ETALEE2021

IngeniørUddannelsernes Pædagogiske Netværk

Exploring Teaching for Active Learning in Engineering Education

University College Absalon, Kalundborg, November 25-26 2021

Book of Abstracts

DTU Technical University of Denmark

VIA University College

Aalborg University Denmark

SDU

Aarhus University School of Engineering

University College Absalon

Programme - ETALEE 2021

Thursday - 25 November 2021	
08.30 - 09.45	Registration - coffee and tea
09.45 - 09.55	WELCOME
09.55 - 10.40	Active Keynote - Mikkel Godsk
10.45 - 12.15	Parallel Hand-on I/Explore session
12.15 - 13.15	Lunch
13.15 - 14.45	Parallel Hand-on II
14.45 - 15.00	Coffee/Tea
15.00 - 16.30	Explore possibillity for Network groups
16.30 - 17.30	Networking/snacks

19.00 - 22.00	Conference dinner at "Strandhotel Røsnæs"

Friday - 26 November 2021	
09.00 - 10.00	Active Keynote - Thomas Ryberg
10.00- 10.15	Coffee and tea
10.15 - 11.45	Parallel Hand-on III
11.50 - 12.30	Summing up Keynote - Rie P. Troelsen
12.30 - 12.45	Closing session
12.45 - 13.30	Sandwich in Helix Lab.
14.00 - 15.30	Company visit - Bus to/from companies. Novo Nordisk A/S Novozymes Unibio Equinor Refining Denmark A/S

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Rie P. Troelsen, Friday 11.50-12.30

”What happened?”

Keynote I
Thursday 09.55 - 10.40

”Student engagement in technology-enhanced, blended, and online learning”

Mikkel Godsk, AU

Across higher education in Denmark and internationally, there is a general desire to increase learning and student engagement with digital educational technology. Research shows that technology has the potential to support a wide range of student engagement aspects, including active learning, performance, motivation, and deep learning. However, the research also shows no direct link between technology and its effect on engagement. The effect depends on the characteristics of the technology and how it is used in teaching and learning.

Based on a large-scale literature review of the current research, recommendations on how educational technology can support the students’ engagement are presented and supplemented with concrete examples from engineering education. Furthermore, the specific recommendations on how to engage students’ learning with learning management systems, discussion boards, quizzes, audience response systems, social media, and audiovisual media are shared as a deck of cards. Based on the cards, the participants are invited to reflect on their teaching practice and discuss challenges and solutions with peers.

Keynote II
Friday 09.00 - 10.00

”A critical-constructive view on educational technology – reclaiming pedagogy”

Thomas Ryberg, AAU

Across higher education in Denmark and internationally, there is a general desire to increase learning and student engagement with digital educational technology. Research shows that technology has the potential to support a wide range of student engagement aspects, including active learning, performance, motivation, and deep learning. However, the research also shows no direct link between technology and its effect on engagement. The effect depends on the characteristics of the technology and how it is used in teaching and learning.

Based on a large-scale literature review of the current research, recommendations on how educational technology can support the students’ engagement are presented and supplemented with concrete examples from engineering education. Furthermore, the specific recommendations on how to engage students’ learning with learning management systems, discussion boards, quizzes, audience response systems, social media, and audiovisual media are shared as a deck of cards. Based on the cards, the participants are invited to reflect on their teaching practice and discuss challenges and solutions with peers.

Keynote III
Friday 11.50 - 12.30

”What happened?”

Rie P. Troelsen, SDU

Attending as many Hands on and Explore sessions as possible during the conference, I look forward to learn all kinds of new and inspiring forms of teaching and learning that motivate, activate and engage students from you.
In my keynote I will present the general trends, patterns of similarities and exciting differences in your contributions and relate them to not only the necessary questions and recommendations on digital enhanced teaching provided to us by the two former keynotes, but also relate them to my own experience as an educational developer for the last 20 years.

So please join me in this last keynote of the conference to sum up the main ideas, insights, inspirations and take-home messages of the conference.

Abstracts/Papers
Hands-on Session I
Thursday 10.45 - 12.15

Seeing student understanding during a lecture - Henrik Skov Midtiby, University of Southern Denmark.

Implementation of a formative, two-stage feedback practice - Claus Thorp Hansen Technical University of Denmark

Seeing student understanding during a lecture

Henrik Skov Midtiby
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ABSTRACT
Keywords – student response system, online feedback during lecture, drawings

Please indicate clearly the type of contribution you are submitting: _x_ hands-on, ___explore, ___poster.

This hands-on session we focus on how to see students understanding during a lecture through the use of the student response system Classroom Shared Drawing. The system lets a teacher send and image out to students, that the students then can draw their answers on top of. While the students are drawing their answers, the teacher can follow along in real time. This makes it possible to actually see how well the students have understood elements of a certain topic. This approach of using drawings as an answer type can be applied in all classes that rely on visual models. Examples of such visual models could be a map of the human body (anatomy), a diagram of an electric circuit (electronics) and a force diagram (physics).

I Background

For a lecturer to adapt a lecture to the current audience the lecturer needs feedback from the audience. How to obtain that feedback is the topic of this hands-on session. If the students understand the topic well, the lecturer can move forward to the next topic. If the students have large gaps in their understanding it might be better to revisit some of the earlier class material. Eric Mazur has successfully implemented such an approach by using ConcepTests to gauge the students' understanding and then adapt the lecture to the students' answers using Peer Instruction [Crouch 2021].

A central question is how to obtain that kind of feedback. Traditional approaches have been to request an answer from students in plenum or to use a student response system to collect responses to a multiple-choice question. By posing a question in plenum, the lecturer can get a detailed answer from one or maybe a few students. The main issue with this approach is that only a few of the students in the class provide feedback to the lecturer and that this sample of students is likely biased towards the students that indicate that they would like to answer the question.

Using a multiple-choice question has some different upsides and downsides compared to asking a few students. The good thing about multiple-choice questions is that a large fraction of the class is heard as they provide their answer to the posed question. There are however two issues with multiple-choice questions: the first issue is that they only provide a limited set of answer possibilities for the students and the second issue is that it is difficult to make good multiple-choice questions including incorrect answers that are plausible.

II Explanation

In this hands-on session, we will look into an alternative method of getting feedback from the students, which can gather feedback from all students in the class and where it is easier to generate new questions compared to high-quality multiple-choice questions. The method is based on handing out images to the students that they then draw on top of. The system aggregates all drawn answers into a single image which is shown to the lecturer.

As an example take a lecture about linear equations. Here the lecturer wants to test well the students are able to draw align given the equation for that specific line. The teacher provides an equation for a line and a coordinate system in which each student should draw the line specified by the equation. As as the students are drawing their answers the lecturer can follow along in an aggregate view of all student contributions in real time. This aggregate view provides the lecturer an overview of the students understanding of the topic. The lecturer can see how many of the students that provided the correct answer and more important can get an overview of the misconceptions among the students in the class. The drawing answer type also forces forces the student to generate a solution which requires more effort from the student than choosing one out of four shown drawn lines.

Figure 1: An example of a question posed to students and a set of student answers to a similar question.

III Set-up

This approach of using drawings as an answer type is implemented in the system Classroom Shared Drawing. The Classroom Shared Drawing is developed at part of an e-learning project at the University of Southern Denmark. To use Classroom Shared Drawing as a teacher you will have to log in to the system, then upload the image you want to send out to the students, press "push canvas to students" and finally you need to provide the link to the students well they can in fact with the system. When the students then draw their answers, you can follow along in real time. Logins to Classroom Shared Drawing will be provided to the participants of the hands-on session.

VI Expected outcomes and results

During the hands-on session you will try to use the Classroom Shared Drawing system as a student, then we will discuss how to make good visual questions and finally you will try to use the system as a teacher.

I have used Classroom Shared Drawing as part of teaching first year mathematics for electrical engineering students. In multiple occasions the students drawing has revealed misunderstandings, that could be addressed immediately. The students often request to see the aggregated view of the answers, that makes it possible for them to assess their own understanding relative to the rest of the class. It also provides a great starting point to discuss different approaches to the posed problem.

REFERENCES

Crouch, C. H., & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. American Journal of Physics, 69(9), 970–977. https://doi.org/10.1119/1.1374249

Implementation of a formative, two-stage feedback practice

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ABSTRACT
Keywords – Formative feedback, two-stage feedback, feedback processes.

Please indicate clearly the type of contribution you are submitting: _X_ hands-on, ___explore, ___poster.

Background
Feedback is important for student learning, but not every way to provide feedback is equally useful for students' learning. This hands-on presentation describes and discusses the feedback practice developed in the course Arenas and concepts. It is a feedback practice that is very effective measured on both the students' evaluation of the course and the grade profile. Furthermore, it is a feedback practice that is not overwhelming in teacher effort.

Description of the feedback practice
The course Arenas and concepts runs in parallel with the students' bachelor projects, and it contributes with theory to the projects. The course terminology and models are practiced on the students' own bachelor projects, i.e. the students work in their bachelor groups when answering the course assignments. In the course, two assignments are handed in during the 13-weeks period: first an *Arena* assignment and later a *Concept* assignment. Students receive formative feedback the week after hand in (i.e. quick feedback while students remember their assignments). Both teacher and teaching assistant provide feedback:

1) First, teacher provides systematic written feedback in relation to the course terminology and models. Thereafter, time is allocated to oral feedback (discussion) with each bachelor group, where they can ask questions and make comments on the written feedback.
2) The teaching assistant gives oral feedback (discussion) from student perspective: What do I believe you can do better in the Final assignment.

Based on the two assignments handed in, the feedback discussions with teacher and teaching assistant and further work in the bachelor project, the students submit a Final assignment. The content of the Final assignment is an improved and updated description of the *arena* for the bachelor project, an improved description of one or more promising *concepts*, and consideration regarding staging of the further design and realization work. The form of the Final assignment is a written synopsis and an oral presentation with subsequent examination.

How effective is the feedback practice?
In order to evaluate the effectiveness of the feedback practice we focus on the students' evaluation of the course and on the grade profile. The students' evaluation of the course in spring 2020 and spring 2021 shows high student satisfaction in general, and with respect to the question "During the course, I have had the opportunity to get feedback on my performance" the course is remarkably better than the department's average as well as the DTU average. The grade profiles from spring 2020 and 2021 shows that more than 50% of the students obtain grades 10 or 12. Thus, we observe that the feedback practice is very effective.

Why is the feedback practice effective?
The feedback practice consists of at least three elements, which are productive for student learning:

1) The students apply the course terminology and models on a relevant and interesting problem: their own bachelor project. Biggs & Tang (2011) write that appropriate student motivating involves: First, the task provided "*must be* valued *by the student and not seen as busywork and trivial*." Second, "*The student must have a reasonable* probability of success *in achieving the task*." It should be evident that assignments, which in content are based on the student's own bachelor project, are motivating.
2) Based on the two assignments handed in and the feedback discussions with teacher and teaching assistant, students are expected to prepare improved descriptions for the Final assignment. Carless et al. (2010) write, "*A more promising assessment design strategy involves two-stage (or multi-stage) assignments in which two (or more) related tasks form the assessment for a course. Two-stage assignments can involve feedback on the first stage, intended to enable the student to improve the quality of work for a second-stage submission*." The feedback practice implemented in Arenas and concepts is a two-stage strategy.
3) Only formative feedback is provided – nothing with partial grades. Research shows that the most effective feedback with respect to student learning is pure formative. As soon as grades or partial grades are included in a feedback process students tend to focus on the grades obtained and loose awareness of how to improve their work (Ulriksen, 2014).

How expensive in teacher effort is the feedback practice?
The course is dimensioned for a maximum of 30-45 students working in their bachelor groups, i.e. groups of 1 to 4 students. In order to submit written feedback to the bachelor groups at the latest the day before oral feedback is scheduled, the teacher has three working days to read and comment on the assignments handed in. During a four-hour module each bachelor group has a discussion first with the teacher and then with the teaching assistant. For the teaching assistant to prepare for oral feedback is allocated in total 14.5 hours.

Hands on session
Introduction (10 minutes)
The feedback practice will be described, empirical data to evaluate its effectivity will be presented, and some reasons for the feedback practice's effectivity will be discussed.

Hands-on activity (60 minutes)
The participants will apply the proposed formative, two-stage feedback practice. The participants will be grouped into smaller groups. Each group will select one of the group members' courses and try to redesign it with respect to improved feedback using the presented feedback practice as inspiration.

Discussion and conclusion (20 minutes)
In the last part of the session, the participants will discuss the result of the hands-on activity and share their experiences focusing on the question: how can you implement elements of the practice in your own teaching?

Expected outcomes/results
The expected outcome from the hands–on session is ideas and/or proposals of how to implement a formative, two-stage feedback practice in own teaching.

REFERENCES
Carless, D., Salter, D., Yang, M. & Lam, J. (2010) "Developing sustainable feedback practices", *Studies in Higher Education*, DOI: 10.1080/03075071003642449
Biggs, J. & Tang, C. (2011) "*Teaching for Quality Learning at University. What the Student Does*", 4th edition, McGraw-Hill.
Ulriksen, L. (2014) "*God undervisning på de videregående uddannelser*", Frydenlund, Frederiksberg.

Abstracts/Papers
Explore Session
Thursday 10.45 - 12.15

Redesigning Course Curriculum for Quarantine Conditions: Experiences from two lecturers in software engineering - Astrid Hanghøj & Knud Erik Rasmussen, VIA University college.

Students metacognitive processes and impact on Self-efficacy in embedded programming - Ole Schultz & Tomasz Blaszczyk, DTU Engineering Technology

Redesigning Course Curriculum for Quarantine Conditions: Experiences from two lecturers in software engineering

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ABSTRACT

The COVID-19 pandemic posed a challenge for teachers and students to adjust to continually changing restrictions in relation to teaching. In response to this challenge, we designed a new course structure for the class Data Analytics Infrastructure. Our aim was to actively engage students without knowing if we would conduct mostly online teaching or face-to-face teaching. This paper presents our experiences with redesigning a course under quarantine conditions to improve student motivation.

Keywords – active participation in online learning, (re)designing online courses, flipped classroom, motivation, COVID-19, blended learning, data analytics infrastructure.

Contribution – Explore Session

BACKGROUND

COVID-19 posed an adaptive challenge for teachers (Reimers et al., 2020) and is the largest disruption of education in history impacting students and faculty world-wide (Pokhrel and Chhetri, 2021) as schools have discontinued face-to-face teaching. In this paper, we would like to present our joint efforts to transform our course Data Analytics Infrastructure into a quarantine-proof online learning experience.

The course Data Analytics Infrastructure (DAI) is a fourth semester course in the Software Engineering program at VIA University College in Horsens[1]. The redesign of the course was carried out in the fall of 2020 and course material (videos, learning paths, etc.) was developed during early spring 2021. The first run of the course was in spring 2021.

DAI enables the students to design and implement infrastructure to support data analytics including tools and techniques for data acquisitions, data cleansing, data modelling and data visualization. The students in the course are fourth semester students who have completed the prerequisite course on database design (DBS). The course is a mandatory course in the Software Engineering program worth 5 ECTS through the European Credit Transfer Scheme. The course is open to exchange students coming to the institution for a semester.

102 students took the course in Spring 2021. 14 students took the class in Danish with Astrid as the instructor, 44 students took the class in English with Astrid as the instructor (Y class) and 44 students took the class in English with Knud Erik as the instructor (X class).

