2023

Developing A Flexible Materials Testing Curriculum For Future Engineers

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Developing a Flexible Materials Testing Course Concept for Future Engineers (PRACTICE)

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Conference Key Areas: *10. Virtual and Remote education in a post Covid world*
Keywords: *undergraduate teaching, material science, mechanical engineering, course design, innovative teaching*

ABSTRACT

Engineering students as future maker of things will face the challenge of keeping pace with rapidly evolving technologies and staying up-to-date with the latest innovations in their field. To cope with these demands a flexible course concept is developed for an undergraduate Materials Science lab course: Materials Testing at HTW Berlin based on a blended learning teaching concept implementing inverted classroom lecture scenarios. High quality micro modules are defined that may individually be combined or restructured and therefore offer sufficient flexibility to match the individual scientific background of the lecturer, the course learning outcome, main study subject or actual need based on recent developments. The Moodle course offers different teaching materials, such as micro-lectures, guided questionnaires, lecture and lightboard videos, H5P-activities, etc. Lecturers will find detailed information on the course concept but independently decide on the main

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aspect of their individual teaching and are therefore granted time for various activating methods in class. With providing well-arranged individual work packages the pressure especially for lecturers from industry -who are teaching on their full time jobs- is relieved and they have more time to interact with students involving them in future common engineering challenges.

1 INTRODUCTION

To meet the demands of rapidly evolving technologies and stay updated with the latest innovations in their field, engineering students face the challenge of keeping pace. At HTW Berlin, an undergraduate Materials Science lab course (Materials Testing) is in the ongoing development of a flexible course concept to address these demands. This concept incorporates a blended learning teaching approach, using different teaching methods .

1.1 Teaching methods and grading

Teaching methods suggested are based upon a blended learning teaching approach such as the inverted classroom method [1], [2] just in time teaching [3], peer instruction [4], peer reviewing [5], fully online teaching and also in-front teaching.

The "inverted classroom" teaching approach [1], [2], [6] involves students studying the subject matter on their own and then using class time to discuss any questions and work on hands-on lectures or exercises. Peer instruction, as described by Mazur [3], may used to assess learning progress before each class. This method of blended learning is effective and utilizes scientific peer-to-peer lecture films, micro module lectures, and different teaching materials, such as hands-on problems, lecture videos, lightboard-lectures, worksheets, mind maps, glossaries, guided questionnaires, interactive learning material (H5P), 360° virtual lab experience and online tests. All materials cater to different learning styles and enable students from different backgrounds to study online equally. The teaching materials were contributed with intensive student counceling during material science projects and colleagues to ensure high teaching standards.

Grading and assessing students' learning outcomes may be conducted as portfolio, single exam or combined assessment technique as long as the grading system is directly connected to the course learning objectives and not just a series of separate assignments, as noted by Carberry et al. (2012) [6]. Still, educators face challenges in grading and reporting student learning, as clear thinking, careful planning, excellent communication skills, and a focus on student well-being are needed to develop effective grading and reporting processes [7], [8]. Shifting the focus to standards and making criteria secondary could lead to significant advances [9]. Therefore, the a portfolio grading seems to be most appropriate to assess students` progress and competencies when preparing them for future engineers

1.2 Course setting

At HTW Berlin, Material Science is a mandatory course taught in the first and second semester of undergraduate programs (5+5 ECTS) such as mechanical engineering, automotive engineering, and economical engineering, using a "design-led" teaching approach [1]. The goal of this approach, particularly in the first year, is to engage students with the question "What is the objective of the design?" from the start of their studies. In contrast, the traditional "science-led" teaching approach starts with the physics and chemistry of materials, progressing from the atomistic to the macroscopic properties, and often loses the motivation for design challenges.

Therefore, the second semster comprises of a practical lab course: Materials Testing (5 ECTS). Through this practical approach, students learn to critically examine materials, properties, alternative materials and processes, as well as the underlying physics and chemistry. While understanding the theory of material science is necessary, the focus of teaching should be to educate students and prepare them for their role as makers of things, as advocated by Ashby, Shercliff, Cebon (2013) [10].

This paper outlines the course structure, explains the individual combination of lecture materials and refers to possible assessment methods.

2 MATERIALS SCIENCE LAB COURSE DESIGN

Besides the engineering courses 12 other study subjects require material science lab skills at a later point of the curriculum such as restauration, textile design and applied IT. However, capacity of lecturers and lab time are not sufficient it is necessary for students to be well prepared before entering the materials science lab. The Moodle based virtual lab online course offers both, the opportunity to study self-directed and a profound materials base for lecturers who are teaching undergraduate materials science. Following the OER (open educational ressources) the course will be available to all lecturers teaching materials science at HTW Berlin. At a later stage the course design may be open to the www public.

