Inverting the classroom teaching material science based on a blended learning concept – a challenge for first year students and lecturer

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Abstract: *Material Science has been chosen as one of the 3 modules during the first year of Mechanical Engineering at HTW Berlin that will be graded the first semester, but not included into the Bachelor`s degree. There is concern that these First Year students may study less sincere, thus, will fail to acquire scientific knowledge that is required to pass the second semester. Hence, flipping the classroom is a method to let the students study the science on their own and then take time to discuss their questions and do extended hands on lectures or exercises in class. One of the basics is that there is a sufficient number and variety of teaching material available that suits different learning skills of the students and meets the diversity of the first year class. Therefore teaching materials and micro modules of lectures to individually chose, combine and study from a distance are provided in a newly established moodle based course. Along with exercises and worked solutions, students can check their learning progress via self-testing. Peer instruction [1] is used to assess the learning progress prior to each class. Blended learning scenarios work that students use different materials to study and understand the science in theory and then the classroom lectures offer the opportunity for students to comprehend the principle of different aspects in material science and apply their knowledge. Not all of the themes taught in first semester are suitable to apply the inverted classroom approach, but is has been proven to be successful and increase the fun of teaching throughout the first semester.*

Key words: *inverted classroom, flipped classroom, peer instruction, material science, blended learning*

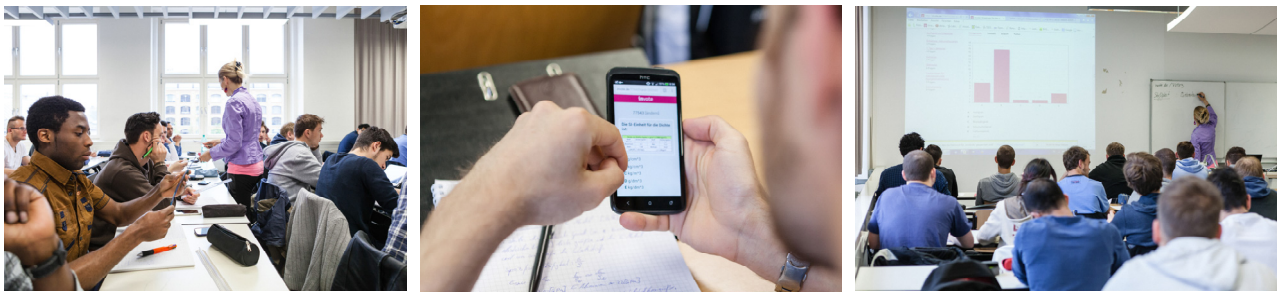
INTRODUCTION

Starting in wintersemester 2014/15 it was decided, that the first semester material science has to be passed as a course, but the grades were not included into the bachelor`s degree for mechanical and automotive engineering at HTW Berlin [2]. This challenges the lecturer, because he or she will face a number of students only interested in passing rather than learning about the important basics. The scientific background of the first semester though is compulsive to understand the lectures of the second semester and the laboratory course. Therefore is was necessary to motivate the students even in their first year to continuously study and keep up to date with the themes covered throughout the first semester of material science. Inverting the classroom [3-6] seemed to be the appropriate medium to gain student`s attention and for them to acquire good exam results assuring each to easily pass the graded exam of the second semester.

The following themes are covered during the first year of material science and available via the content management system "moodle": Material selection, Stiffness and elasticity, Strength and ductility, Materials testing, Phase diagrams, Iron and carbon, Corrosion, Creep and diffusion, Fatigue, Light weight alloys: Aluminum, Magnesium, Titanium, Shape Memory Alloys (in progress), Various themes chosen, worked and presented by students.