[1] The course description can be found here: https://en.via.dk/tmh-courses/data-analytics-infrastructure

The students who took the course in spring 2021 had some previous experience in online education from the initial lock-down in March 2020. Both lecturers in the course were also teaching the course during the initial lock-down and thus had some preliminary experience in teaching the course in an online format, though not with the structure and materials described in this paper.

As a result of the pandemic, we decided to redesign the entire course format. We needed to think of a structure that would remain if we were allowed to return to in-class teaching. We also wanted to undertake the redesign in such a manner that the new course would also work in a regular teaching environment post-pandemic.

We have focused on building a learning experience that addresses the three fundamental needs of students: autonomy, competence, and relatedness (Deci and Ryan, 2001) to improve motivation which is essential in online learning (Salmon, 2004, p.15).

EXPLANATION

Traditional in-class lectures continue to be the predominant instructional strategy despite being criticized as being an ineffective instructional form (Gilboy, Heinerichs and Pazzaglia, 2015) with students generally only remembering 20% of what has been presented in class. Flipped classroom is one kind of online learning that promises to reduce the time spend on disseminating information (Johnson, 2013) in favor of increasing the time spent “challenging student thinking, guiding them to solving practical problems, and encouraging direct application of material through active learning with the instructor present” (Gilboy, Heinerichs and Pazzaglia, 2015) thus being a form of active learning and blended learning (Olesen, 2020).

Course designs for online learning vary and redesign towards online teaching may be based on different considerations (Twigg, 2003). Further, Twig (2003) proposes that online learning may reduce costs for institutions of up 40% and improve student learning (Twigg 2003, p. 30).

However, online learning may also be a challenge for students. Some learners may find it difficult to adapt and adjust whereas others may quickly adapt to the new learning environment (Pokhrel and Chhetri, 2021; Nwosisi et al., 2016). Some students may find it especially challenging to participate in online learning because of issues related to motivation and access (Salmon, 2004) and students with low digital competencies may experience problems with access to online materials (Salmon, 2004).

Surveys during the COVID-19 pandemic have found that students rate motivation lower, that they had less contact with fellow students and with instructors (Zambach, 2020; EVA, 2021), which may further lead to demotivation as relatedness needs are not being met (Deci and Ryan, 2001).

Feedback is important for learning (Hattie and Timperley, 2007; Dolmer et al., 2016). Students in higher education want more feedback and especially formative feedback. According to EVA (2021), educators often fail to provide the right, structured conditions for a feedback culture. When participating in online learning the need for constant feedback is apparent for confident as well as less confident learners (Salmon, 2004, p.16).

SET UP

We decided to redesign the DAI course into a blended learning model with asynchronous activities which the students completed and received feedback on, as well as synchronous activities that students would complete together in order to serve motivation needs related to socialization.

The course redesign is split into three tracks. Each of these three different learning experiences cover the same learning aims. See Figure 1 below.

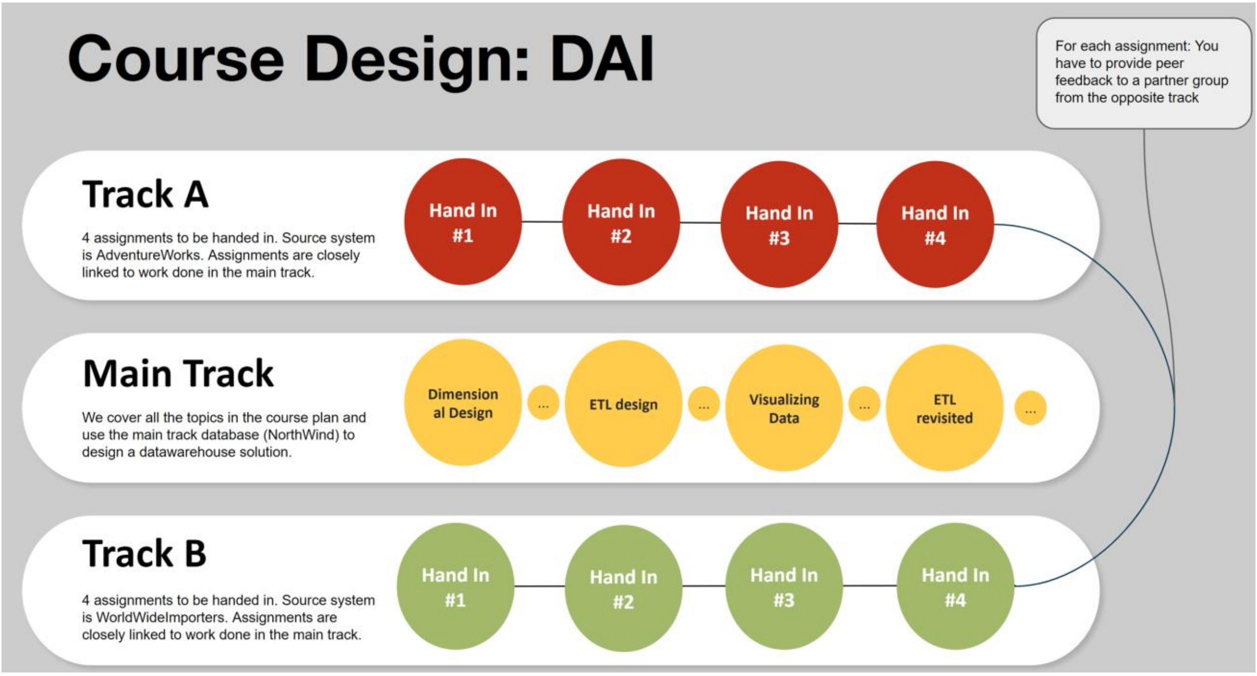

Figure 1: Course Design

In the main track, students complete individual exercises aimed at building competence in the different learning aims for the course. This learning experience is supported with learning resources, focused on dissemination as well as individual and group practice. The learning experience was supported using learning paths in the online Learning Management System itslearning.

Two of the learning aims of the course are: ” Use basic statistics and visualization to find and explain patterns of information in data” and ”Discuss and argue pros, cons and trade-offs of choices”. The structure of the course is exemplified for these learning aims in Figure 2 and Figure 3 on the following pages.

Before starting the course, the students are asked to complete a small prologue which take the form of a learning path like the ones they will be working with in the course. The prologue introduces the students to the course, the lecturers, and our expectations of the students. We have done so because more than just simple access to online materials, students need to know how to participate (Salmon, 2004).

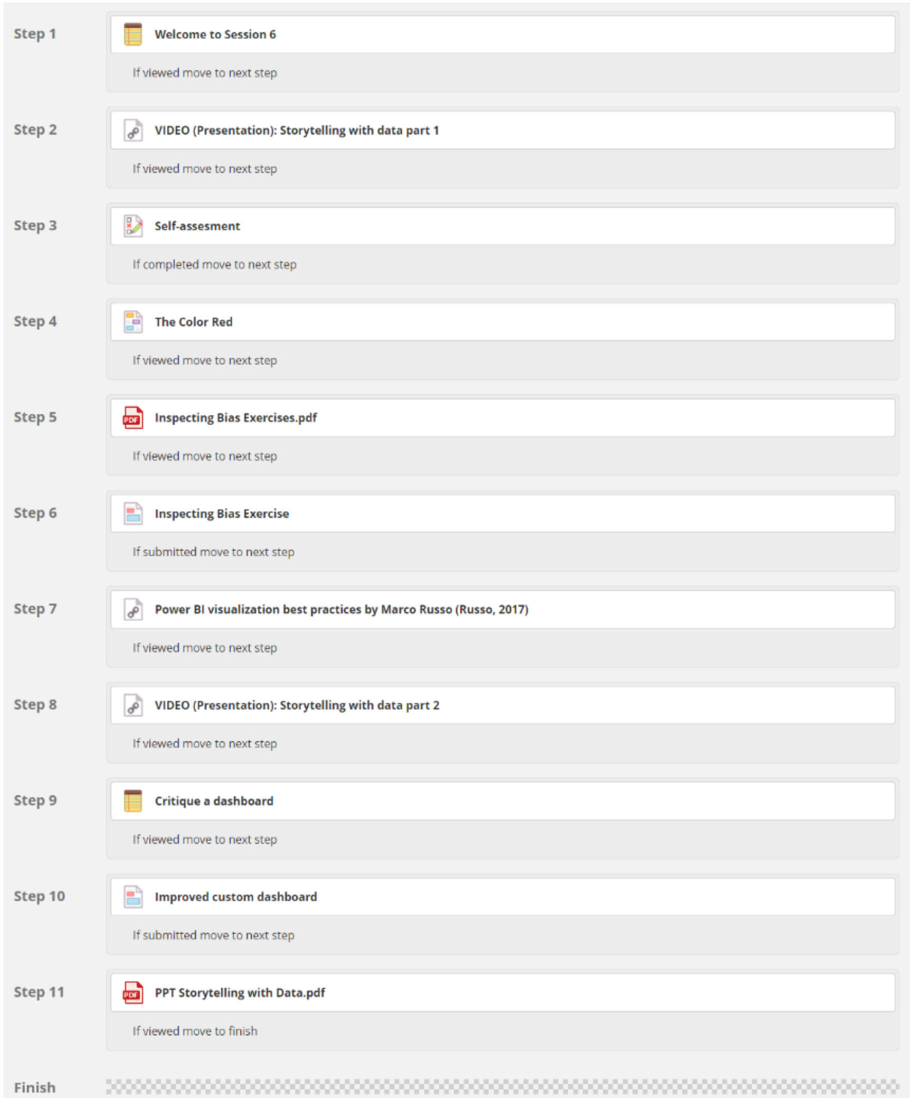

Figure 2: Example of Learning Path

These learning paths allows the teacher to structure the course content in such a way that resources are accessed in succession and even allows for setting conditions on progression. This allows the teacher to create a path with an intentional didactical causality in the materials presented (Krogh, Christensen and Qvortrup, 2016, p.305). Further, inspired by the buffet model (Twigg, 2003), supplementary resources are offered to the students (see Figure 3) in addition to the learning path ("Flipped Teaching Session 6"). All learning paths in the course have been developed using the same structure.
The learning paths should take the average student between 1,5 and 2 hours to complete depending on the session. The learning paths are done by the students ahead of the scheduled class-time as an asynchronous activity (cf. Olesen, 2020).

Different methods are used to assess student performance in the classroom. Namely observations, conversations, and student materials (Vilslev and Rønn, 2006), which may be used to provide the student with feedback. In an online setting the act of observation becomes more difficult, and conversations are typically affected by the need to have microphones turned off in large gatherings. To serve the feedback needs of students, we designed the course with three different feedback mechanisms in mind.

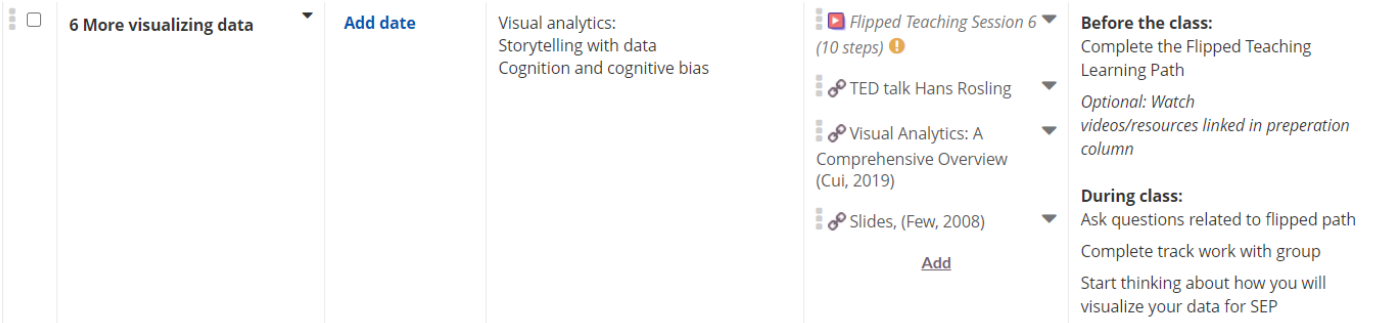

Figure 3: Example of structure and supplementary materials

For the individual main track, the students would receive individual feedback either from teachers (formative feedback) or from a self-administered multiple-choice test (summative feedback). To receive feedback from the teachers, the students were instructed to complete the individual exercises minimum 24 hours before class start.

The student tracks (Track A and Track B) were developed as a collaborative project that forms the basis of their final, individual evaluation at the end of the semester. The students complete the group assignment in self-chosen groups of maximum four people. Beyond the work done in the course, the students also use their knowledge from the course to complete a 5 ECTS points semester project (similar to a capstone project) providing the students with several learning practices that have proved beneficial to student learning (cf. Kuh, 2008)

In the student tracks, the students would peer-assess each other's hand-ins based on correction sheets provided by the teachers as students need concrete criteria to use for their assessment of others work (EVA, 2021). For an example of a peer feedback correction sheet, please see Appendix 1.

The type of feedback students were required to give each other was formative and students were instructed to consider the feedback carefully as opposed to following the guidance provided blindly. In case of doubt, they were encouraged to discuss the feedback given and/or received with the instructors. Peer feedback was given and received group-wise and was not anonymous as anonymity makes the students feedback more critical and divergent from the educator's feedback (EVA, 2021).

All instructional material created by the teachers was uploaded to a YouTube channel and linked from the course website on itslearning[2]. Most videos in the course were 5-10 minutes long with some exceptions with videos that were 15-20 minutes long due to the nature of the subject. This is in accordance with what others have suggested as an optimal length for media (Fidalgo-Blanco et al., 2016; Franciszkowicz, 2008; Johnson, 2013).

In addition to the videos recorded for disseminating the course material and providing instruction videos for how to design and implement the data infrastructure, we recruited three practitioners to participate in supplementary video material showing how data analytics infrastructure is applied in practice. These videos

[2] The interested reader may refer to https://astridhanghoej.dk/dataanalyticsinfrastructure/ to see some of the course materials created for this course.

were generally longer and most of them were offered as supplementary material in accordance with the buffet model for online learning (cf. Twigg, 2003)

RESULTS

In this section, we would like to present the preliminary results of the course redesign evaluation using both quantitative and qualitative data. The quantitative data is gathered from the course evaluation survey, the LMS platform, third party platforms (e.g. YouTube) as well as grades from the exam system (WISEflow™).

Quantitative data

In Appendix 2, quantitative course evaluation data is shown for all three classes. In the Danish language class, 12 out of 14 students responded to the survey. In the English language classes, 37 out of 44 and 36 out of 44 responded to the survey. Yielding response rates of 85.71%, 84.09% and 81.82%, respectively. The response rate is considered good in comparison to typical response rates for online evaluations which may range from as low as 17 up to 83 percent according to a literature review by Ahmad (2018) with online response rates typically being around 50 percent.

In the course survey, we evaluated students' attitudes towards the course in relation to autonomy, relatedness, and competence as well as their overall attitude towards the course (see Appendix 2). We further asked the students to assess the different types of learning resources/methods used in the course in terms of their self-evaluated learning outcome.

We also collected qualitative data from the students by asking them "What worked well in this course?", "What would you like to see more of in this course? and giving them the opportunity to provide "Suggestions for improvements".

Students had an overall positive attitude towards the atmosphere in the class (majority of student answered agree or strongly agree). Most students likewise indicated that they perceived a high degree of freedom in the class. Less than half of the students indicated that they felt competent in the class (see Appendix 2).
In one class, almost 20% of the students taking the course evaluation survey stated that they did not have a good feeling towards the course with 13,9% stating disagree and 5,6% stating strongly disagree. (11% disagree, 0% strongly disagree and 8,3%, 0% strongly disagree respectively in the other classes). However, attitudes towards the flipped course format were not as favorable as Nwosisis et al (2016) in which 94% of students had a positive perception of flipped learning.

