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Design and manufacturing of a LIGHTBOARD - Combining the peer-to-peer idea with project based teaching

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Abstract
Lecturers in higher education find it challenging to involve students into critical thinking, carefully pondering solutions to mechanical engineering problems. Project based teaching gives the opportunity to gain both, higher learning outcome and self-reliant study skills. During fourth semester mechanical engineering a guided one semester project (180 hours workload, 6 ECTS) related to a complex real engineering problem focusing on customer demands and possible solutions. It comprised of the design and manufacturing of a lightboard – a "learning glass panel" consisting of a high quality optiglass panel which is surrounded by LED lights. As on regular whiteboards a lecture may be given and filmed directly writing on the 16:9 screen glass panel with fluorescent pens – the lecturer always facing the audience. This lightboard project directly involves students in the production of a teaching device (peer-to-peer approach) and the teaching method is regarded beneficial in terms of students` learning outcome and self-reliance as well as engineering skills. However, the work load is very high and grading is insufficient. Therefore, the method and the role of a lecturer as facilitator is discussed.

Keywords: *Lightboard, project-based learning, peer-to-peer teaching.*

1. Introduction

Globalization and ready accessibility of information nowadays encourages HTW Berlin to move to a competency-based teaching model helping graduates to acquire autonomy and to appropriate the learning process: Huguet et al. (2017), Pfennig (2020), Pfennig (2022). Practicing problem-based learning in education enables students to gain skills above and beyond sheer theoretical and factual knowledge: Balvea and Albert (2015) and reinforces their natural desire to learn: Gomez-Pablos et al. (2016). In general, project based learning methods: Efstratia (2014), Balve and Albert (2015) improve

- interpersonal and interaction skills,
- the capacity of dealing with conflicts and uncertainty,
- communication and presentation skills,
- the ability to work autonomously and assume responsibility,
- the capacity of reasoned decisions,
- and the ability to dive quickly into new areas of knowledge and apply this knowledge in practical situations

The peer-to-peer approach applies well in project based teaching where advanced students generate teaching material for first and second year students: Pfennig (2020), Pfennig (2019). Class results indicate that involving students directly into teaching activities (preparation of lecture videos) can be very effective in getting students to engage in critical thinking: Lord, (2012) entailing deeper learning outcomes: Goto and Schneider (2010). Lecture videos produced via the peer-to-peer approach during student projects: Pfennig (2019) are successfully implemented in inverted classroom teaching scenarios in a first year materials science course at HTW Berlin: Pfennig (2020). Inverted classroom teaching covers the scientific input via defined self-studying phases enabling communicative teaching approaches (group work, discussions, hands-on problems, etc.) during face-to-face time: Pfennig (2020), Pfennig (2022), Setren et al. (2019).

Most self-study phases of the inverted classroom lectures are accompanied by lecture capture videos because lecture videos provide both, an audio and visual stimulus: Gulley and Jackson (2016). But, -with exception of screen casts- the lecturer generally turns her or his back towards the students which is rated disruptive by students. Therefore, lightboard video recording offers a promising low threshold solution to teach short sequences online and simultaneously face students. A lightboard is a "transparent blackboard" consisting of a high quality optiglass panel surrounded by LED lights: Pershkin (2020). The lecturer may directly write on the lightboard with fluorescent pens, being filmed in front. During post processing the video is mirrored and the video lecture topics may be directly used e.g for self-studying (Figure 1). As the production of lightboard videos is easy and post productions not time consuming at set of lecture films were produced partly on student demand. These can directly be implemented in the self-study phase of inverted classroom teaching scenarios correspondent to video captures, online lectures, written information and other teaching ressources: Pfennig (2018), Pfennig (2019-3), Pfennig (2020), Pfennig (2022). However, since there was no device readily available, a completely new lightboard was designed and manufactured as a one semester student project and implemented in teaching at HTW Berlin starting 2019.

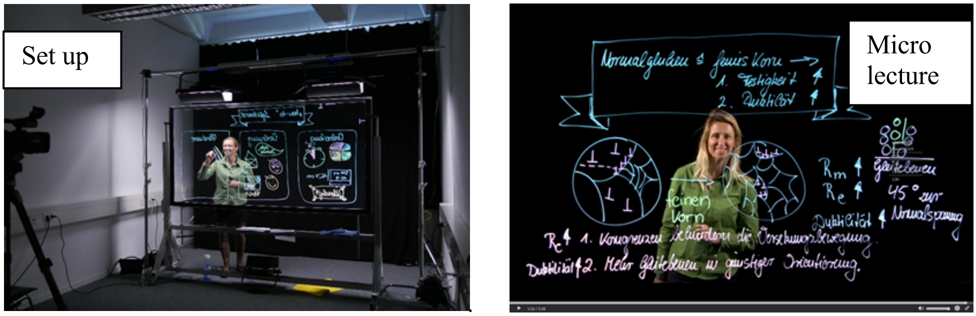

Figure 1. Examples of lightboard videos at HTW Berlin: left: production, right: lightboard video ready to use.