The flipped classroom constitutes a role change for instructors, who give up their front-of-the-class position in favour of a more collaborative and cooperative contribution to the teaching process. There is a concomitant change in the role of students, many of whom are used to being cast as passive participants in the education process, where instruction is served to them. The flipped model puts more of the responsibility for learning on the shoulders of students while giving them greater impetus to experiment. Activities can be student-led, and communication among students can become the determining dynamic of a session devoted to learning through hands-on work. What the flip does particularly well is to bring about a distinctive shift in priorities— from merely covering material to working toward mastery of it. [7]

Moreover students got to know each other a lot better, obviously were fond of the course and found materials science entertaining and had personal success when understanding complicated contents. The quality of the work comprised in class was successfully high and the seriousness of the students working on their tasks was astonishing resulting in better grades than the previous semester. Lectures are the appropriate platform to exercise, ask questions and discuss matters with student colleagues and lecturers. Methods such as "Think-pair-share" or "peer instruction" [8] via the open-source "invote" program (www.invote.de) works very well to get a quick overview of students` state of knowledge before questions are answered and students begin working on their assignments (group, pair, single) (figure 1).



"think-pair-share" [8] | peer instruction via "invote" [8] | answering questions

Fig. 1: Students learning session in class after preparing scientific backgrounds at home

CONCEPT OF INVERTING THE CLASSROOM

During summer semester 2015 we got very good results when students were to prepare lectures, watch introductory films [9] and do homework exercises prior to the lecture in presence. An important issue of the concept is, that the students were able to study individually, self-directed, location-independent, asynchronously and according to their individual tempo. In class we had time to discuss problems, work on exercises and engineering related problems, share difficulties and thoughts with neighbours and classmates and especially experience that the background information (self-taught at home) delivered a great deal of understanding of connections between materials properties and their microstructure.

Lecture information and a wide range of teaching materials are provided in the moodle-based material science course [10], offering small units so that necessary theoretical background information could be prepared precisely. Among those most important are:

- Micro module lectures intermixed with problems and worked solutions
- Worksheets and worked solutions
- Lecture videos (actual semester) and teaching videos
- Mindmaps
- Memory sheets to memorize most important aspects
- Online tests (for self testing and assessing through lecturer)

The material science course for first year mechanical engineering students at HTW Berlin is taught via the "design-led" teaching approach [11] (figure 2). In contrast to the conventional "science-led" teaching approach that begins with the physics and chemistry of materials, progressing from the atomistic through the microstructure to the macroscopic

properties [10], the design led approach starts with the needs of the design and then explains why and how properties can be influenced and changed.

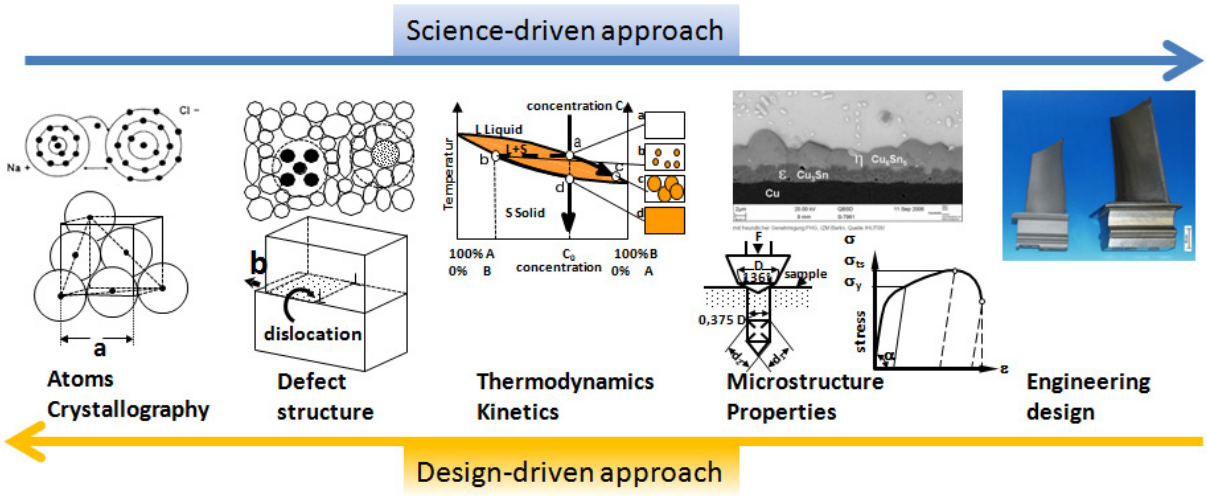


Fig. 2: „science-led-approach" and „design-led-approach" [adopted from 11]