One student reported failure to complete the exercises in the learning paths in the course evaluation survey. However, all students completed the learning paths prior to concluding the semester (prerequisite to attend the exam). Not all students managed to complete all learning paths before each weeks' class. The requirement to complete learning paths ahead of class was mentioned by some students in the open-ended questions on the course survey (see section on qualitative data) as a restriction and as requirement that they would struggle to fulfill.

Using YouTube quantitative data on video views, we see that students revisit material later. In fact, the highest number of views on the YouTube channel were achieved during the exam period (see spike in Figure 5 below) across all the videos on the YouTube channel for the course. This shows that students used the accessibility of materials to further engage with the material when the extrinsic motivation to do so presented itself (the week of the exam for the course).

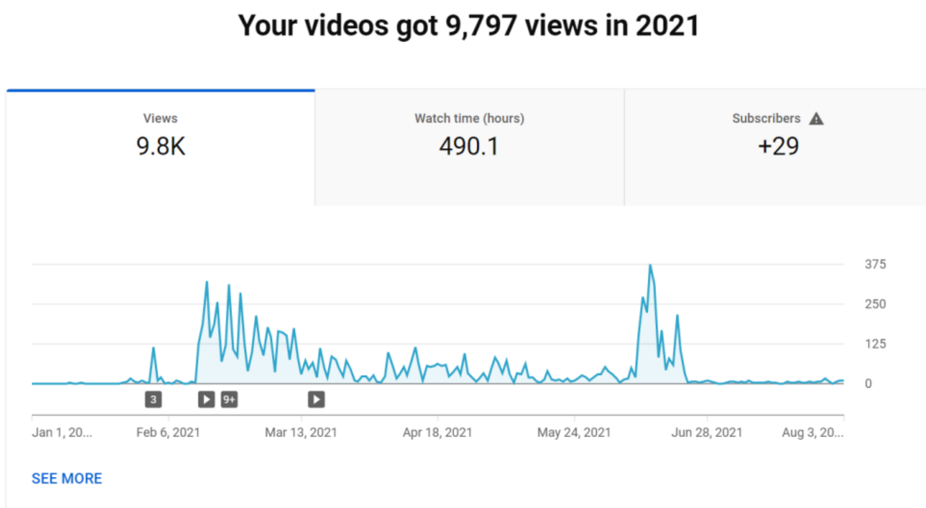

Figure 4: Video views (aggregated across the entire channel) of teaching materials

On the YouTube channel, we are provided with metrics for the videos uploaded. Most views on the channel come from students taking the course as most views arrive from external attribution through the itslearning website; however, some views were also reached through organic attribution on the YouTube platform as some videos were posted as publicly available.

Looking at the audience retention metrics for one of the videos, we can see the following chart:

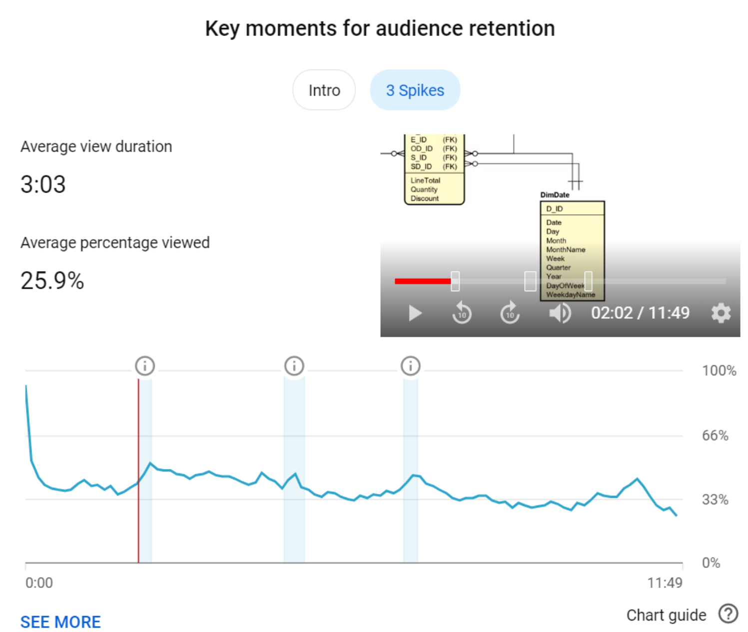

Figure 5: Video Analytics (Key moments for audience retention). Percentage of retained viewers per segment watched (mm:ss)

In the above figure, the x-axis represents the timeline of the video measures as mm:ss and the y-axis percentage retained viewers. The graph shows are that there is a drop in viewers in the first minute of the video, but once the viewers "stick around" the audience retention remains uniform throughout the video.

We are also provided with three shaded bars that show the spikes in viewer retention. This may indicate that viewers return to watch parts of the video again – either through interest or to repeat parts of the material that was hard to understand.

In the quantitative data from the YouTube channel, we can see the number of overall views for each video. Videos posted later in the semester received fewer views than those earlier in the semester in accordance with the overall trend of views in Figure 4. Optional videos (not included in learning paths or indicated as such in the learning paths) received far fewer views than mandatory videos included in the learning paths.

The opportunity to practice has been shown to improve student performance (Eddy, Converse and Wenderoth, 2015). Clicker questions have been shown to improve learning (Preszler et al., 2017). Students who were able to create their own explanations were better graded on exam questions than students simply reading expert explanations (Willoughby, Wood and McDermott, 2000; Wood et al., 1994). Further, video-material has been shown to improve preliminary test-scores when used as additional material to in-class teaching (Franciszkowicz, 2008, p.12). Repeated testing correlated with increased learning (Dunlosky et al., 2013).

From the learning management system, we can export data on the student's activity in the course room. This allows us to compare the students time spend on course webpage with the final grade for the course. Students who did not attend the exam have been omitted from the analysis.

Comparing time spend on learning paths and student performance (grades), we see that there is no clear linear relationship. However, students who received the highest grade have spend noticeably more time on course material (average 713,5 minutes) than other students (average 522,55 minutes). See Figure 6 below:

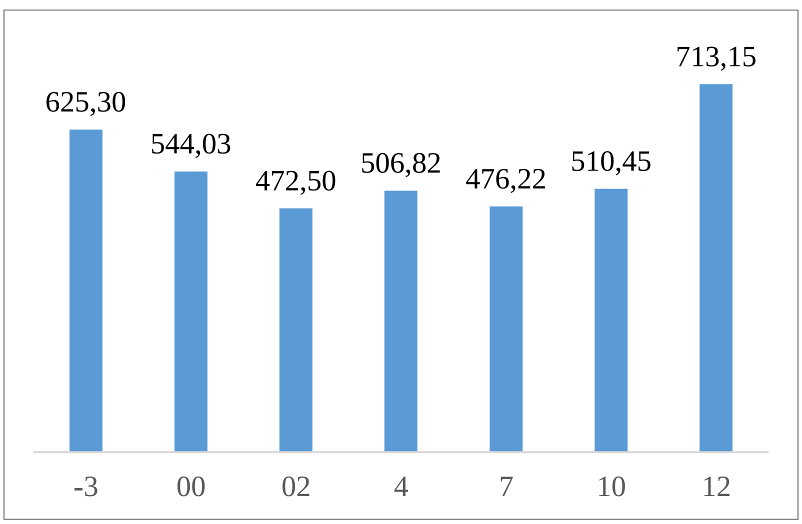

Figure 6: Average time spend on course webpage (in minutes) by final grade of the semester

ANOVA test for differences in variance were not significant and we cannot reject the null hypothesis that at least two of the groups have significantly different means.

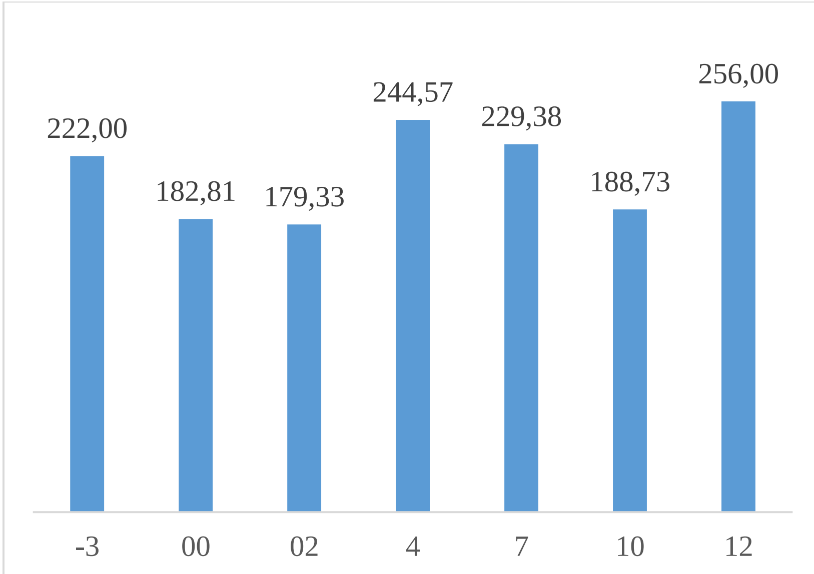

Figure 7: Average number of visits to course website by final grade of the semester

Comparing number of visits to course website and student performance (grades) in Figure 7, we see that there is no clear linear relationship.However, ANOVA test for comparison across number of visits to course website by final grade of the semester were significant (p-value 0.00192, one-sided). One-sided t-test assuming unequal variances showed that students who received the highest grade (12) had different mean of website visits than students who got 10 (p-value 0.00789) and the grades 00 (p-value 0.01328) and 02 (p-value 0.01126). Students who got a 10 had a different mean of website visits than students who got a 4 (p-value 0.03570).

Data on course website engagement may be noisy. Time spend on course webpage only captures the time the student has been logged into the course webpage. Actual engagement with material cannot be adequately measured and students may "leave" the course webpage to pursue materials hosted on third party platforms (e.g. YouTube videos, Kimball website etc.). Further, students may collaborate on the learning paths which may only add to the time spend metric for one student while in fact it should be attributed to all students pursuing the learning efforts collectively. The number of visits to course website may therefore be a better indicator of student activity since it requires actual engagement (clicks to course website). However, this metric may also not adequately track student engagement when students decide to work together on learning paths.

Qualitative data

In the open-ended questions in the course survey several themes emerged. The themes were: peer review, group work, structure and lastly the nature of the course format.

Qualitative data suggested that peer review divided the classroom. Some students commented "Working in the groups and getting peer review was pleasant to do" or "more peer review would be nice", whereas others commented "I don't really think that peer reviews are very useful or helpful. I would prefer to get feedback for group assignments from teachers", "peer review seems useless" or "I sometimes feel like it was useless doing them".

Many students commented on the group work. In general, students commented positively on the group work stating that it was nice to do, improved communication, helped understanding. One student commented on group work and explained:

“Group work, since it is easier when we are communicating between each other while doing the assignments, knowing what we're all supposed to work with.”

While another student wrote:

“Working in teams was very nice because we could merge our understanding upon the theory or the tasks we have to do, and we managed to learn together and that is very helpful for me. By doing things together I got to understand more about the subject”

These student expresses an opinion in which the students can use the group work as a mechanism for formative feedback. The students can compare different views on the subject and arrive at a mutual understanding of the material and use this knowledge to solve the problem at hand collaboratively.

Some students appreciated the structure of the course. Comments said:

“[Teachers name] is really good at helping and structures the class well.”

“The atmosphere, pacing and structure of the course are nice. There are clear segments of what needs to be done before something else and that helps with knowing if you are behind or not. The learning paths are a great idea”

“It is good that we are able to complete all activities before class so if we have any questions, we are able to ask.”

“[The] structure of the course [worked well]”

Among the comments on the structure of the course format, many student commented that it was nice to have the videos to return to later and/or rewatch to improve understanding. They mentioned that the way the videos were tailor-made for the flipped format made them more accessible than complete recordings of lectures. This is in accordance with Gilboy, Henrichs and Pazzaglia (2015) who find that students generally like the ability to watch videos as opposed to lectures.

Most comments that we got in the course evaluation were on the nature of the course, which divided the students. Among some of the positive comments that we got, students said the following:

"[I liked] The idea of learning paths and having to get acquainted with the information before the actual class"

“Flipped learning paths are a good idea. They remove the boring stuff from the classroom” (translated from Danish)

“Flipped Learning Paths are a great idea. You are forced to go over everything” (translated from Danish)

While others were less appreciative of the format:
“this course is change for the sake of change - standard format is a lot better”

“don't know what exactly worked well in this course. It felt strange from the beginning and confusing so that a lot of people I think lost interest. But if one kept being consistent and worked the proposed plan and exercises it starts to click and the concepts start to make sense.”

“not a big fan of the flipped teaching. feels like twice as much as work while doing nothing in the actual class”

“The flipped teaching just doesn't work well in this format. In the class we don't do anything apart from (maybe) ask for some advice. Otherwise, there is no incentive to wake up in the morning and join the zoom when we can work on these at any time.”

“it feels like it's a last-minute generated mess".

“I think it’s annoying that you have to complete the learning paths ahead of the lecture.” (translated from Danish)

“I like the videos, but I think it’s annoying that you have to complete them before the class. I would rather do them after class, especially since Monday [day of the class] is a long day” (translated from Danish)

Most of the negative comments came from one class out of three parallel classes that semester.

The end of semester survey showed that the students in the class did not read the book associated with the class. Data shows 33.3%, 24.3% , and 16.7% of students reporting that they did not use the book.

CONCLUSIONS

In the following section, we would like to conclude our paper by summing up our findings from the result section as well as presenting our recommendations for other teachers who may be interested in redesigning course curriculum to a flipped learning format.

We found that our redesign addressed the students need for autonomy and relatedness. Students had a positive attitude towards the atmosphere in the class. This could indicate that we were successful in designing a learning experience that catered to the student’s relatedness needs. Most students likewise indicated that they perceived a high degree of freedom in the class which may indicate that we were successful in designing for their autonomy needs. The course redesign may however benefit from considering how we may improve the students feeling of competence as less than half of the students indicated that they felt competent in the class.

Contrary to previous findings, we do not find that student engagement with course material in the flipped learning path appears to improve performance at the exam. I.e. students who spend more time engaged with learning materials did not receive a higher grade than those who spend less time engaged with the learning materials.

In the qualitative data from the end-of-semester survey, four themes emerge as the most prominent: group work, course structure, peer review, and the nature of course format. In our data we also see that some students may perceive the format as too strenuous making them part of the group that Olesen (2020) refers to as “De opgivende” (in English: “The quitters”), who place responsibility for learning on the teacher rather than adopting a reflective and socially engaged approach to learning.

We would like to end this paper by presenting our practical recommendations for colleagues who may consider redesigning courses for online teaching:

Collaborate with other educators to minimize overtime.
There are no short-term gains in redesigning for unknown quarantine restrictions. More than 700 hours went into designing this course in addition to time spend in-class. Each video of approximately 10-15 minutes could easily take an entire day to produce – even more if post-editing was not kept at an absolute minimum. Producing audio and visual material is time consuming which is consistent with what other educators have found (e.g. Atlason, 2017) and course redesign should thus be approached as a collegial process (cf. Nwosisi et al., 2016).

Ensure management support.
Management support should be ensured both for extra time to prepare, but also because students may have adverse reactions to a different format and more time will be spend on following up with these students. The overtime related to a course design is especially heavy in the first take of the course when no material has been created yet. The overtime related to students who have adverse reactions may persist until the students learn to adapt to changes in course formats. Educators may also benefit from thinking about how they might early on identify students who may have adverse reactions.