2. Project Lightboard – design

The fourth semester of mechanical engineering comprises of a 6 ECTS course "interdisciplinary engineering project" to be conducted in 6 months. Students chose among 20 to 40 projects facilitated by different lecturers, that is: all students voluntarily chose the "lightboard-project. The entire scenario accounts for 180 hours in total (contact time in meetings is approximately 20 hours), 70 for self-studying and design, 8 hours for presentation and 82 hours of lab work on the lightboard. The lightboard project was selected by 9 students (generally too many, but all of the students were very eager to work on and contribute to the project). The project was sub-classified into 3 phases: kick-off: directly at the beginning of the semester, design: 8 weeks (+4 weeks time to adjust) and manufacturing: 12 weeks.

To keep all students in the lightboard project, they agreed on 3 teams of 3 students each working on different designs in a competitive manner with the best design to be transfered into the product. Teams were formed easily according to students` preferences, because these students knew each other for more than 2 years. Work packages were agreed on 1. layout of the design, 2. order and setting of the room for the lightboard, 3. manufacturing and redesign and 4. documentation. The first milestone, the layout of the designs was set for a period of 6 weeks, finish after 12 weeks. This implied intensive work, but offered time for the finding of the design, feasibility study and evaluate order and/or shipping time of components. The role of the lecturer was to facilitate, answer questions whenever these aroused, manage conflicts once students asked for advice or help and keep track of mile stones and dead-lines.

3. Project Lightboard – manufacturing

3 different designs were presented differing in complexity of the design. After presentations and approximately 4 hours of discussion the students agreed on a design comprising of electrical adjustment of height (Figure 2). The group defined new competencies and responsibilites with 1 student in charge of welding, 2 for orders, 2 for room installation, 2 for construction and 2 for documentation.

Figure 2. Images of lightboard procution and glass micro flaws/precipitations.

During manufacturing of the lightboard e.g. welding, construction, electrical installation it was soon clear that the motor of the chosen design was not deliverable. The group agreed on another design with the same student competencies. Another drawback was the low quality of the glass panel consisting of inacceptable micro flaws and precipitations (Figure 1, right). All the time the students were facilitated by the lecturer and project leader via skype, slack and email contact. However, the rebuying of the second glass panel was done by the project leader/lecturer. Due to the redesign the time scheme was extended 4 weeks.

The manufacturing report was delivered on time and applied for instruction manual for other projects (HTW Berlin delivered the design in 2020 to a university in southern Germany). The film documentation lacked of professionalism.

4. Discussion: lessons learnt, evaluation and self-reflection

Project based teaching allows students to learn science and learn how to be independent thinkers. Students should be capable to take responsibility of their own learning process and find their own study pathway. The project based method implements a structural teaching change with grades not being the main focus: Balvea and Albert (2015) emphasizing in non-technical skill development although the capability of planning actions to solve situations might stay ominous: García (2016). However, as traditional courses do not always prepare individuals to be competitive, and consequently may have little value or relevance to students after they graduate: Sarta (2014) project based learning prepares engineering students for market needs in a globalized world.

The lightboard project directly involves students in the production of a teaching device implementing their skills received in former classes. Therefore, these students were not only engaged in the design and manufacturing itself but also in the process of project work. The sustainability of the product, the implementation of the lightboard as teaching device further encouraged students. Students had to arrange with different engineering related tasks such as the design, manufacturing, welding, ordering components, handling equipment and reporting properly on their project progress. But also social skills were accomplished, such as: communication with sales person, team building, reporting properly written and orally, discussions of project related problems, discussing social related problems during workflow, to deal with unforeseen problems during the project postponing of orders and finding experts to support (e.g. welding, calculation, etc.). For them it was the first time to actually be involved in a real product related work giving them the feeling of importance of themselves as engineer, person and project college.

When implementing the project based teaching method, the attitude of lecturers is of great importance to the success of the method: Lasauskiene et al. (2015). It is strongly suggested to assign a sufficient substructure for both the teacher and the student. Every student should relate to a duty according to his or her own ability: Ergül et al. (2015), where their characteristics and qualities, environmental conditions along with fundamental principles should be taken into account: Kaya et al. (2014). Transparent steady course demands and sufficient high quality learning material need to be provided to make the method successful – even in terms of better grades: Kaya et al. (2014). Tasks were clear, grading was transparent all the time (Figure 3), contact hours set, the project leader available online all the time offering valuable advice and helping with viable tasks or decisions. Still, grading of the course (comprising of: engineering skills, creativity, feasibility, communication, management, documentation, reporting regularly was mixed (Figure 3): 1 students scored: A+, 1 student: A, 1 student: A-, 2 students B and 4 students: B- (note, students were members of different groups). The B- was mainly related to lack of participation and communication as well as missing of deadlines and quality of the reports.

