverted classroom methodology. The concept may already be introduced to first year mechanical engineering students to teach material science (well-known as being unbeloved) and gain deep understanding how to interpret microstructure and properties of engineering materials. Questions that may arouse when implementing lecture videos and/or the inverted classroom teaching method are: How do students respond to the peer-to-peer lecture films in inverted classroom teaching scenarios? and how do grades change? When starting with renewing lecture concepts it is usually not easy to begin and understand the now role as facilitator rather than frontal lecturer. Therefore, the author wants to encourage and provides findings offering ideas how to overcome initial problems by taking one step at a time. Because generally it is not easy to find stimulation, this paper may be of help for lecturers starting to teach or changing lecture methods taking one lecture at a time. Parts of this findings have been presented at HEAd`18 and are now summarized and commented to give a broader picture of small steps towards modern teaching methods.

2. Material Science Course Construction

Teaching first year students at HTW Berlin applied university is challenging because students arrive with different backgrounds regarding education, language, family situation. This benefits the course, but also requires special needs for teaching successfully. During the first 2 semesters it is mandatory to scientifically study material properties, understand material and microstructural behavior in a mechanical design. Although students are responsible for their individual learning progress, discussions in class are encouraged and hands-on problems are solved during small group work during face-to-face time. Various teaching materials support different learning styles (Pfennig, 2017; Pfennig, 2018), e.g. Mind-maps for summarizing the content of online micro module lectures. These are intermixed with quizzes and self-assessment tests covering the most crucial issues. Web Based Trainings (WBTs) allow students to study individually and time and place independent. Life demonstrations and short course mind-maps help to memorize technical terms, understand and transfer science and correlate the different micro modules. Students are encouraged to assess their own learning progress by assignments and extended self-tests with worked solutions. Also, the lecturer is informed of skills, knowledge and progress.

However, as accounting for many classes students are not attracted to self-study beforehand, because most of the time the learning material given is dull, overloaded or does not align with the course learning outcome. The worst are very challenging, often chewy courses that disappoint lecturers and students. Because in inverted classroom scenarios it is very important to study properly (especially before lab courses) the lecture materials have to be selected carefully. Initialized by students lecture videos were brought to concept, designed and produced in order to improve the learning outcome and joy of learning materials science.

3. Peer-to-Peer Lecture Films

The "peer-to-peer" approach (Ware, 2015; Wilson, 2012) includes lecture materials designed and created or developed with students` involvement into to teaching first year mechanical engineering students at HTW Berlin. The 3I-model including *information, instruction and giving impulse* as basic approach for planning and completing lecture films has been described in detail earlier (OLP Online Lehre Plus /Online Teaching Plus, 2016; Pfennig, 2017; Pfennig, 2018). Most lecturers have a high inhibition threshold for producing lecture videos, because the orkload of production and technical expertise are often assessed as unknown and even ominous factors. They back away from suspected high workload in video production. However, all these fears can be overcome if the lecture video production is based on the individual learning experience of students and refer to their special needs.

Student groups working on lecture film concepts comprised of four to six students worked on a full concept. Each lecture film is approximately two to eight minutes long, always taking into account the attention span and necessary time to take notes or read outside references. Film formats have been proven successful are: cut-out animation, lecture video, power point, digital animation or even comic. Careful proof reading of the lecture screen play is important, because each word has to be correct and for self-study purposes the overall sense of paragraphs and sentences needs to be precise; that is clear enough so that students can understand the content even without pictures (Pfennig, 2018).