Start with low hanging fruits
Are there learning aims that may be adequately served with existing material? Careful: It takes a lot of time to screen material and existing material may not fit with the intended didactical narrative causing intentional didactical causality to be difficult to achieve.

Prepare the students for change in format.
A prologue explaining the format may not be enough, be prepared to continuously follow up on your expectations regarding the format. Students may appreciate the heavily structured course format but may experience difficulties in a new learning format. Some students may find it especially hard to adapt - Be prepared to follow up with these students – and think about how you might identify them when your ability to observe students may be obstructed because of lack of in-class presence.

Modularize your material/videos.
Not everything is going to be perfect in the first try – and if you avoid making videos too specific it makes it easier to replace them with a new version later. Think about how you may strike a balance between making videos interlinked and making them replaceable and/or reusable in other contexts. As we developed the materials for this course, another colleague (who teaches an elective course in the last year) found the videos and included them in his teaching. Since creating materials is a very time-consuming process, you may benefit by "thinking ahead" and creating material that may fit several agendas.

The generalisability of our findings is clearly limited by the conditions imposed by the ongoing pandemic and experiences from teaching the class using the flipped materials may be different as we return to face-to-face teaching.

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APPENDIX 1

Peer Review Correction Sheet Hand in #1	
Comment on ER-diagram Does it have all relevant dimensions? Does it follow star schema? Is it linked to dimensional design approach?	
Comment on design Are dimensions/attributes linked to background description for its track? Does it use Kimball terminology? Does it include relevant attributes?	
Comment on documentation Is the SQL code there? Does it contain relevant commenting? Are you able to run the code without errors (see section with installation guide below)? Does it include source-target mappings? Is everything documented/explained? Are the transformations in datatypes explained? Do you agree with the groups' implementation?	
Comment on installation guide Did the installation guide explain what you had to do? Were you able to install the data warehouse by following the installation guide?	

APPENDIX 2: End-of-semester survey, quantitative data

Number of respondents: 12

1. Matrix question

Attitude

Please rate the following statements

	Strongly agree	Agree	Neither agree nor disagree	Diasgree	Strongly disagree	Not answered
In general, I have a good feeling towards this course	8,3%	50%	25%	8,3%	0%	8,3%
I feel competent in this course	16,7%	25%	33,3%	25%	0%	0%
I like this atmosphere in this class	25%	33,3%	25%	8,3%	0%	8,3%
I have a lot of freedom in this course	25%	41,7%	8,3%	8,3%	8,3%	8,3%

2. Matrix question

Perceived learning outcome

How much did the following resources help you learn in this course?

	Great help	Much help	Moderate help	A little help	No help	Did not use	Not answered
Completing the flipped learning paths	25%	33,3%	25%	16,7%	0%	0%	0%
Watching instruction videos (How to)	41,7%	33,3%	8,3%	8,3%	8,3%	0%	0%
Watching theory videos (PowerPoint)	16,7%	0%	33,3%	50%	0%	0%	0%
Watching videos with practioners	8,3%	41,7%	25%	16,7%	0%	0%	8,3%
Doing the individual exercises in the learning paths	33,3%	50%	16,7%	0%	0%	0%	0%
Interacting with the teacher	25%	33,3%	33,3%	0%	0%	8,3%	0%
Peer review exercises	8,3%	16,7%	33,3%	16,7%	25%	0%	0%
Group work on track assignment	66,7%	16,7%	16,7%	0%	0%	0%	0%
Reading the book	0%	8,3%	41,7%	0%	16,7%	33,3%	0%
Using the linked resources in plans (e.g. kimball website, SQL server documentation, datadeo etc.)	8,3%	0%	50%	33,3%	8,3%	0%	0%

Number of respondents: 37

1. Matrix question

Attitude

Please rate the following statements

	Strongly agree	Agree	Neither agree nor disagree	Diasgree	Strongly disagree	Not answered
In general, I have a good feeling towards this course	16,2%	37,8%	29,7%	10,8%	2,7%	2,7%
I feel competent in this course	10,8%	32,4%	43,2%	5,4%	2,7%	5,4%
I like this atmosphere in this class	13,5%	37,8%	27%	10,8%	5,4%	5,4%
I have a lot of freedom in this course	35,1%	40,5%	16,2%	5,4%	0%	2,7%

2. Matrix question

Perceived learning outcome

How much did the following resources help you learn in this course?

	Great help	Much help	Moderate help	A little help	No help	Did not use	Not answered
Completing the flipped learning paths	18,9%	29,7%	29,7%	13,5%	8,1%	0%	0%
Watching instruction videos (How to)	29,7%	37,8%	10,8%	16,2%	5,4%	0%	0%
Watching theory videos (PowerPoint)	13,5%	29,7%	18,9%	24,3%	13,5%	0%	0%
Watching videos with practioners	24,3%	8,1%	32,4%	29,7%	5,4%	0%	0%
Doing the individual exercises in the learning paths	13,5%	35,1%	37,8%	13,5%	0%	0%	0%
Interacting with the teacher	21,6%	37,8%	18,9%	10,8%	0%	10,8%	0%
Peer review exercises	5,4%	13,5%	45,9%	16,2%	8,1%	8,1%	2,7%
Group work on track assignment	24,3%	43,2%	21,6%	0%	8,1%	2,7%	0%
Reading the book	8,1%	16,2%	21,6%	27%	2,7%	24,3%	0%
Using the linked resources in plans (e.g. kimball website, SQL server documentation, datadeo etc.)	16,2%	18,9%	27%	27%	2,7%	8,1%	0%

Number of respondents: 36

1. Matrix question

Attitude

Please rate the following statements

	Strongly agree	Agree	Neither agree nor disagree	Diasgree	Strongly disagree	Not answered
In general, I have a good feeling towards this course	2,8%	33,3%	44,4%	13,9%	5,6%	0%
I feel competent in this course	5,6%	30,6%	41,7%	19,4%	0%	2,8%
I like this atmosphere in this class	5,6%	27,8%	44,4%	16,7%	5,6%	0%
I have a lot of freedom in this course	16,7%	36,1%	33,3%	8,3%	5,6%	0%

2. Matrix question

Perceived learning outcome

How much did the following resources help you learn in this course?

	Great help	Much help	Moderate help	A little help	No help	Did not use	Not answered
Completing the flipped learning paths	11,1%	16,7%	38,9%	19,4%	8,3%	5,6%	0%
Watching instruction videos (How to)	30,6%	36,1%	22,2%	11,1%	0%	0%	0%
Watching theory videos (PowerPoint)	5,6%	25%	27,8%	27,8%	13,9%	0%	0%
Watching videos with practioners	11,1%	22,2%	25%	16,7%	13,9%	5,6%	5,6%
Doing the individual exercises in the learning paths	19,4%	22,2%	27,8%	25%	2,8%	2,8%	0%
Interacting with the teacher	13,9%	27,8%	19,4%	19,4%	2,8%	16,7%	0%
Peer review exercises	8,3%	16,7%	19,4%	27,8%	25%	0%	2,8%
Group work on track assignment	36,1%	36,1%	13,9%	13,9%	0%	0%	0%
Reading the book	8,3%	11,1%	27,8%	25%	11,1%	16,7%	0%
Using the linked resources in plans (e.g. kimball website, SQL server documentation, datadeo etc.)	13,9%	13,9%	33,3%	27,8%	2,8%	8,3%	0%

Students' metacognitive processes and impact on Self-efficacy in embedded programming

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ABSTRACT
Keywords - Metacognitive process, self-efficacy, Emotion, Vignette questions

For minimizing students drop out on 2nd semester, Electrical Engineering (EE) BEng we experiment with a written and video process guideline for support of solving programming problems and metacognitive awareness. We will try to measure how students emotional experience programming by using a special self-assessment vignette inquiry. On 1st semester, we will measure when programming as novices in two study lines (EE - and IT-Electronic BEng students (IE)) and do a comparison with 2nd semester for EE students. On 2nd we introduce a process for program development in Digital electronics and programming (DEP) and we will measure 3 times during the semester the effect of the process by using self-assessment vignette inquiry. The working hypothesis is: Can the emotional experiences become lower, then the self-efficacy will be higher and the drop out will be lower. The articles describes the theoretical background for both the process and the students' self-assessment resulting in emotional experiences. The results so far are that on 1st semester IE there is only 20% of students, which has a total score greater that 40 (total score max 78) whereas among the 2nd semester EE students 33% students has a score above 40. High score means great emotional impact.

I INTRODUCTION

This article here is part of a project running in DTU Scholarship of Teaching, where we wonder about that through several years, we have experienced that few students are dropping out from taking the exam in programming courses in the first two semesters at Electrical Engineering (EE) BEng programme and IT Electronics (IE) BEng programme. During the past years, we have observed that more students have difficulty to figure out how to proceed and cope with a so-called compiler message, or when the program does not work as expected. They do not understand what to do in the process of programming. After conducting several interviews, we identified that students drop out or do not take the exam due to their programming difficulties and low self-efficacy. On 2nd semester in DEP, 5-10% of the students who persist in the first part of the semester express that they do not how to start the programming an assignment and find it exceedingly difficult understanding how to use binary operators in C-programming.

Research question

Our hypothesis: If students get a process for tackling problem presented in the course, then they will get more self-efficacy and thereby the motivation for learning should increase. That leads to the question: 'Can metacognitive processes help students to gain more self-confidence and thus continue to be active during the course?'

Blended learning used in the DEP

We use the approach of so-called blended learning as teaching method, which requires that students prepare before attending traditional face-to-face lectures. For comparison and for future improvement we studied (Alammary, 2019), where he did a systematic review on blended learnings models used for introductory programming courses. The course content is a mix between understanding the hardware/digital electronics and programming registers in microcontrollers. Assignments are about communicating data to and from the microcontroller and operate on the data.
Thus, pedagogical method is blended learning, and with a reference to (Alammary, 2019), the method is called "Supplemental model", which means that online activities is added to the course and connected to activities in the class. The online activities before each lecture are video recordings presenting digital electronics and programming tutorials, online conceptual and programming quizzes. Typically, during the face-to-face lecture, the class starts by reviewing answers to questionnaires and discussing the results. This followed by a presentation with introduction to relevant parts of the theory (for example about the microcontroller or the C-construction) needed for solving the assignments. There are five assignments for hand-in during the 13 weeks course, where four of these includes an assignment report. The students work in groups of 2-3 students. They have three hours for solving the assignments, with supervision by lecturer and teaching assistant.

II METHOLOGY

For answering the question, we have studied some articles dealing with how to teach in programming and how students' self-asses their ability and how the process of programming has an impact on the self-assessment.

Literature studies - related work

When we use Self-efficacy as a term, we found in (Bandura A. 1977) his definition we find useful. Self-efficacy perception understood as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" Bandura A. 1977.

For answering the hypothesis and research question, we have done several studies regarding criteria students use to evaluate their programming ability. For example, (Lewis, C. M. et al. 2011) mention students think about speed and grades. In (Gorson, J. et al. 2020) and their prior work, students' thoughts about looking up syntax and getting errors are signs of low ability. Gorson found some of the criteria contradicts with what instructor's think are important for novice programmers' success or professional practices.
The authors suggested that students', to their opinion, inaccurate expectations of the programming process could have an impact on how they self-assess. (Kinnunen, P. et al. 2012) have studied how the students' emotional experiences during the programming process relates to the self-efficacy assessment. They found the programming process has an impact on the students' experience with self-efficacy and their expectation. Criteria such as fluency, and time spent on assignment has an impact on their assessment of their abilities. They also compare themselves with other students and how those progress in solving assignment and the time spent. For instance, students are feeling bad, because other students managed to finish faster. External factors as working together can also have a negative or positive impact on the self-assessment, where supporting partner relationships, partners helping each other contributes to positive experiences. Whereas in the case of unsupportive partner relationships, the partners direct negative feedback directly contributed to negative self-efficacy. This work does not considered the groups' relationships factors.
The assignment formulation can have an impact on student's self-efficacy. For example, is it not understandable, or if it is not obvious what to do, it can result in a negative self-assessment of the

abilities. In contrast to this, in literature study we found, the students do not believe that the teacher will give an assignment that cannot be solved, so even if it hard to understand this can make a positive impact on the self-assessment.
In (Gorson, J. et al. 2019) they discuss the students' mindset and it's influence on the students perceived ability and persistence in Computer science. We also think it has an influence on the perceived self-efficacy. Gorson pointed out that research in psychology has demonstrated that students' beliefs about the malleability of intelligence can have a strong impact on other reactions to challenge and academic performance. Literature (Dweck, C. S. 2006, Loksa, D. et al. 2016, Prather, J. et al. 2019) concludes that the mindset theory about Growing mindset and Fixed mindset have an influence on the learning and approach to problem solving. Students with Growing mindset are more likely to persist challenges.

Programming Process guide

In (Loksa, D. et al. 2016) they describe and discuss problem solving stages and metacognitive prompts. They propose two interventions that teach learners how to converge toward programming solutions while teaching them how to recognize, evaluate and refine their problem-solving strategies. One is to provide students with explicit instructions on the goals and activities involved in programming problem solving, while another is about using an explicit questions technique. When students want advice, they were asked about where in the programming process they are.
A study by (Prather et al. 2019) did an experiment for investigating whether an explicit metacognitive prompt discussion and if a process guide support metacognitive awareness. In (Falkner, K. et al. 2014) they discuss how they can assist students in self-regulated learning strategy. The study proposes an example guide to development of scaffolding activities to assist learning development. (Falkner, K. et al. 2014) propose introduction of diagrams class diagrams or flow charts, assessment of the task difficulty, identifying the needed skills - leading to time management and sub goal plan. Therefore, it is important to conceptualize the design by diagrams as a part of the software development process, and link it to the planning tasks. At the same time the conceptualizations means, it can change during the programming process and therefore viewing it as an iterative approach. It can help explicit inclusion of experimentation as a part of the design, exploring alternative design, evaluation, and comparisons. Both studies have inspired us to formulate the process guidelines shown here below. We adjusted and added further questions to be used in the Digital Electronics and Programming ourse (DEP).

Process guide

In the first lecture in the 2nd semester EE class in Digital Electronics and Programming, we introduce a process guide sheet to support the process of programming. We want to measure the effect of using self-assessment vignette questionnaires in 1st week, the 6th week and the 12th week, for measuring the experiences of programming when students use the process.

The process guide:

1. Read the whole assignment. Does the assignment make sense?

2. What could a solution to the task /subtasks look like? Outline the solution with a pseudocode and / or a flow-chart.

3. Imagine a simulated execution of your hypothetical program / parts of the program. Use your pseudocode and flowchart. Simulate that you provide running the hypothesis program. Does the expected happen?

4. What can the C-code for the sub-task / task solution look like?

5. Open Microchip studio, start a new project, select GCC C executable, give the project a telling name and place the project somewhere where you can find it again. press ok. Choose to use an ATmega2560. Program the solution you have found for each sub-task found under 2.