These deficits could have been detected earlier if fellow students had reported the difficulties. Students often lack of help and support among each other when carrying out the tasks: Gomez-Pablos (2016) and may not know how to interact effectively so that lecturers and administration should discuss and reinforce social skills along with providing guiding templates to help staying focused.

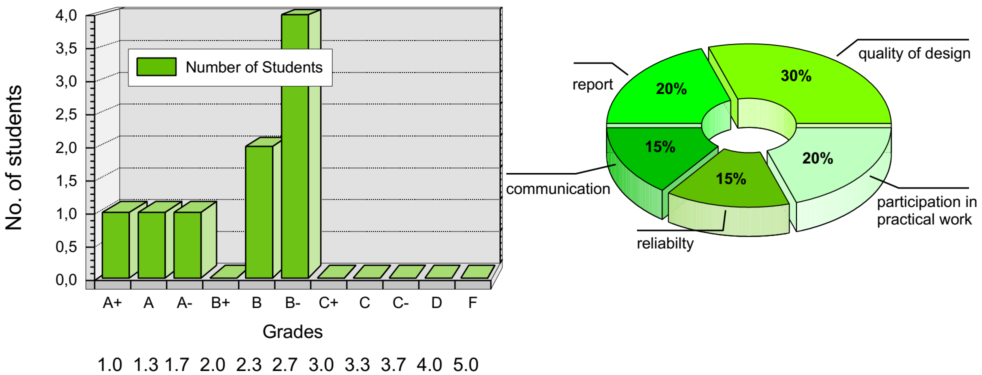

Figure 3. Distribution and constitution of student grades: project lightboard.

Four draw backs during the project were vital to its ongoing: First, the insufficient quality of the glass panel which was costly in terms of time. Second, the framing was calculated according to a feasibility study and highest load and strain. However, aluminum profiles distort during welding leaving the frame of the glass panel bent (it does not impair the functionality of the lightboard). Third, the electrical motor for the electrical height adjustment was not deliverable so that the group hat to change to a different design. Forth, was related to the project leader because here the lack of tight guidance during the project and the renunciation of close reporting intervals was disadvantageous in terms of project planning.

Therefore, one of the most important lessons learnt is to not accept more students that were intended initially. And during this project, closer guidance and facilitation by the lecturer is highly advised to keep students working on the main tasks fulfilling the work packages. Decisions have to made earlier to direct students and it is also necessary to set non-negotiable deadlines. These were not given ahead of the project start because a lightboard has never been designed before (now there are custom-ordered designs available) and no one new about the project outcome. However, the creativity of the engineering design is not suppressed with strict framing, moreover it may help students to focus on the project outcome. The most important lessons learnt are:

- Closer facilitation towards fulfilling milestones
- Clear advice on task (deliverables of the work packages)
- Feasibility study and component availability right from the beginning
- Mid-term reports and/or weekly reports to keep close the project proces
- 6 students are a good working group size to handle well for lecturers

5. Conclusion

The peer-to-peer approach was combined with project based teaching to design and manufacture a lightboard that may be used by every lecturer at HTW Berlin to generate low threshold lecture videos. Advantage of lightboard videos over lecture capturing is that students are faced directly during online teaching and are therefore secured in their teaching process. A guided one semester project (180 hours workload, 6 ECTS) related to a complex real engineering problem focused on customer demands and possible solutions. The lightboard project directly involves students in the production of a teaching device and therefore these students were not only engaged in the design and manufacturing itself but also in the process of project work and sustainability of their project outcome. 4 work packages were defined. Results were compiled and presented at milestones. Students had to arrange with different tasks: design, manufacturing, welding, ordering components, communication with sales person, team building, reporting properly, discussions of project related problems, discussing social related problems during workflow, handling equipment, dealing with the postponing of orders, finding experts to support (e.g. welding, calculation, etc.). Lectures learnt to facilitate properly are: offer closer guidance, make decisions earlier to direct students and to set non-negotiable deadlines. Quintessence is that the creativity of an engineering design is not suppressed but supported by close guidance allowing for students to focus on the project outcome. During the project based work students took over the responsibility for their own learning process. Although grades were not sufficiently high, the teaching method is still assessed as beneficial in terms of lightboard design and construction, learning output of students and lecturer, understanding of project work, concentration and attentiveness as well as both joy of studying and working as a future engineer.

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