Studens virtually “walk” through the following topics as virtual lab rooms:

- Ultrasonic testing
- Hardness testing
- Charpy test
- Tensile test
- Heat treatment of steels
- Metallurgy
- Light microscopy

They can experience the testing machines as well as analytical equipment. The main functions are explained and theoretical background given (Fig. 1).

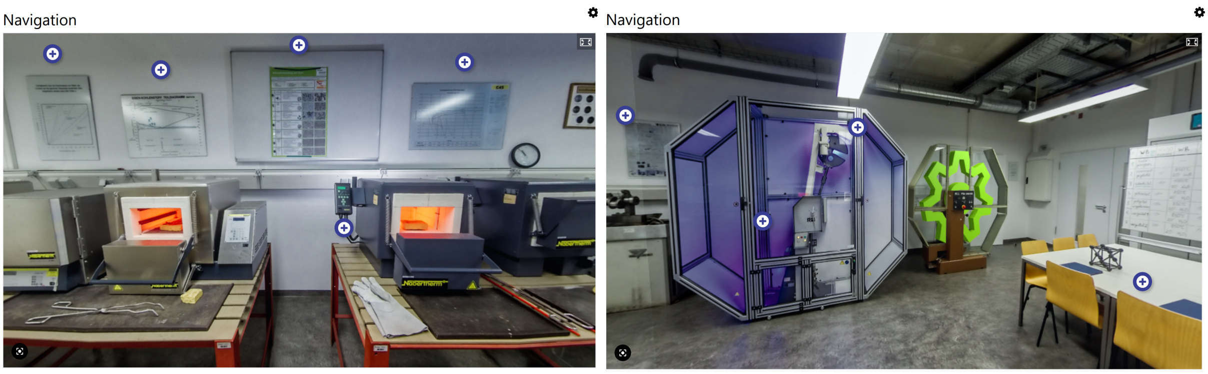

Fig. 1. 360° virtual material science lab

Micro lectures are arranged along with lightboard lectures and lecture videos within the 360° lab. Additionally, all activating materials for self-assessment are implemented (purple crosses). The 360 °C virtual lab course (Fig. 2) comprises of :

- micro lectures
- interactive activities
- guided questionaires
- glossaries
- lecture videos
- lightboard lectures
- tests
- interactive assignments

Fig. 2. Moodle course design

3 BENEFIT FOR LECTURERS

The high quality micro modules are always arranged the same throughout every theme so that students easily manage the Moodle-format [6] and know exactly where to find which information (recommendation – graded activities – micro lectures – lecture videos – interactive videos – assignments – gloassaries – guided questionnaires – additional OER). Lecturers will find detailed information on the course concept but independently decide on the main aspect of their individual teaching and are therefore granted time for various activating methods in class.

All micro teaching materials may individually be combined or restructured and therefore offer sufficient flexibility to match the individual scientific background of the lecturer, the course learning outcome, main study subject or actual need based on recent developments. Lecturers may individually pick, sort and alter the teaching materials within the lab rooms as it suits the individual teaching method allowing for maximum freedom of teaching (pick and place). At the same time the all teaching ressources are valid and do not have to be prepared beforehand. This allows for activating methods, discussions, role plays, micro projects and precise questions&answers in class.

Rooms as well as individual teaching material may be opened or closed so that the content is aligned with the courses` learning outcome. With providing well-arranged individual work packages the pressure especially for lecturers from industry -who are teaching on their full time jobs- is relieved and they have more time to interact with students involving them in future common engineering challenges. However, students need to be advised thoroughly how to work the course and its grading. Right from the beginning lecturers point out the importance of individual work and contribution of every student throught the semester.

4 EXAMPLE OF WORKLOAD

The lab course is suitable for individual studying (self-directed), fully online studying, inverted classroom teaching methods, just in time teaching following the blended learning approach. It may also be ressource for present teaching using different teaching methods and assigments adding to students` total workload as depicted in a possible example outlines in Fig. 3.

Standards-based grading assesses students' achievement of the course's learning objectives, providing them with personalized feedback that is clear and meaningful in terms of meeting the course's objectives and helping them identify their weaknesses in the course [10]. Therefore, the course design offers a portfolio grading and assigns competencies but criteria based grading may be applied when necessary.