Examples of lecture films offered via moodle HTW and youtube are:

- Lecture video: Phase diagrams (10 lecture films) (2:35 hours)
(https://www.youtube.com/playlist?list=PLUOlZMSZYz5zha5EbwAKrQ8w8W65ST3fN)
- Lecture video: Iron-Carbon phase diagram (11 lecture films, 2:47 hours)
(https://www.youtube.com/watch?v=_RdbQFk4jWU&list=PLUOlZMSZYz5yHjaqEAaPj77ignXqACXaD)
- Corrosion (4 lecture films) (10:10 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5z_aPBqnCjjr5OXqF997-dJ

- Materials Testing (5 lecture films) (11:42 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5wHGs9vEu-5DWqmsktUvtx7

- Composites – fiber reinforced polymers (6 lecture films) (35:31 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5y8XYE1S09HlH60tSxlUERe

- Plastic deformation – Hardening mechanisms - smith diagram (6 lecture films) (38:17 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5wm7m-ahbD8r4dCjDU498mV

- Defects in crystals – (5 lecture films) (32:55 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5wlO3gea5jLFhxgAr3IiOja

- Polymers – (5 lecture films) (22:43 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5wUlfwge0VTxKokobD_OOK7

- Materials families: polymer, elastomer, hybrid, metal, glass, ceramic – (8 lecture films) (41:16 min)

https://www.youtube.com/playlist?list=PLUOlZMSZYz5zu5oBgrsbpySESNdJ3Cupx

Also available or in progress: a) stress-strain diagram (3 lecture films) b) diffusion (4 lecture films) c) recrystallization and recovery (4 lecture films) d) duplex steels (3 lecture films) e) corrosion fatigue (2 lecture films), heat treatment 4 + 4 lecture films, deformation of polymers and metals (2 lecture films).

These lecture videos could be directly employed into the face-to-face lecture but -according to the inverted classroom teaching method- students prepared the film contents before class during self-study periods. Lecture videos are advantageous because the path of thinking and deriving solutions is shown to help students understand the science. However, lecture films are not meant to be stand-alone. Micro-lectures, testes and group homework in addition to many other teaching resources (Pfennig, 2017-2) build the bigger picture. Most questions arousing during the self-study period are answered and students solved hands-on with worked solutions in class preparing students for the so-called night exam to be taken at the end of each topic which added to the overall grade of the material science course (Pfennig, 2017-2).

To succeed as a lecturer in inverted classroom teaching scenarios, it is important that the method is explained to students thoroughly beforehand, clarify course rules and explain the assessment of cumulatively counting lectures and lecture videos right from the beginning. The course setting and the moodle learning management system is introduced and students got instructions how the different activities are used properly. Because the teaching sources most likely have an impact on their learning outcome it is important to explain the expectations and the role self-study periods when starting he course. At any time of the semester the students knew their level of proficiency summed by the number of graded activities. It is important to know the percentage of total grading for each single lecture video test because of extrinsic motivation factors and also because of time management and self-assurance. The time for so called night-exams was chosen between 4 pm and 2 am the next morning. These tests contribute to the overall grade of the course and are considered part of the time spend during individual studying. The role of the lecturer is not to lecture but rather to guide and think about lecturing in a more cooperative and collaborative way. However, the setting must be clear. Otherwise students – especially first year students- are often lost, do not exactly know what to do, do not take the tasks seriously and eventually fail the course learning outcome. During face-to-face discussion of worked problems it is often advised to physically stay behand the class and let the students find their own solutions. Therefore, they take over responsibility for their own learning progress and success in material science classes. But the combination of "letting-go" and giving guidelines and providing lecture videos that follow the general course outcome resulted in high learning progress, transferal competence and self-employment.

The lecture-scenarios given as examples are stand-alone topics where no lecture was given ahead of time and usually no postprocessing.

4. Examples of Lecture Scenarios

4.1 Fiber-Reinforced Polymers, Face-to-Face Time, 2 Hours of Self-Studying, 1 Hour Test

6 Videos were produced to introduce fiber-reinforced polymers (frp) to first year students as well as master students provided via moodle (Figure 1). Communication, instruction and assessment was also done via this learning management system. the films and communicate with the students in winter semester 2015/16 as a voluntary study topic:

- Introduction (3:09 min)
- Preparation and Processing (5:45 min)
- Constituent parts (4:53 min)
- Mechanical properties (5:47 min)
- Design (5:39 min)
- Recycling (2:31 min)

Figure 1: *Video Film Set: Fiber-Reinforced Polymers (https://www.youtube.com/playlist?list=PLUOlZMSZYz5y8XYE1S09HlH60tSxlUERe)*