6. Does the program perform the hypothetical run-through performed in. 3?

The link to the full process guideline is in the reference (Schultz, O., 2021)

III DATACOLLECTION

Measuring impacts from programming situations

(Gorson, J. et al. 2020) compared three different universities undergraduate students in Computer Science. In his study, he shows students who self-assessment negative tend to have lower self-efficacy and concludes “We also found that the frequency with which students negatively self-assess correlates with their overall self-efficacy in their programming courses”. For data collection, Gorson uses a summative survey together with interviews. The survey is interesting as he uses a vignette survey, for measuring 13 distinct moments in programming and how they influences the feelings.
We find this method interesting to use in our study especially measuring if the process with guideline has a positive impact on the student self-assessment of problem solving while programming. The vignette questions used by (Gorson, J. et al.) 2020 relates to the professional way of working with programming, therefore it is relevant to use for our BEng students. As they are educated to conduct the professional practice of engineering.
We used the 13 vignette questions shown in (Gorson, J. et al. 2020), but have translated them to Danish and we have substituted the person names with 1st and 2nd person singular subject pronoun. The reason for not using original questions is that students find it hard to follow another person's feeling - therefore we adjusted appropriately. We also used another scale, from 1 to 6, where 6 is most negative and 1 is least negative. The vignette statements presented in Table 1.

Table 1 Vignette statements

A. A Simple Mistake:	You are working on your programming task. You compile its code. An error is displayed. You immediately realize that she has omitted a parenthesis. You add parentheses. How does it affect you?
B. Start over:	You are working on a hard programming task. You are planning a solution. You write a few lines of code. You realize the approach to the problem is not working. You decide to start over. How does it affect you?
C. Do not understand error message:	You are working on a programming problem. You compile your code. An error is displayed. You have no idea what the error message means. You are not sure what to try to do. How much does it affect you?
D. Stop programming to plan:	You start working on a programming problem. You write a few lines of code. You realize I am confused about what the next step is. You pause and plan your next step. You wish you did not have to stop writing code to plan. How much does it affect you?
E. Get help from others:	You are working on your programming task. You are stuck. You get help to complete the task from the teacher or assistant teacher. How much are you affected?

F. Spending time looking up syntax:	You are working on a programming problem. You cannot remember the syntax. You use Google to look up syntax. You are disappointed that you could not remember the syntax yourself. How much are you affected?
G. Spending time planning in the beginning:	You are unsure how to start your programming task. You spend time planning how to solve the problem. Eventually, you come up with a plan and start writing code. You wish you did not have to spend so much time planning before writing code. How much does it affect you?
H. Spends a lot of time solving a problem:	You work hard at programming to solve a programming problem. You solve the problem. You are proud of yourself. You look at the clock and realize how many hours you spent on the problem. You feel sorry for it because it took so long to fix it. How much does it affect you? How much does it affect you?
I. Do not know how to get started:	You solve your programming task. You open the program editor but have no idea where to start. You feel disappointed in yourself because you do not even know how to get started. How much does it affect you?
J. Spends a long time finding a simple mistake:	You are working on a challenging problem. You are running into a mistake. You are looking through the code but cannot find the error. After a long time, you realize that it was a small typo. You think to yourself, "Wow. I am so bad at programming. A good programmer would not take that long to find a simple error." How much does it affect you?
K. Struggling to find the error:	You are working on your programming homework. You run your program and get an error. You struggle to correct the mistake for a long time. After the error correction, the program runs, and another error occurs. You fight again. Eventually you solve it. How much does it affect you?
L. Unable to complete within expected time:	You are working on your programming task. You expect to finish it in one night. After a while, you decide to stop work because it was late. You feel sorry that she was not able to finish it in one night. How much does it affect you?
M. Do not understand the problem of the task:	You solve your programming task. You do not understand what the task asks you to do. You feel sad and frustrated because she cannot even understand the question. How much does it affect you?

The vignette in Danish is in the references.

The sentences to the left cover moments in programming process and to the right there are related sentences about what thoughts are coming up. In another study (Kinnunen, P. et al. 2012), described six stages of experiencing programming: getting started, encountering difficulties, dealing with difficulties, succeeding, submitting, and stopping. Stopping can happen without submitting because of struggling with difficulties. In table 2 we have mapped the 13 vignette statements to the six stages of experiencing programming, finding what type the vignette statements evaluate in the six states of experiencing programming. As can be seen in table 2, the vignette statement will measure mostly on how to handle difficulties. It does not measure the release of stress by submitting. The reason for that is the 13 moments of programming is while we are in the process of developing a program.

Table 2 Six stages of experiencing programming

Stage	vignette questions
Getting started	B, D, G,L,M
Encountering difficulties	A,I,J,L
dealing with difficulties	C, E, H, J, K, L
succeeding	H
submitting	
stopping	C, D,I

IV RESULTS AND DISCUSSION

Vignette answers

We collect answers during the first 4 – 5 weeks in September 2021 from three different classes two on first semester and one on 2nd semester. Before we used the vignette enquiry, we did a test in June in 2nd semester class at EE study line and these results are presented here as well.
After 3 weeks we asked It-electronics - IE students on 1st semester in the course Introduction to Embedded Systems and the results are shown in figure 1. In figure 1 and figure 2 we have all answers for each student summed up, on the y-axis is the sum of scores of each vignette, on the x-axis is p1 to pn each students answers. Vignette A has the most dark grey colour and lightest for vignette M. The course number is included in the headline.
Referring to figure 1 and table 1, in figure 1 to the left 26 students answered out of 37. We assume it is the active students who responded. 20% of the IE students has a total score above 40. In the figure 1 to the right, we have unfortunately only 18 responses out of 55 1st semester students enrolled in the course 02318 at EE. If the results is regarded representative then the impact is much higher that 1st sem. IE. As 55% has a total score above 40. This fact can be explained by that IE students received very strong motivation in first few lessons by demonstration of previous results achieved after 1 semester by engaged students. Whereas 1st semester EE students did not receive any demonstration

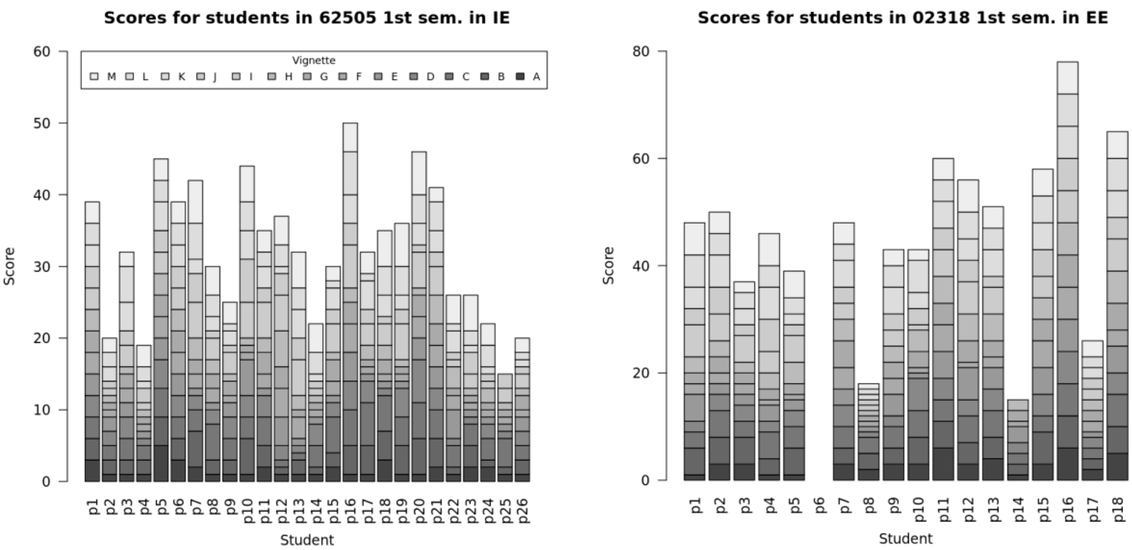

Figure 1 Sum score for: 1st sem. IE students (26) and EE 1st sem. Students (18)

We also asked the students if they had been programming before enrolment on the study and 85% had

programmed before in the IE class. Whereas in the EE 1st sem. class 50% out of the 18.
That can be another reason for the difference between the two first semester classes. Another reason can be the IE students have three different course dealing with programming on 1st semester, whereas the EE students only have one course. For now, we do not know if there is a correlation between the lower score and the previous experiences, but it has to be further evaluated.
In figure 1 to the right, P6 in the EE 1st semester did not answer the vignette statements therefore empty and the p16 has just scored six for all vignettes, which perhaps is unserious. The authors does not have the class and the students got an e-mail with the link in and this had been repeated three times each time with explanation about why they should answer.
Figure 2 shows the sum of scores for 2nd Sem. EE students (27) out of 33 and 2nd sem. EE students (20) out of 45 students. Students here have had the 1st semester programming course and when having the 30082 course they have had the 2nd semester DEP (62734) course.

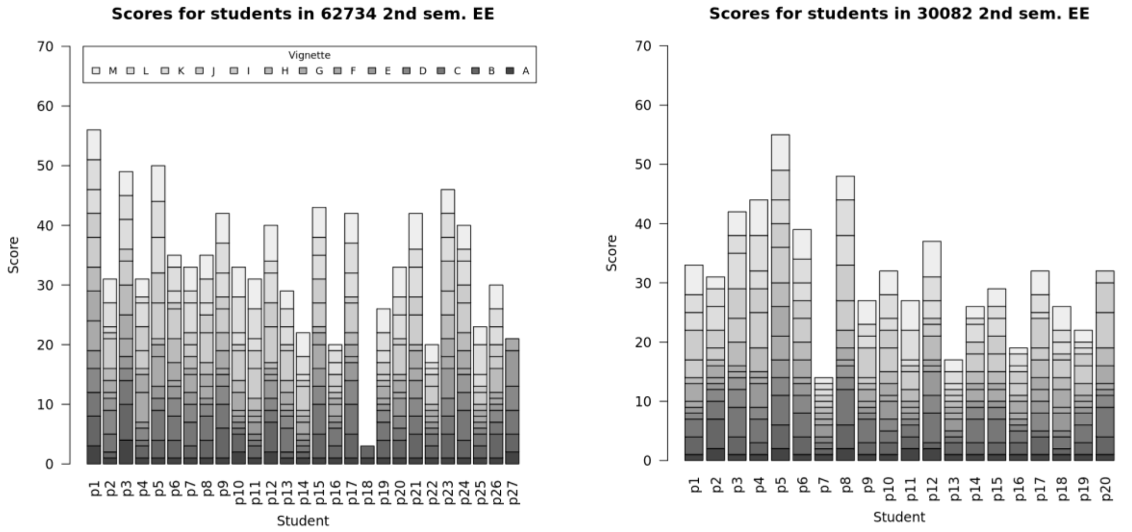

Figure 2 Sum score for: 2nd sem. EE students (27) and EE 1nd sem. Students (20)

In the first lesson on 2nd semester in DEP (62734) we asked the students to do the vignette inquiry before introducing the course. 33% of the responses show a score above 40 – where maximum is 78 – Compared to the IE students they are more influenced, it could be lack of previous programming experiences, which can explain it – That must be evaluated further.
In June as a pre-test, we used vignette questionnaire on a 2nd semester class running in 3 weeks – 20 students answered (45% of the whole class) in digital design (30082) where they are using the 13 weeks course DEP course together with another 13 weeks course Digital design(30082). Results presented in figure 2 to the right.
It seems only 15% total score is above 40 in the right figure, which is lower that the results in figure 2 to the left – it could be the representation of students(only 20) is not representative or due to their programming experiences they do not become so hard influenced.

For overall comparison in the figure 3 (next page) a boxplot is chosen to reveal differences between the 13-vignette statements for the four classes. Y-axis shows the possible score for each vignette. The X-axis show the individual Vignette statement by Letter A to M from Table 1. The vertical rectangular box horizontal line shows seen from top respectively the upper 3rd quartile and the lower 1st quartile. The lines going up and down from the box is showing the spread in the dataset up to maximum score and least score. The bold line between the two boxes indicates the median value. Open dots shows Outliers. We will here take a closer look in some the values found in figure 3. When comparing the 1st semester's responses, it is clear the 1st semester students at EE have a general higher median value and 3rd quartile for the most of the vignettes compared to the 1st semester students from IE.

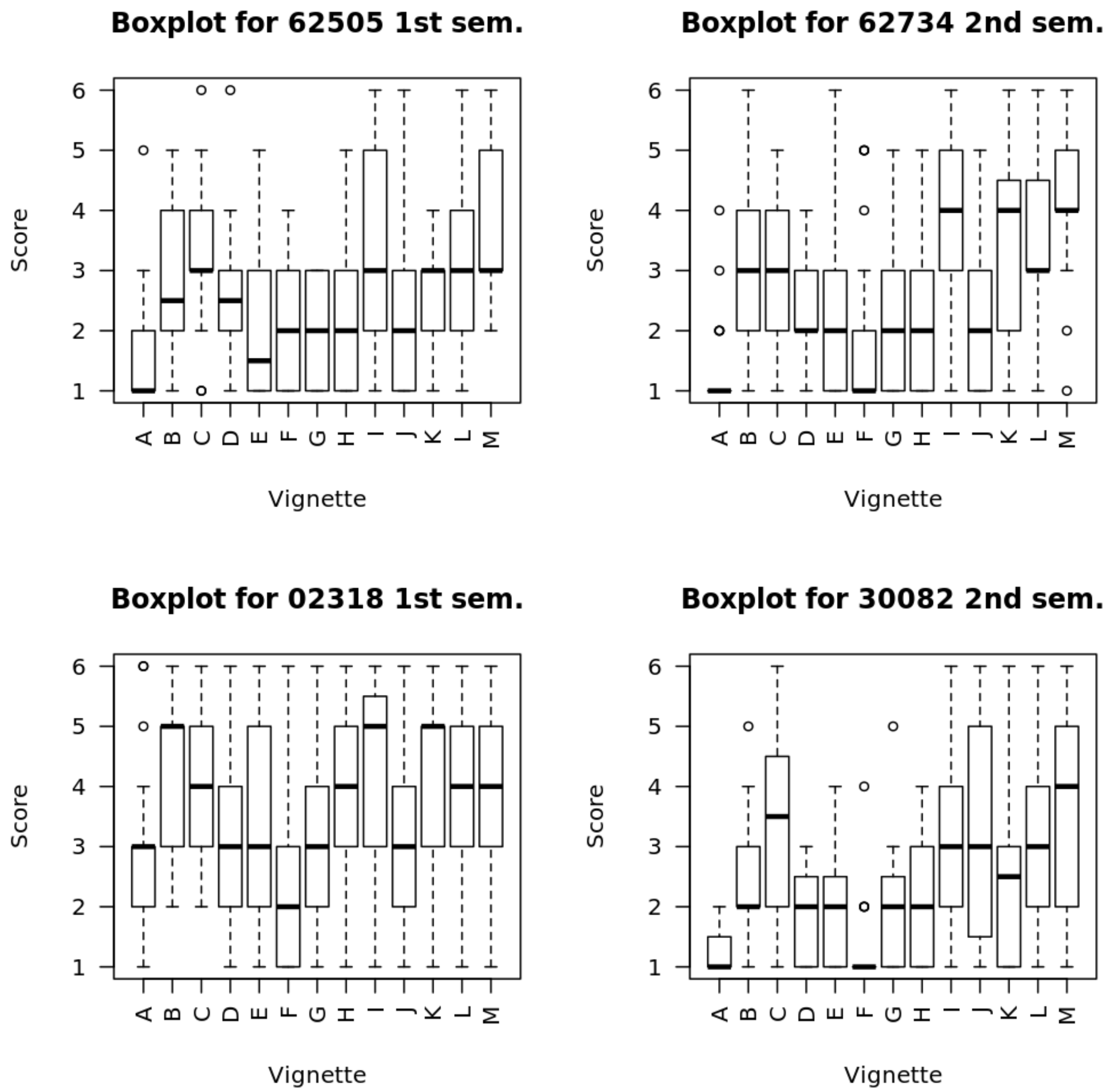

Figure 3 Boxplot for the students' answers

The vignette statement K “Struggling to find the error” has a median score of 5 and for the 1st semester students EE and for IE it is 3. For all four classes of students the M “Do not understand the problem of the task” has the high negative impact the 3rd quartile is 5 and the median value is 4 except 1st semester students at IE study.