PRACTICE EXAMPLE 1: Introducing microstructure the first day

Microstructures of materials can be regarded as the origin of materials properties. Understanding them and their impact is very complicated. Usually microstructures are introduced when talking about thermodynamics and cooling of alloys, which is towards the end of the first semester. In our opinion this is too late. Students need to know what materials look like, if you have the chance to view the interior and get a much better understanding of their properties. Therefore easy lectures introducing materials, components and their microstructures were given as homework assignment prior to the first lecture in class. Along with the microstructures the most important properties had to be summarized into given templates, building basically on high school knowledge. Each student then was asked to bring one favorite material the first day. These materials were introduced and the students talked about the materials history and why they chose this component. The class was given several typical viewgraphs of microstructures and had to match these with the components and describe what they thought was characteristic about the microstructure. Later the students played "memory" using these components and match them to the microstructures. Besides a lot of running around students got to know each other and were delightful when matching the right component to the microstructure. During the course there was a lot less difficulty for the lecturer to talk about microstructure in any context, because students remembered and combined rather quickly.

Fig. 3: Matching microstructure and component the very first day of materials science (microstructures [16,17], pictures [11,18]

PRACTICE EXAMPLE 2: Hardening mechanisms

There exist four hardening mechanisms in materials science basically to generate changes in microstructure in order to increase the strength of materials. The scientific background was given as homework, such as working through the moodle-lecture, memorizing the most important impacts and voluntarily reading of a simple and short scientific research paper dealing with microstructural properties. Along with the online lectures questions and tests had to be taken and one specific technical term had to be explained in a topic related glossary. This was commented and corrected by the lecturer in the week of the homework assignment.

In class the open-source software "invote" [12,8] was used for peer reviewing. Therefore the lecturer got an overview of the student`s knowledge and the students could assess their learning progress. Questions were answered and important issues individually explained. Then students were divided into groups with 4-6 students each. A special template had to be used to summarize one of the 4 mechanisms, including: microstructural changes and impact on mechanical properties. To make sure all students had nearly the same level of scientific knowledge; students who were not able to work properly at home got different, more basic assignments and were then later intermixed with groups doing the hands on lessons on hardening mechanisms. All students were then asked to prepare their results and briefly present these in front of the class as well as hand in a one page precise summary. These summaries were reviewed by the class and lecturer and uploaded in moodle to be available to all students. Then 2 engineering problems focussing on increasing strength in steels were solved in groups of two students each. Testing the following week proved good understanding and delivered better results than obtained the previous semester.

ADVANTAGES AND DISADVANTAGES

Advantages: Class results indicate that giving students more responsibility for their learning progress is effective in getting students to engage in critical thinking [13,14]; thus, producing deeper learning outcomes [15,8]. The digital teaching materials are independently reusable once generated and provided. The advancement of the wide variety of lecture materials will be in cooperation with colleagues (community-character) and therefore are timeliness and focused on students` needs. Lecturers had a better overview on the progress of the class and were able to help and give advice where

necessary. In general students were very eager to learn and study and share their knowledge helping others and contributing to solving problems. The atmosphere in class was very pleasant and students seemed to have fun experiencing and playing with their newly gained knowledge finding this to lead to useful solutions to material science problems. Lecturers will teach lively students eager to dispose their knowledge and learn more of the details.

Disadvantages: The preparation time of the lectures and the teaching material is outrageous and does not compare to conventional lectures. Students who are not willing to study at home will be lost in the long run, first because of lack of background knowledge, second because they are not able to contribute to group or class work or work on assignments independently. Therefore it is always necessary to prepare teaching and learning material involving these students during the lecture and helping them catch up with missing information. This also results in more work ahead of the lecture and may demotivate those students that are well prepared.

STUDENTS OPINION

Since this concept has only been applied starting in April 2015 there is little results from evaluation available. The students` evaluation forms are still under survey at the moment of writing this paper. However first opinions are that the course requires an "awful lot of work", which has not changed compared to classes taught earlier, but not the work has to be done during the course and not towards the end with exams following closely. Starting with 41 students 26 to 32 were present until the end of the semester, who were still very eager to work and gain knowledge. Those present stated that although it is much to learn and a very theoretical subject thought that the learning activities enhanced their learning progress and diversified the class.