Students groups (bachelor as well as master students, Figure 2) comprised of four students the most preparing thoroughly for one lecture film in such a manner that they were able to explain the scientific content to their fellow students. To guide the self-study period the remaining lecture videos had to be studied at their own responsibility but micro lectures and small quizzes could be taken on a voluntary basis. During face-to-face time students were encouraged to ask questions, discuss these in detail and get the chance to “fill the gap” regarding scientific background knowledge. The open-source software *invote* (invote, 2016), Simon et al., 2010) was used for classroom response giving the lecturer the overview of the class` level of proficiency. The presence time was divided in two lecture sessions: first the six students preparing the same video summarized the key points of the lecture film en-group for approximately 30-40 minutes using a special template. This open work period offered was the lecturer time to answer questions individually and properly that aroused among the various teams. This helped tremendously to understand complicated parts of the science studied at home guaranteeing that the final summary of each team was correct. Copies of the summaries were uploaded for all students via moodle serving as preparation worksheet for the following night exam. During the second part of the presence lecture students were grouped according to one student being expert for one film adding to six students per group. Each "expert" was ask to explain the film content and science to their fellow students and answer remaining open question from the summary sheets and then present the most relevant issues to the plenum.

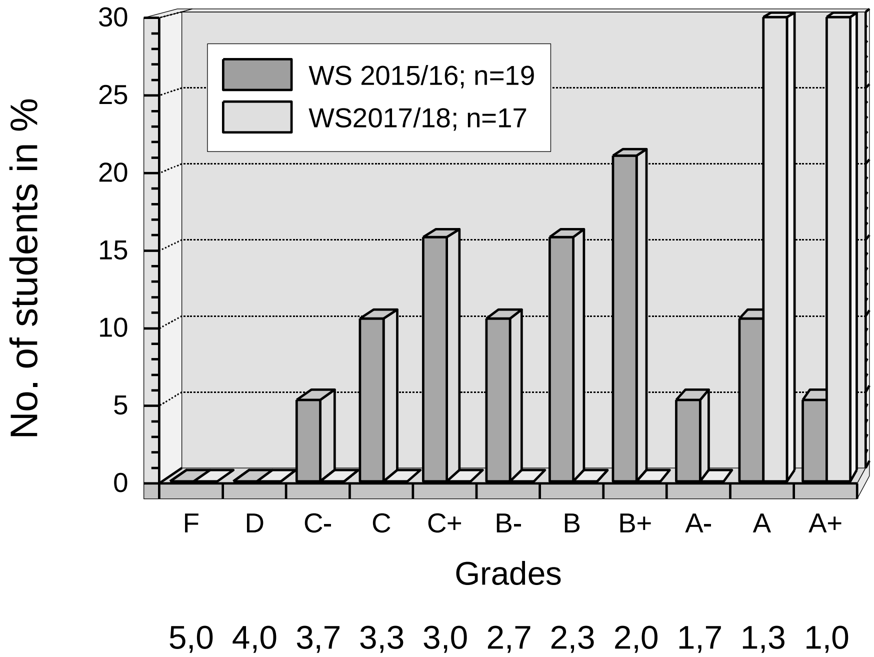

Figure 3: *Test Results (Voluntarily) on Fiber Reinforced Polymers. Comparing First Year Bachelor Students (NO Tryout Time) with Second Year Masters (One Week Try-Out Time)*

Starting from 4 pm and lasting until 2 am the next morning an online exam could voluntary be taken via moodle offering extra credits. 19 students out of 36. All students taking the exam passed. Test results were rated very good (20% of the students scored with 70% or more, Figure 2) taking into account that this test was only voluntarily in WS2015/16. In comparison one week of practicing lectures and online-questionnaires lead to overwhelming success when the test was part of the overall course assessment and compulsory (masters second year, introduction to lightweight design, review of basic scientific knowledge, one week of preparation).