The box plot to lower left corner in figure 3 shows students at 2nd semester 3-week 30082 course. These students have answered while they were terribly busy solving their project and only 40% answer – We use the data but is aware about it is only 40% who has answered.

For 1st and 2nd semester EE students the I, K L, M vignette is showing most negative impact -the I: “I do not know how to start”, the K: “Struggling to find the error” L: “Unable to complete within expected time” and M: “Do not understand the problem of the task”. In Table 3 is listed the most significant results for the 4 vignette (I to M) in numbers of students and the boxplot median values Where the median values is respectively found in figure 3, from left upper corner to lower right corner in figure 2

Table 3: Results for vignette I to M.

Vignette	Stud. course	Median	Students Score >=4
I	1st EE 02318	5	11 61%
	1st IE 62505	3	8 31%
	2nd EE 62734	4	18 67%
	2nd EE 30082	3	7 35%
K	1st EE 02318	5	11 61%
	1st IE 62505	3	4 15%
	2nd EE 62734	4	15 56%
	2nd EE 30082	2.5	<4 <12%
L	1st EE 02318	4	11 61%
	1st IE 62505	3	8 31%
	2nd EE 62734	3	13 48%
	2nd EE 30082	3	7 35%
M	1st EE 02318	4	11 61%
	1st IE 62505	3	12 46%
	2nd EE 62734	4	13 65%
	2nd EE 30082	4	21 77%

From table 3 we conclude that the M (Do not understand the problem of the task) has the absolute strongest negative impact on the students' feelings.

Aspect of the programming is error messages and finding faults. The Vignette J: "Spends a long time finding a simple mistake" and C: "Do not understand error message" show the impact.
Table 4 lists the results

Table 4: Results for vignette C and J.

Vignette	Stud. course	Median	Students score >=4
C	1st EE 02318	4	11 61%
	1st IE 62505	3	11 42%
	2nd EE 62734	3	12 44%
	2nd EE 30082	3.5	10 50%
J	1st EE 02318	3	7 38%
	1st IE 62505	2	2 <10%
	2nd EE 62734	2	5 19%
	2nd EE 30082	3	8 40%

It most negative impact has the understanding of error messages, which means the compiler responses, can be a challenge to understand and that is for all 4 classes. The influence of spending time is most influencing the EE classes
When using the table 2 above as a classification with the 6 stages of experiencing programming, then the vignette answers is in the two difficulties stages "Encountering difficulties" and "dealing with difficulties" is the I and M part of.

Discussions

When the results above is interesting compared to the process guideline. As the process, guideline is as the first question is Reading the assignment text and "Does it make sense?" and step 2. If understanding and finding part problem is clear, it should minimize the negative influence from M and gain the self-efficacy. If it is clear what each part of the program should do then the struggling finding errors could be minimized. But if the error is about understanding the compiler message, then it is experiences which will do I, which perhaps is the reason for 1st semester IE students' responses has low score- due to privies experiences with programming.

Introduction of the process on 2nd semester EE

In the second lesson, the student should in groups of 2 to 3 student start doing the exercise 2. I orally introduced the process guideline. The process description were before the lesson uploaded to Learn (CMS system). I told them to use the process described and make ex. make flow chart before coding. Observation where that only very few students did do process work, they open the programming IDE and started up beginning writing code and discuss which register, and which bits should be set. As supposed in the literature, the slides for the lesson2 introduced the code snippets- so they could get some hints – regarding the step 4 in the process description sheet. Even the exercise text was adjusted compared to earlier semesters text, so it was pointed how the process step should be done, they just started writing code.
In week 4 they got the next exercise – and there I intervened – so they were all asked to go through the process, understand the text, find sub-problems sketched flow charts for each part. They got 30 min. And then we discussed their findings and, on the whiteboard, sketch some flow charts – I asked how they find that, and the answers were that it had been fine – I seems helping them that I wanted them to deliver on the process.

V CONCLUSSION AND FUTHER WORK

In this paper, we collected results from 71students from 1st sem. IT-Electronic, EE, and 2nd sem. EE. Interestingly, we noticed significant difference in questionnaire answers between two study lines at the 1st semester. One questions rises here does the students background, before enrolment have an influence on their answers. We found if the students don not understand what the task is about can have a negative impact on their self-assessment. Therefore, the process should help lowering it. In addition, we had become more aware about how important the text description of assignments are. We still have to collect two times vignette inquiries from the 2nd semester class. These results is important for answering the hypothesis. At the conference, further results will be shown and discussed. At the conference we should be able to present if the process lower unregistering from exam.
We think that future work might focus on investigation how to measure and where we measure and to what extend the process has a motivation factor and can influence self-efficacy then other factors such as social networking can be performed.

ACKNOWLEGDEMENTS

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BIOGRAPHICAL INFORMATION

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Abstracts/Papers
Hands-on Session II
Thursday 13.15 - 14.45

Getting from *Why* to *How* in Sustainability Education -
Mette Lindahl Thomassen, VIA University College
Hanne Løje, Technical University of Denmark

How to Uni: Blended Study Start for Engineering Students
- Sara Kvist & Jørgen Bro Røn, University of Southern Denmark

Getting from *Why* to *How* in Sustainability Education

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ABSTRACT

Keywords – learning objectives, sustainability, active education for sustainable development

Please indicate clearly the type of contribution you are submitting: __x_ hands-on, ___explore.

Background

Higher education plays an important role in the context of sustainable development and has a significant influence on the way in which future generation of engineers will deal with the sustainable challenges (Barth *et al,* 2014). However, there is a need for a revision of engineering education to meet this call (Rubio *et al*, 2019).

So far, engineering education has achieved some milestones regarding sustainability with regards to awareness of the sustainability crisis/challenges (Guerra, 2016). But to reach further, engineering education needs to change sustainability education from a strategic *why* focus towards an action-oriented *how* focus. This entail curriculum development and implement student-centred, experiential, constructive and transformative learning pedagogies such as place-based learning, inquiry-based learning, problem based learning (PBL), discovery learning, case-based learning, conceive, design, implement, operate (CDIO) and community-based learning (Guerra, 2016).

Explanation

In a study by Løje & Thomassen (2020), it was explored how sustainability influence learning objectives in innovation and entrepreneurship education in Denmark. It was found that the main focus was on strategic management and arguing for sustainability. Very few learning objectives reflected education on how to create sustainable solutions. Perhaps this tendency is due to the high complexities regarding teaching a sustainable engineering practice. Moreover, sustainability is defined, measured and goal set in different ways. This calls for a contextualization of sustainability education, but also a practice-oriented approach to educating how-to- rather than solely focusing on why.

Gueera (2016) suggest that problem based learning (PBL) could be an answer to integrating sustainability in engineering curricula. Applying PBL as teaching methodology for undergraduate engineering courses, the students will learn how to adjust to situations and solve problems, and empower them to solve sustainability-related problems later on.

To educate the new generation of engineers with a more action-oriented approach to sustainability, we need to review and revise the focus in learning objectives and in extension educational approach. With this contribution, we wish to start a dialog about how to formulate learning objectives, which are action-oriented less focus on arguing for sustainability. We are beyond the point of arguing for the importance of sustainable solutions, we need to walk the talk and educate engineers, who can create them. But how can learning objectives be designed to reflect that and what challenges is then faced in education?

Set up Hands-on session

Introduction (10 min)

In the introduction, participants will be presented to findings regarding current sustainability learning objective in innovation and entrepreneurship courses in engineering education. Current state will be discussed including why this is relevant and which dilemmas can be identified. Then we will introduce the hands-on activities. The focus here will be to dream up future scenarios for contextualized active learning in sustainability, through the formulation of new learning objectives.

Hands-on activity (60 min)

Part A: In groups, the participants will be asked to share current practice in relation to sustainability education. They will be asked to identify current challenges, opportunities and context specific considerations. During group work, the discussion will be guided through questions and notes made in the groups in a padlet or on post-its.

Between part A and B, there will be a short plenary sum-up and introduction to formulating learning objectives.

Part B:New groups will be formed based on professional focus. Then the participants will be asked to formulate sustainable learning objectives relevant to their courses or domain expertise. These learning objectives should be contextualized and practise oriented.

At the end of the session (20 min)

At the end of the session, there will be wrap up of the group discussions by sharing examples and predicted opportunities and challenges. The authors will discuss the results of the hands-on activity and develop questions for further inquiry.

- Expected outcomes/results (possibly data/experience from own practice).

The hands-on session is designed to inspire educators to work with a contextualized activation of sustainability education through development of learning objectives. This is no easy task; we therefore also expect to identify challenges and searching for possible solutions together. From prior experience, collaborations have been established, ranging beyond the session, sparked by common interest and passion for engineering education. Finally, we expect to collect the data during the session and use them for developing a scientific journal contribution.

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How to Uni: Blended Study Start for Engineering Students

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ABSTRACT

Keywords –study start, blended learning, online pre-activities

Please indicate clearly the type of contribution you are submitting: _x__ hands-on, ___explore, ___poster.

Background

The Faculty of Engineering (TEK) at the University of Southern Denmark decided to work with blended learning as part of the study start for new engineering students beginning with the fall semester/August 2021. An online "study start course", "How to Uni", was developed and set up in the university's learning management system and was accessible to students well ahead of their on-campus study start.

The background for setting up the course is to ensure that students gain crucial knowledge about the university and the faculty, and to aid in their preparation to become university students. Logistically, moving part of the study start online would also allow TEK and the students to make the most of the time period from when students accept their place in a programme until the on-campus study start activities begin. It would also allow for tutors, mentors, 1st semester teachers a.o. to spend more time actively engaging with the students during the on-campus study start, as the information best suited for one-way communication was moved into a pre-activity.

As a pre-activity, the online study start course aims to raise awareness among the new students on important issues such as study competencies, motivation, and specific aspects of engineering education at TEK, thus providing prerequisites for them to participate actively at their engineering programme. The different course elements have been deliberately selected to ensure an adequate distribution of online and face-to-face activities, relevant use of particular online tools, options for learner-content/learner-learner interaction, and facilitation of flexible self-regulated learning, as recommended in the European Maturity Model for Blended Education, EMBED (Valkenberg et. al, 2020), and in accordance with the underlying principles for teaching and learning at SDU (SDU, accessed 2021) and TEK (DSMI, 2015). More specifically, the course includes five learning paths with a number of texts, videos, tests and discussion boards.

Set-up:

The hands-on session will include a 20 min presentation of selected parts of the online study start course and the thoughts behind it, as well as data on course completion and student evaluations of the first run-through in August/September 2021. The theoretical context will be the EMBED blended learning framework (Valkenberg et. al, 2020).

Hands-on activity:

After the initial presentation, the participants will reflect on and discuss their own potential use of online pre-activities as part of one of their courses. The proposed structure is:

- The participants have 5 minutes to reflect on their own (potential) use of online pre-activities, using the information from the initial presentation and the EMBED framework as a starting point.

- The participants share their reflections with each other using an 'inside outside circle' method, which allows them to develop their reflections in collaboration with others.
- The participants are divided into groups to discuss the potentials and pitfalls of using online pre-activities.
- The groups share their potentials and pitfalls with each other and the presenters.

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Abstracts/Papers
Hands-on Session III
Friday 10.15 - 11.45

Knowledge production in Engineering Education - Hanne Løje, Technical University of Denmark, Anders Buch & Loren Ramsay, VIA University College

Peergrade Workshop - Janni Alrum Jørgensen & Gry Green Linell, University of Southern Denmark

From chaos to complexity – Digital collaborative problem designing and interdisciplinary reflexivity - Maiken Winther, Henrik Worm Routhe & Niels Erik Ruan Lyngdorf, Aalborg University

Knowledge production in Engineering Education

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ABSTRACT
Keywords – knowledge production, teaching, research, practice

Please indicate clearly the type of contribution you are submitting: X___ hands-on, ___explore.

Background
Universities of applied science (UAS) in Denmark are responsible for the professional education of nurses, public school teachers, and bachelor-level engineering education. Since 2014 (Danish Parliament 2014), the UAS have been engaged in research activities. Following the OECD Frascati manual (Frascati manual, appendix 2), the research undertaken by the UAS should be 'applied research' – defined as "original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective." Furthermore, the executive order states that the research should be conducted in "close proximity with labor market employers, other educational and knowledge institutions, and the surrounding society" (Danish Parliament 2014, §5).

Various drifts in higher education – the academic, the applied and the third mission - have been described in the literature. The tendency to transform former occupational non-university education to resemble more prestigious university education has been referred to as academic drift (Tight, 2016). Recently, the academic drift has been accompanied by an applied drift (Bleiklie, 2005) that transforms traditional academic standards of knowledge production from mode 1 research to mode 2 research. Finally, a third mission (in addition to the teaching and research missions) has been observed that provides knowledge transfer directly to companies and society in general (Laredo, 2007; Compagnucci & Spigarelli, 2020). The third mission has been accompanied by pedagogical and didactical approaches, e.g. problem-based learning and the CDIO initiative that stress the practical basis of knowledge acquisition. Academic, applied and third mission drifts in higher education tend to reconfigure the so-called research-teaching nexus (Tight, 2016) where the forces of the drifts are often discussed as research drift and teaching drift, respectively (Clark, 1994).

But how is this applied at UAS? We have recently explored how knowledge production is enacted in the teaching-research-practice-nexus in two UAS in Denmark. The results identify that four discursive positions in this nexus are enacted and that three discursive positions were unavailable (Buch *et al.* 20XX).

In this hands-on session, we will present our results from a recent study. Furthermore, we will discuss how the nexus between teaching, research and practice is enacted or not enacted at Danish Universities.

Set-up

Introduction (10 min)

At this session, the authors will set the scene by introducing the research question hinted at above and describe why this is relevant and which dilemmas they see based on their study.

Hands-on activity (40 min)

Part A *(20 min):*

The participants will be asked to relate knowledge production practices carried out at their own institutions to the teaching-research-practice-nexus.

Part B *(20 min):*

Participants will then be divided into small groups. Each group will discuss how using the nexus as a practical tool can provide insight to inform strategies for navigating in an educational world with conflicting drifts.

At the end of the session (10 min)

At the end of the session, there will be wrap up of the discussions. The authors will discuss the results of the hands-on activity and compare them with their own findings.

Expected outcomes/results

The expected outcome from the session is greater awareness of how to navigate in a setting with conflicting educational drift.

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Peergrade Workshop

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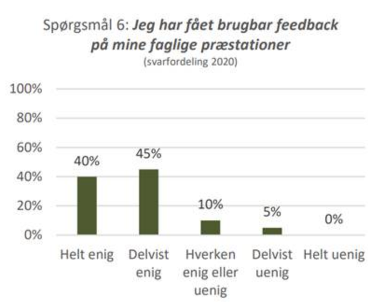
ABSTRACT

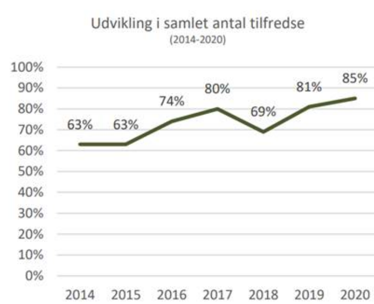
Keywords – Peergrade, peer feedback, active learning.