CONCLUSIONS AND FUTURE WORK

For the first time the inverted classroom technique was introduced to first year mechanical engineering students taking material science course. Therefore micro moodle-based online lectures, films, screencasts, lecture slides and various teaching material were provided along with a distinct assignment for one week. In class the students focussed on discussing scientific backgrounds and solving hands-on engineering problems in groups of 2 to 4 students. Flipping the classroom involved students to take over the responsibility for their own learning process and the method was assessed as beneficial in terms of student grades, concentration and attentiveness as well as joy of studying. Still, evaluation over a long period of time has to prove in future, if this concept will enhance students` material science skills and grades in general.

REFERENCES

[1] Simon, B., Kohanfars, M., Lee, J., Tamayo, K, & Cutts, Q., Experience report: peer instruction in introductory computing. Proceedings of the 41st ACM Technical Symposium on Computer Science Education (2010) 341-345.

[2] BerlHG; § 33, Absatz 2 und im Speziellen auf der Rahmenstudien- und –prüfungsordnung für Bachelor- und Masterstudiengänge – RStPO - Ba/Ma; § 14, Absatz 7 der HTW

[3] Berrett, D.: How 'flipping' the classroom can improve the traditional lecture, The Cronicle of Higher Education (2012)

[4] Brame, C.J.: Flipping the Classroom, http://cft.vanderbilt.edu/files/Flipping-the-classroom.pdf

[5] Fischer, M und Spannagel, C: Lernen mit Vorlesungsvideos in der umgedrehten Mathematikvorlesung, in Desel, J., Haake, J.M. und Spannagel, C. (Hrsg.), DELFI 2012,

Die 10. E-Learning Fachtagung Informatik der Gesellschaft für Informatik e.V., S. 225-236, Bonn: Köllen Druck + Verlag, Copyright © Gesellschaft für Informatik

[6] Braun, I. et al., Inverted Classroom an der Hochschule Karlsruhe - ein nicht quantisierter Flip, Beitrag zu „Das Inverted Classroom Model: Begleitband zur ersten deutschen ICM-Konferenz", Jürgen Handke, Alexander Sperl (Hrsg.), erschienen im Oldenbourg Verlag, 2012

[7] Educause Learning initiative, THINGS YOU SHOULD KNOW ABOUT…™ FLIPPED CLASSROOMS, https://net.educause.edu/ir/library/pdf/eli7081.pdf

[8] Simon, B., Kohanfars, M., Lee, J., Tamayo, K, & Cutts, Q., Experience report: peer instruction in introductory computing. Proceedings of the 41st ACM Technical Symposium on Computer Science Education (2010) 341-345.

[9] Online Lehre Plus / external fund: Berliner Qualitätsoffensive für die Lehre/ https://www.berlin.de/sen/wissenschaft/wissenschaftspolitik/finanzierung/vereinbarung_berliner_qualitaetsoffensive_fur_die_lehre_2012_bis_2016.pdf

[10] Qualitätspakt Lehre – Teil-Projekt „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

[11] Ashby, M., Shercliff, H., Cebon, D.: Materials Engineering, Science, Processing and Design, 2013: ISBN-13: 978-0080994345, 2013: ISBN-10: 0080994342, Pub date: Oct 02, 2013 (3rd edition)

[12] http://invote.de/

[13] Colorado State University, Using Peer Teaching in the Classroom, (2015), http://teaching.colostate.edu/tips/tip.cfm?tipid=180

[14] Lord, T., 101 reasons for using cooperative learning in biology teaching. The American Biology Teacher 63(1) (2012) 30-38.

[15] Goto, K. & Schneider, J., Learning through teaching: Challenges and opportunities in facilitating student learning in food science and nutrition by using the interteaching approach. Journal of Food Science Education 9(1) (2010) 31-35.

[16] www.metallograph.de. [Online] [Zitat vom 13.05 2013]

[17] Schumann, Prof. Dr. Metallographie. Leipzig: Deutscher Verlag für Grundstoffindustrie GmbH, Leipzig 1991, 1990. 13. Auflage.

[18] "CES EduPack", materials science data-base, edition 2013

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The paper has been reviewed.