4.2 Introduction to Polymers, Face-to-Face Time, 2 Hours of Self-Studying, 30 Min Test

During first year material science course for mechanical engineers polymer structures are usually only discussed briefly. But because both, polymers and elastomers are important engineering materials it is important to know the differences in microstructure compared to metals. Therefore, polymer and elastomer structures were included in the class curriculum as self-study lectures with the content basing on 4 lecture videos (Figure 3):

- Classification according to structure (3:09 min)
- Classification according to reaction (5:45 min)
- Application (4:53 min)
- Demonstration video (5:47 min)

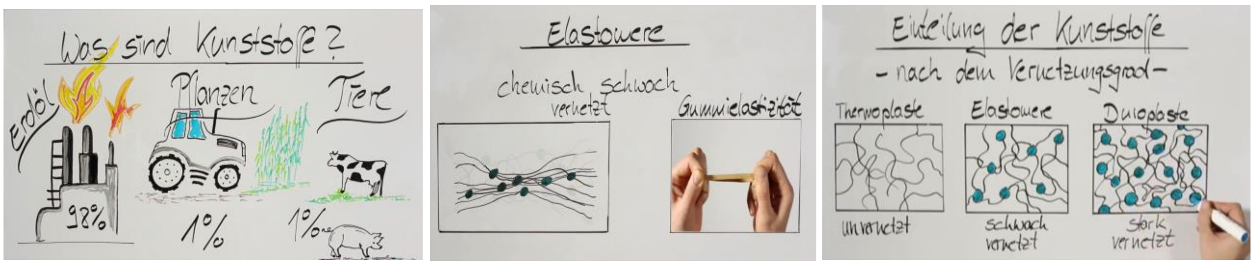

Figure 3: *Lecture Films: Polymers (4 lecture vid) (19:54 min), (https://www.youtube.com/playlist?=PLUOlZMSZYz5wUlfwge0VTxKokobD_OOK7)*

Questions were answered thoroughly during face-to-face time individually and in the plenum. Here also to get a good idea of the class` learning proficiency invote (invote, 2016, Simon et al., 2010) was used as classroom response system. In general most students passed the nighly exam (open from 4 pm until 2 am the next morning) with 60% and more of the students scoring very good or excellent proving both, good study skills and sufficiently deep learning outcome (Figure 4). The compulsory nightly online exam via moodle) added to the credits of the course (2 out of 60 possible grade points). Note, that there is a shift towards lower grades in SS2018. This is accounted for the high percentage of non-German native speakers in the first year mechanical engineering at HTW-Berlin as a result from the migration of mostly Arabic-speaking refugees in 2017/2018. German was second or third language for 68% of the class. Still, compared to results from other classes with high language competency these results are satisfying, especially with no students failing this test! Learning via lecture videos allows students to prepare in their own tempo, repeat lectures, take notes and understand