Please indicate clearly the type of contribution you are submitting: _x__ hands-on, ___explore, ___poster.

Background

Students at the professional bachelor program at Civil and Architectural Engineering (CAE), SDU says that they lack feedback during their education. With larger classes the lecturer does not have time for much individual feedback to the students. The section wanted to find a way to ensure feedback to the student without having to cut down on teaching and supervision. The lecturers also wanted to broaden their tools for active learning. The section got a spear head fund from SDU-UP for the project "*Feedback plan for the first four semesters of the BEng in Civil Engineering programme"* in June 2019. For the next 1,5 year the section tried out different types of feedback. It was mainly peer feedback that the section focused on and Peergrade was used as a tool.
A plan for systematic and progressive feedback in the first 4 semesters of the professional program was developed and implemented. Latest evaluation of the program shows that the students are more satisfied about feedback after the plan was implemented.





From "Studiestartsprøve" dec. 2020

Explanation

Feedback must be PURT (Personal, Understandable, Relevant, Timely) to develop the students. Because of the size of the class, it is difficult for the lecturer to give personal and timely feedback. By using peers, the students will receive more personal and timely feedback. At the same time the feedback can be more understandable and relevant when it comes from peers who themselves recently learned the material.
By using peer feedback, the learning is moved from the private room to a more public domain. The weaker students can get a lot of inspiration from viewing others work and in that way their own assignments improves. The stronger students get a deeper learning from explaining errors to weaker students. The students get confident in receiving and giving feedback which is a skill they need for their future work life as engineers. They also practice the nomenclature and technical terms of the subject.

The Hands-on session
First Janni and Gry will share their experiences with trying out and implementing peer feedback in their teaching. Then there will be hands-on activity with the online platform Peergrade. The participants will try to give/receive peer feedback and will have time to create a rubric for their own teaching. At the end we hope the participants will share their own experiences with peer feedback so there can be an open dialogue about peer feedback and Peergrade.

Bring your laptop and consider which activity you will create a rubric for in Peergrade.

The participants will learn about Peergrade and how to use it. If all participants are familiar with how to use Peergrade the hands-on session will be used more for knowledge sharing and discussion.

From chaos to complexity
– Digital collaborative problem designing and interdisciplinary reflexivity

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ABSTRACT

This paper aims to introduce and analyse a workshop on digital collaborative problem designing and interdisciplinary reflexivity with the purpose of developing engineering students' PBL-competences within problem-orientation and meta-reflection as an answer to the complex problems that engineering students face in a time of globalisation and sustainability challenges. Existing teaching practices are in need for original and creative solutions to handle the complexity of interdisciplinary teamwork and problem designing. Based on theories of interdisciplinarity and learning, and visual data from actual workshops, we analyse the outcome of such a learning activity and conclude that digital learning tools can be implemented meaningfully to facilitate collaborative learning processes and develop the PBL-model in relation to problem design and interdisciplinarity in a time of complex global problems. Lastly, suggestions for other uses and implementation of the learning activity are suggested.

Keywords - PBL, problem design, interdisciplinarity, digitalization, complexity, competence development.

I INTRODUCTION

New complex problems emerge and with global challenges like sustainable development (SD) and Industry 4.0 there is a need to change the educations accordingly (Kolmos 2021). Engineers are an important resource regarding technology development and the complex problems increasingly demands competences like interdisciplinary collaboration across disciplines and programs and project management skills (Hadgraft & Kolmos 2020; Kolmos et al. 2020). Since the foundation of Aalborg University (AAU) in 1974, the university has worked with problem-based learning (PBL) as the pedagogical educational methodology. In a PBL learning environment the problem act as point of departure for learning and it is important that the students learn to identify, analyse and formulate problems themselves (Holgaard et al., 2017). Previously, the main focus has been on what Ryberg et al. (2018) denotes as small-group PBL - work in static groups within disciplinary teams (mono-disciplinary), which has been implemented with success for engineering students (Times Higher Education (2021); US News & World Report 2021). However, complex problems represent a new class of problems that challenge the students and introduce a requirement for interdisciplinarity (Kolmos et al 2020; Klein 1996). In autumn 2019, Aalborg University introduced Megaprojects that incite students to work on complex global problems related to the UN's 17 Sustainable Development Goals (SDG's) (UNESCO 2017; Aalborg University 2020). Two years after the initiation there are still challenges with the Megaprojects (Routhe et al 2021; Winther et al 2020). In particular, students struggle with 1) The depth of multi-disciplinarity when working with complex problems. Different problem types and contexts call for different types of execution and decisions (Snowdon & Boone 2007)

and it may involve different levels of disciplinary and interdisciplinary approaches (Kolmos et al 2020). By definition, the solving of complex problems requires a high level of multidisciplinary understanding and teamwork, and contextual awareness that students have not faced in their previous schooling years. 2) Outlining and understanding their own and others' disciplines. When students are working across disciplines it is important that they understand their differences and mutual dependencies (Routhe et al. 2021) or else they are only working in their own domain and complex problem-solving needs solutions from multiple disciplines.
This paper introduces an activity for digital collaborative problem designing and interdisciplinary reflexivity that facilitates student reflection on contextual awareness and depth of multidisciplinary projects by visually outlining the problem and potentially necessary domains of collaborative partners.

From a progression and assessment point of view, this activity answers to several ILOs of PBL. Recent research at AAU has exemplified four types of generic PBL competences: problem-oriented, interpersonal, structural, and meta-cognitive competences (Holgaard & Kolmos 2019). Students must be aware of the competences, tools, and methods they have acquired during their time of study, both in terms of domain specific knowledge and generic PBL competences. Newly research have found that students' PBL competences become tacit during their study time, giving them limited to no language to articulate what is needed in different collaborative problem settings (Holgaard & Kolmos 2019). This is an issue, not only in terms of future employability and articulation of competences, but also in terms of emphasizing and using the progression of competences the students experience during their time at the university into more complex interdisciplinary settings. Focus, in this contribution, will be on the problem-oriented and meta-cognitive competences with point of departure in the following question: How can students at AAU be supported to create a progression in their competences of working with interdisciplinary problem identification and problem analysis using a collaborative digital learning activity?

II BACKGROUND

In spring 2021, the first PBL workshops, based on a new university wide PBL strategy, were launched for students at the Technical and Engineering faculties at AAU. As an answer to the tacit and limited articulation of PBL competences, and as a support to the facilitation of progression in problem-oriented, interpersonal, structural and meta-cognitive competences, a number of PBL workshops has been introduced. With a range of workshops, all with different focus and output, the disciplines at the technical and the engineering faculties have the opportunity to align and specify the workshops to the individual disciplines. The workshops can be placed at all semesters and for now, the workshops are optional for the students to participate in. There is no immediate assessment to the individual workshops, but students are appointed to make a PBL competence profile at their 8th semester articulating and documenting competences and skills earned through their education, including participation in different PBL workshops. The Aalborg PBL centre has been tasked to offer a number of PBL workshops all elaborating on different PBL competences expanding students' PBL toolbox to all disciplines at the faculty. One such workshop is the "Workshop on interdisciplinary problem designs". The aim of this workshop is for students to get a better understanding of how to approach and work with an interdisciplinary problem design. The workshop is activity based, focusing on exercises and theories that can help the students plan and work in an interdisciplinary setting. An important part of the workshop is for the students to become aware of differences and challenges being part of an interdisciplinary environment, reflecting upon the setting and opportunities in the development of better interdisciplinary tools and methods to expand their understanding of an interdisciplinary problem design. An important output of the workshop is to provide students with a better understanding of their own discipline's possibilities and limitations, which is important to have in mind when working together with other disciplines. In spring 2021, 7 programs chose this workshop spanning from 2-6 semester from both Aalborg and Copenhagen campuses of AAU. The different disciplines attended the workshop in their disciplinary semester formation coming from Software, Bachelor IT, Interaction Design and Urban, Energy and Environmental planning. Due to the pandemic Covid-19, the workshops were fully online, fostering new possibilities for online collaboration on common visualisations in and across the participating groups. Approximately 250 students participated in the 7 workshops. The workshops were placed in the middle of the semester, giving the students time to be introduced and work with their problem type in their semester project. Doing so, the students had a deeper and better understanding of their chosen problem area and therefore the ability to connect and compare their more traditional analysis of the problem with the more complex and holistic understanding presented at the workshop.

III THEORY

Problem designing in PBL

With an institution-wide implementation of PBL at AAU, students at all faculties elaborate and attend in a number of PBL projects during their time at the university. For each of these projects, students must identify, analyse, and scope relevant problems as their point of departure into suitable project designs spanning a full semester. This process of problem designing is often described and illustrated (Holgaard et al., 2020) as an abstract movement through a funnel that narrows and delimits the problem, see figure 1.

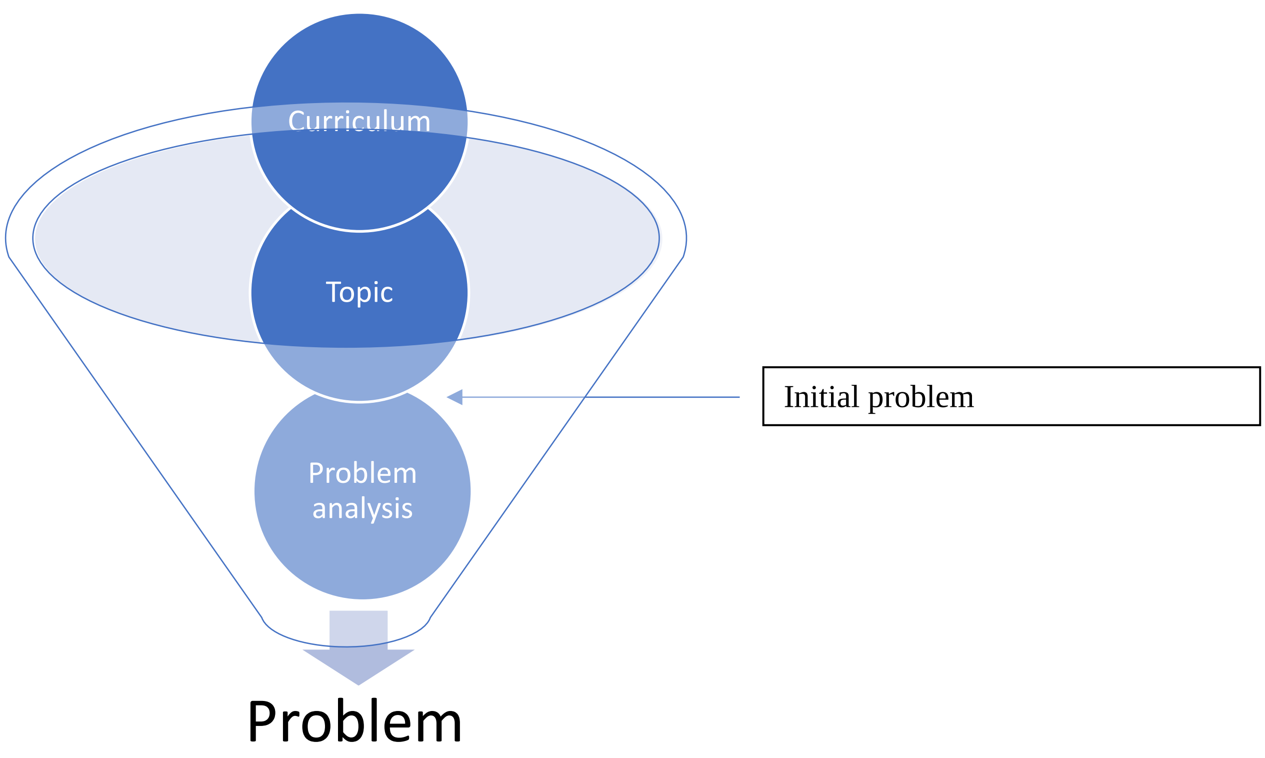

Figure 1: The process of a PBL problem design.

As a start, the curriculum of a particular program delimits a certain area of knowledge, skills, and competences that students are required to engage themselves in. Next, the program/semester coordinators most often have a specific topic or theme for a semester, e.g., sustainability, one of the SDG's, digitalization etc., that the students need to address in their project. This semester topic is typically very broad and not limited by the discipline. It is at this point students are asked to define an initial problem for further problem analysis. In this connection, we want to point out two challenges of interest. First - how can we better help students move from topic to a relevant initial problem? Second - in this connection, how can we help students develop a better understanding of their own discipline and interdisciplinarity?

By formulating initiating problem statements, students create a point of departure for their problem-designing phase. Students must understand and elaborate on the scientific foundation and relevance, focusing their problem identification and problem delimitation from a broad, undefined theme or problem area to defined, delimited problem formulations possible to work on in the given time of the semester (Holgaard et al., 2020, Pedersen, 2005). Though problem design is considered important it is also seen as challenging for engineering students, and some semesters are more designed to socialize students into a discipline (Holgaard et al, pp.1074, 2017). Often, the step from topic to problem analysis is either reliant on supervisors defining the problem for the students, and thereby reduces an important component of student centred learning, or, it is left for students to cobble something together themselves. We suggest a middle road, where teacher, or supervisors, take the roles of facilitators, to support students' problem identification process and to eventually foster relevant and interesting problem formulations.

The rest of the process, the problem analysis, will include a phase where students identify which elements and aspects are important to take into account working with the problem in question. Through an iterative process, students gather information and data about their current knowledge related to the problem in focus, connecting this to relevant literature. With this, students dive deeper into a specific area of knowledge and elaborate on a "knowledge gap", either in terms of their own knowledge or a societal challenge. With a mapping of what the students know and do not know, they delimit their problem focus into a specific problem formulation presented and elaborated through a funnel moving from an initiating idea or theme to a specific problem in focus.

Concepts and levels of interdisciplinarity

In literature, different understandings, and approaches to interdisciplinarity, cross-disciplinarity or integrated research have been formulated to describe a better integration and alignment between disciplines. (National Academy of Science 2005) The challenge in this is the lack of a common language for how to address and talk about the term of more efficient collaboration across disciplines, creating a diverse range of degrees and stages of interdisciplinarity.

This paper uses the term of interdisciplinarity as it has been acknowledged in literature as a term consisting of a range of approaches and understandings to interdisciplinary collaboration ranging from borrowing up to transdisciplinarity. (Klein 2005, Stock and Burton 2011)

- *Borrowing* refers to the lightest degree of interdisciplinary research, where disciplinary researchers detect and elaborate on relevant research and findings from other disciplines. In a PBL environment, the aspect of borrowing information and elements from other disciplines is an elementary element of the problem analysis phase elaborating and expanding the students understanding of the problem they are dealing with. (Kolmos et al 2020)
- *Multidisciplinarity* refers to constellations where researchers and/or professionals produces individual contributions to a common issue or goal. In such research constellations, researchers share understandings, methods, approaches and findings, though with no interest and attempt to cross the disciplinary boundaries between them. Needed expertise and inputs are provided and shared in these collaborative settings providing a more qualified product to an issue or goal. Educational multidisciplinary project settings are often observed in bigger courses across disciplines, where students work in parallel on the same problem areas. (Kolmos et al. 2020)

- *Interdisciplinarity* refers to project settings where the problem has a degree of complexity that requires new approaches and understandings across the participating disciplines. Researchers must agree upon a joint focus, approach, tools and plan for the process all adding complexity into the interpersonal and structural sphere of collaboration among the participants. As interdisciplinarity are trying to cope with the complex setting of having researchers to work together on joint contributions and outcome across different knowledge paradigms and ontological and epistemological understandings literature have highlighted a distinction to the term interdisciplinarity. To cope with this intern range of differences to interdisciplinarity Klein (2005) introduces the concept of "narrow" and "broad" interdisciplinarity while Stock and Burton (2011) frames it as "small" and "big" settings. Common for both articulations, are the distinction between teamwork in groups of researchers ontologically and epistemologically close to one another and researchers with more distinct understandings, methods and approaches to research. Both narrow and broad interdisciplinarity occurs in PBL settings, though with variation to the degree of success. Interdisciplinary teamwork becomes especially challenging when integrating the collaboration into the disciplines formal curriculums learning outcomes. (Kolmos et al 2020)
- Lastly, *transdisciplinarity* occurs when a variety of researchers, professionals, practitioners as well as "non-academic participants" collaborate on real-world problems and challenges. The term is often referred to as the highest degree of integrated research and refers to constellations where the participants are not only far from each other in relation to ontology and epistemology, but also in terms of how to approach, talk and deal with the problems addressing related to their academic or non-academic background. Transdisciplinarity is occasionally used to describe entirely new interdisciplinary educational programs.