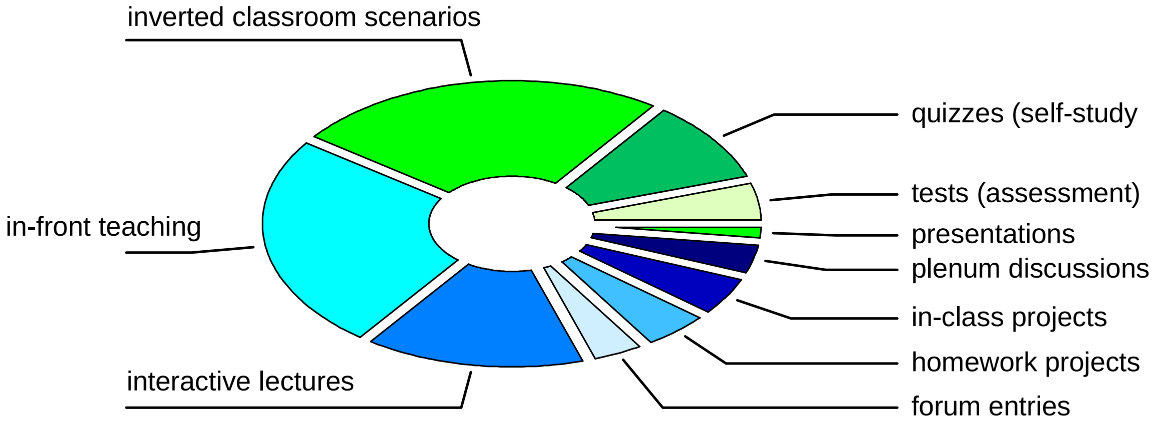

Fig. 3. Moodle course design

Table 1 shows an example of content, teaching method and competency achieved throughout teaching the course as a blended learning course.

Table 1. Example of Materials Testing lab course: Content, teaching method, teaching material, competency and learning outcome

Topic	**Teaching Method**	**Self-study period**	**In-front/lab work**	**competency**	**learning outcome**
Ultrasonic testing	Fully online	Lectures, lecture videos, H5P, guided questionnaires	Lab	Remember, understanding, apply, analyse, evaluate	Reading and interpretation of ultrasonic test results
Hardness testing	Inverted classroom	Lectures, lecture videos, H5P, guided questionnaires, problems	Mini-project/lab	Remember, understanding, apply, analyse, evaluate	Application and Interpretation of hardness testing: Rockwell, Vickers, Brinell
Charpy test	Fully online	Lectures, lecture videos, H5P, guided questionnaires	lab	Remember, understanding, apply, analyse, evaluate	Interpret of fracture surfaces according to brittle and ductile failure
Tensile test	Inverted classroom.	Lectures, mikro project, lecture videos, H5P, guided questionnaires, problems	Hands-on problems, lab	Remember, understanding, apply, analyse, evaluate	Conduction of tensile tests (push-pull), setting up and interpretation of a stress-strain-diagram: yield and strength
Phase Diagrams	Inverted classroom	Lecture videos, Lightboard-lectures	Hands-on problems, lab	Remember, understanding, apply	Reading of the iron-carbon phase diagram
Heat treatment of steel	In-front		Plenum discussion, hands-on problems, Mini projects	Remember, understanding, apply, analyse, evaluate, create	Conduction and application of heat treatment with regard to alterning mechanical properties of steel
Metallographic analysis and microstructure	Inverted classroom	Lectures, quizzes	Mini projects	Apply, analyse, evaluate	Interpretation of microstructural graphs as result of heat treatment

5 STUDENT`S BENEFITS

Right from the beginning, students are provided with a clear understanding of how the course is structured, including content, theoretical background, self-study periods, and hands-on lab time. This knowledge empowers students to adapt their learning behavior and take full advantage of the study freedom offered. The course outline and the use of Moodle as the platform contribute to this clarity, serving as a guide for students as they work on their weekly assignments.

The assessment process is transparent, enabling independent and self-directed learning while allowing students to reflect on their individual learning progress. By combining practical and theoretical work, the course facilitates a deeper understanding of the subject matter and enhances students' study motivation. This approach also prepares students for their future roles as engineers, where they will consistently be expected to engage in practical work while possessing a solid foundation of theoretical knowledge, a skill set that students today are required to develop independently.

6 SUMMARY AND ACKNOWLEDGMENTS

A flexible curriculum is developed for an undergraduate Materials Science lab course based on a blended learning teaching concept. Different teaching methods may be applied and combined (inverted classroom lecture scenarios, just in time teaching, etc.). All teaching ressources are made available in a 360° Moodle course comprising of high quality micro modules with various teaching ressources (micro-lectures, hands-on problems, guided questionnaires, lecture videos, interactive learning material (H5P) and lightboard micro lectures). Lecturers are therefore granted time for various activating methods and project work in class. Main aspect of the course is to encourage lecturers to individually combine and restructure the content according to the courses learning outcome. The 360° lab offers joy of use to students who virtually experience the practical aspects of materials science testing with regard to self-directed learning preparing as future engineers.

The authors would like to thank the teaching center of HTW Berlin for support and funding. The fund 2022/23 allowed for the 360° lab implementation and completion of sections: ultrasonic testing, charpy test and hardness testing.

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