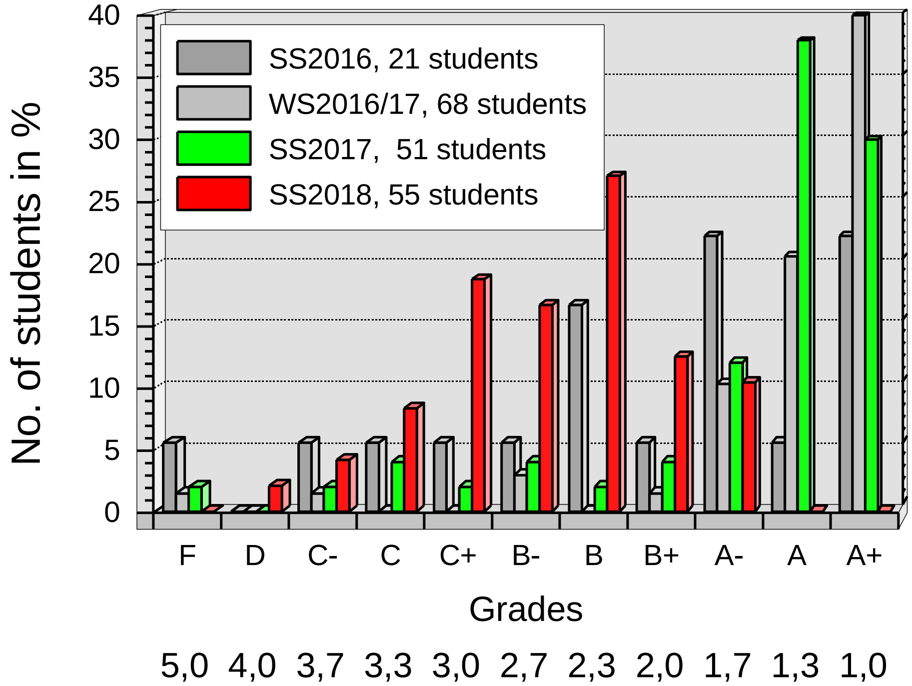

Figure 4: *Results of Nightly Online Exam on Polymer Structures*

6. Evaluation and Discussion

Students in general are attracted to lecture videos which may be rated a suitable media to encourage students to self-study and improve results in the first year as well as master material science courses. In inverted classroom lecture scenarios lecture videos most likely provide phantastic, easy-to-use and appealing learning requirements (Fischer and Spannnagel, 2012; Braun et al., 2012; Berret, 2012, Brame, 2015; Pfennig, 2016; Pfennig, 2017-1/2/3, Thai et al., 2017). After students watched introductory or science videos for either lab courses or microstructural topics they spent more time on moodle downloading various other activities such as mindmaps and summary sheets, and studied online micro lectures. In general, students took the online assignments very serious with most of them bringing along handwritten notes and summaries. This add-on teaching material supported students in understanding the science behind the results properly that were originally introduced in class or demonstrated during lab hours. Small group work before tests improved the results slightly (pre-test results and classroom response) but teams worked closely together and students appeared motivated and inspired asking asked important questions and initiating discussions among themselves. In the plenum students eagerly disposed their newly gained knowledge. In general, more detailed knowledge even to students preferring home-lecturing and self-studying was steadied and complicated science was understood and correlations made correctly.

Note, that there is a possibility that students get bored after the first excitement of using lecture films wears off which was not evaluated. But, since every lecture film set is conducted by a different students group the formats always change giving each theme a special note. Surprise of format and content keep the level of interest widely awake as well as keeping each lecture film strictly limited to five minutes (Al-Jandon et al., 2015) there was no measurable lack of interest (24 students watched the lecture films on polymers 68 times which indicates that the students averagely worked 3 times on each lecture video without interruption. With exception end titles students who started to watch the videos completed them.

Students with foreign language background especially favored lecture films and assignments related to working with lecture films. It guaranteed maximum freedom and high learning output. Lecture films are location independent reusable, repeatable and stopped for studying single sequences and taking notes. The language used is well-pronounced and adequately slow so that even with little language knowledge a rather high learning outcome may be achieved. Students remarked that lecture films are much more substantial compared to plain text with figures because the path is explained which they considered most important in their learning expertise.

Students who produced the lecture films gained substantial knowledge of microstructural behavior of engineering materials which contributes to self-attentiveness and thus high learning outcome. Their understanding of material science was much better compared to the time they studied in the traditional manner.

7. Conclusion

The peer-to-peer approach is beneficial when designing, conducting and producing lecture videos for a material science course that are central learning material in a blended learning course setting implementing inverted classroom teaching scenarios. Therefore, students produced different formats of lecture film during student projects guided by lecturer and director of film. Necessary self-studying learning material contributes to this interdisciplinary approach of teaching materials science. Especially the different approaches from different student groups are in favor regarding student attentiveness, progress during face-time, concentration and grades. Hands-on problems were solved thoroughly because students were prepared well and therefore able to develop solution strategies. Even students in German as a second language environment stated high benefits from lecture films accounted with independency, good pronunciation, no time-pressure, clear pictures that explain difficult scientific backgrounds. The lecture video based inverted classroom concept is regarded successful for a diverse group of students and though time consuming in terms of maintenance will be extended to themes as material testing, phase diagrams, corrosion, polymers and hybrid materials.

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