The different approaches and understandings of interdisciplinarity all require an attention for how to approach and cope with elements such as problem identification, teamwork and project management. Research have indicated that students find it difficult to transfer their PBL skills and competences from a disciplinary to interdisciplinary setting. (Routhe et al 2021, Winther et al 2020) As the project settings becomes rapidly complex, students tend to forget how to approach and tackle challenges related to their project work, aligning and articulating how each of the group members address and work with problems in their disciplinary team formations, inhibiting their interdisciplinary teamwork. Students stress a need for more methods, tools and approaches to overcome challenges and difficulties in the interdisciplinary project work breaking down barriers between the involved disciplines. (Winther et al 2020)

Interdisciplinarity and PBL

For years, disciplines have acted as the combining body for shared understandings, concepts and language. Disciplines provide an institutional frame of reference, theory, methodological approaches and relevant topics of study, giving researchers and scientists a shared language and an ontological and epistemological attachment, important for efficient and significant research to progress. (Stock & Burton 2011) With a recent acknowledgement of the world's societal challenges as complex and/or chaotic, disciplinary boundaries and divisions are increasingly recognized as limiting for more holistic and comprehensive solutions. (Global Sustainable Development Report 2019) Dörner and Funke (2017) stresses the importance of understanding and acknowledging real world challenges as problems that extends beyond disciplinary educational problem-solving skills. The level of complexity generates and determines the level of options and elements to consider, creating a need for future graduates to understand and elaborate further on a variation of problem types and approaches. (Kolmos et al 2020) As a result, new research has been focused on developing more interdisciplinary approaches to research, teaching and learning, developing new ways to integrate and connect disciplinary methodologies, ontologies and epistemologies in the development of a more shared understanding and language for the future complex problems, we are facing. (Stock & Burton 2011)
Interdisciplinarity arises from a need to designate and address grey zones and interfaces between disciplinary defined problems. The learning pedagogy of PBL has for years, had a point of departure in problems, letting students determine and address the problem in focus accordingly to its structure and

appearance. As research have indicated an increasing focus on complex and/or chaotic problems students must experience a variation and progression in the problems and project structures they attend and participate in, letting the student develop their PBL competences further. (Kolmos et al 2020)

IV THE WORKSHOP

Description and analysis of the workshop - A digital collaborative approach to problem designing and interdisciplinary reflexivity

The workshop lasts approximately 3 hours with an exchange between lecturing and teamwork in and across smaller groups. In the following, we will give a step-by-step description and analysis of the workshop elements.

Teaching and learning objective. The aim of this workshop is to facilitate students in developing competences within problem designing and interdisciplinary reflexivity.

Teaching and learning method. This is an unfocused and collaborative teaching and learning task. Students work in groups but also across groups as they share ideas and complement each other. The intended product is open in the sense that the workshop will give groups different inspiration for further refining their problem design.

Teaching material. For the workshop, the platform MS Teams was used, giving the possibility for sharing information and facilitating the online workshop. Having an aim of giving the students as many opportunities for interaction and activity-based learning as possible, the platform Padlet was used as a collaborative whiteboard for sharing inputs and ideas.

Prior to the workshop. The students do not need to prepare anything prior to the workshop. Teachers need to prepare two digital whiteboards that can be used simultaneously by several groups.

During the workshop, step 1. In the beginning of the workshop, it is important to create a common ground for the students, letting them discover their shared and opposite understandings of interdisciplinarity. In addition, the students are asked to reflect and elaborate on the concept of an interdisciplinary problem design: When is a problem design interdisciplinary and have they ever experienced this kind of design before? For this part of the workshop, a digital whiteboard was used as a platform for noting findings and reflections from each group. The group work was followed up with a plenum discussion of the input noted in the digital whiteboard. This part of the workshop will let students activate pre-existing knowledge about interdisciplinarity and problem designing.
After a plenum sharing of understandings of interdisciplinarity and interdisciplinary problem design, a slideshow is presented to give the students a better theoretical understanding of interdisciplinarity. With point of departure in Stock and Burtons (2011) explanation of interdisciplinarity as a way to try and "*break down methodological, epistemological and ontological boundaries that prevent shared understandings of complex issues",* students are given insight to the contextual background for why we talk about interdisciplinarity. Snowdon and Boone presented in 2007 an illustration of ordered and unordered problem types giving a theoretical understanding of the progression of problems from simple to chaotic (Snowdon and Boone, 2007). Kolmos et al. (2020) combined this framework with the problem-based learning approach to problem solving illustrating the differences to project types, problem design, project management and collaboration. Combining this understanding of different approaches to problems with different degrees of interdisciplinarity, students become aware of the dependency and causality between problem types and teams of collaboration. As interdisciplinarity is a common concept used to describe integrated research it is important that the students are aware of the range of stages presented in interdisciplinary research ranging

from borrowing to transdisciplinary collaboration. (Klein, 2010) With an understanding of different problem types in combination with different approaches of collaboration, students will be able to assess what is needed in different stages of their project work.

During the workshop, step 2. For the second group activity, the class is divided in project groups again and asked to open the link to the digital whiteboard. Here they are met by a broader topic of interest and a description of the task. In one of our examples, the groups were asked to do a concept map of Covid-19 or sustainable construction depending on the discipline (see appendix 1 and 2 for examples). By choosing a broad case for this activity, it is possible for the students to make a general brainstorm of aspects and inputs to the case. The activity should take place on a digital whiteboard where all groups share the same digital space. The activity is divided into two phases with the first being a general brainstorm of the case worked on. Students should try not to limit their focus to their domain specific knowledge but broaden their understanding and perspectives of the case more in general and identify all possible angles of interest. In the second part of the activity, students combine their overall brainstorm with their domain specific knowledge, elaborating on what they as engineering or technical students can give insight and inputs to. But also, identifying what kind of problems that are out of their area of expertise. Having all these considerations in mind, it is possible for the students to relate the different items of problems or focus points to one another. Doing so, the students create a concept map that visualizes the complexity of the case worked on. The map may seem confusing or unmanageable for the students, but the task is then to recognize the complexity of the topic and try to figure out which relations are essential for the given situation in the case, and which are possible to leave out.

During the workshop, step 3. With the above inputs, the last activity is focused on the student's semester projects. With point of departure in their current project work, students are asked to elaborate on the problem type, degree of interdisciplinarity and to investigate if elements in their problem analysis could benefit of inputs from other disciplines. Doing so, students become aware of possibilities for collaboration with other disciplines in their current project work, but also which elements in their project work that has roots in other disciplines.
The session ends with a reflective part, where students have to articulate which competences, they have in relation to interdisciplinary problem design. Students are asked to answer questions as: When is interdisciplinarity needed, how has previous experiences with working interdisciplinary been (if any) and what are the differences between disciplinary and interdisciplinary work?

V DISCUSSION AND CONCLUSION

In this section, experiences, observations and thoughts for how to structure the workshop in the future, will form the basis of the discussion and conclusion. As mentioned above, the workshop has been completed by 7 disciplinary study programs spanning from 2-6 semester, all ending with an oral feedback and evaluation session where students had the opportunity to elaborate on the structure and content of the workshop. These experiences will be elaborated together with the authors' observations and experiences from a learning and teaching point of view.

Overall impressions and experiences

The overall experience from the students was that the workshop provided them with a good understanding and insight to the terms of complexity and interdisciplinarity and how these affect and influence how to approach and structure a problem design. Students had from the beginning of the workshop an overall understanding of interdisciplinarity as situations where competences and disciplines are coming together to solve and work on a problem. Some groups even had the ability to articulate interdisciplinary work as the ability to mix methods and theory from different disciplines into a shared, more holistic solution to greater problems. Having this as point of departure in the workshop, the authors had the possibility to elaborate further on the students' existing understandings, giving them a more varied understanding of problem types and how that align with different understandings of interdisciplinarity.

In the second step of the workshop students experienced different frustrations during the exercise with the mapping of the brainstorm. More of the students articulated that they had a hard time creating an overview of all the elements that actually were a part of the case, and that it easy became unmanageable for them. From an observation point of view, the students experienced putting the case into a broader context than they are used to. Often, students frame and articulate an idea based on preferences and interest. Here, students were not at any point told to focus on a specific topic of interest or preference related to the case, but instead just cover all aspects of the problem they could think of. This, creating a complex brainstorm of points and relations. Complex problems are a landscape of relations, aspects and focus points expanding the ability and competences of one discipline. Trying to break down the complexity of such problems, into more manageable concrete problems, it is important to have in mind the complexity in the problem itself. Often, problems are reduced into disciplinary subareas possible to solve within a manageable time and effort. The term, delimitation, is often used as an argument for omitting elements of a problem, forming and structuring a problem in relation to the context and social aspects in which researchers are working in. Students experienced a much more complex landscape of the case (or problem) working on, giving the student another view on complexity and problem work depending on focus and scale. (see Appendix 3)

Another reflection, important for the students to take from the workshop, was to be more aware of to what degree they are actually being interdisciplinary in their problem design. Often, students are asked to get a contextual understanding of the problem, borrowing literature and material from other disciplines. Simply being in this low degree of interdisciplinary sphere, students have to be aware of the influence of interpretation and mistranslations. Further, students often get the impression that they are placed in groups because that is a relevant and good competence to develop. With a better understanding of the problem design phase, students should let the problem decide the team constellation and determine whether a multi-, inter- or transdisciplinary approach is needed, or if borrowing from other disciplines is sufficient enough.

In the third step of the workshop the students were given time to reflect on their problem designs for their semester projects, elaborating on the degree of complexity and interdisciplinarity within their problem area. When finishing of the workshop, more students expressed that they would have liked the workshop in the beginning of their semester. They could see a relevance in including elements from the workshop into their problem designs. The thoughts behind placing the workshop in the middle of the semesters was to give them the possibility to reflect upon how they have made their problem designs so far, to how they could incorporate more direct thoughts on how to obtain data, ideas and insight from other relevant disciplines into their semester projects, giving a more holistic problem analysis and design. It could though be relevant to try placing the workshop in the beginning of the students' semesters to follow the flow of their semester project more, supporting their problem design phase.

Future workshops

For future workshops, it could be interesting, and highly relevant, to let different disciplines and semesters work together in the workshop. As the aim of the workshop is to give the students a better understanding of an interdisciplinary setting and to get a deeper understanding of their own discipline's possibilities and limitations. The workshop has though still been meaningful to complete in the disciplinary formation. The online setting made it possible to gather and share input and insight into the different group's discussions and output. During the workshops, it became clear for the students that even though they were working together with other groups from the same discipline each of the groups had different opinions and input to the exercises worked on, giving the students a feeling of the complexity within the provided topic even within their own disciplinary field.

Giving students the opportunity to work together in interdisciplinary teams for this, would also give them the opportunity to elaborate further on how each of the disciplines could contribute to the case in focus. Not only does it give the students a common objective to talk and collaborate on, but it also provides the students with an understanding for where their disciplinary competences are, and ends, and what other disciplines may contribute with and provide deeper knowledge about. Students should know when information sharing and collaboration with other disciplines are necessary for better problem solving and when relations in the complex landscape of the problem can be neglected.

Conclusion

The aim of the workshop has been to provide students with a more holistic and complex understanding of problem designs, dependent on the problem at hand. With an understanding of complexity and problem types, students should become more aware of the different degrees and approaches to interdisciplinary work and collaboration and what the opportunities and pitfalls of borrowing or collaborating with other disciplines might be. With a better understanding for how to use the mapping of the problems as a method for elaborating and expanding the students understanding of the problem, they also get an approach for how to create dependency and a common object for communication in an interdisciplinary constellation in the future. Problem design is challenging, even if it is related to the students' own disciplines. Nevertheless, with increasing complexity and the need for interdisciplinarity it becomes even more challenging. However, a workshop on digital collaborative problem designing and interdisciplinary reflexivity has shown a support to the students. Using the digital learning activity supports the students to create a progression in their competences when they are working with interdisciplinary problem identification and problem analysis and thus can be a useful tool for the students when they are working on complex problem design in an interdisciplinary context.

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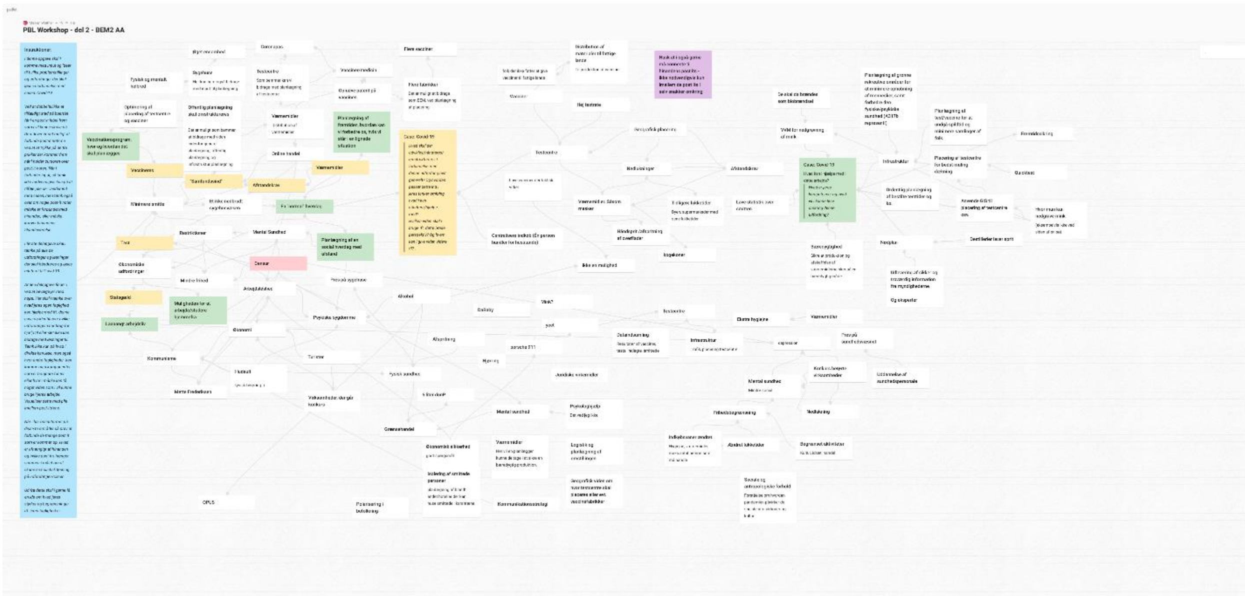
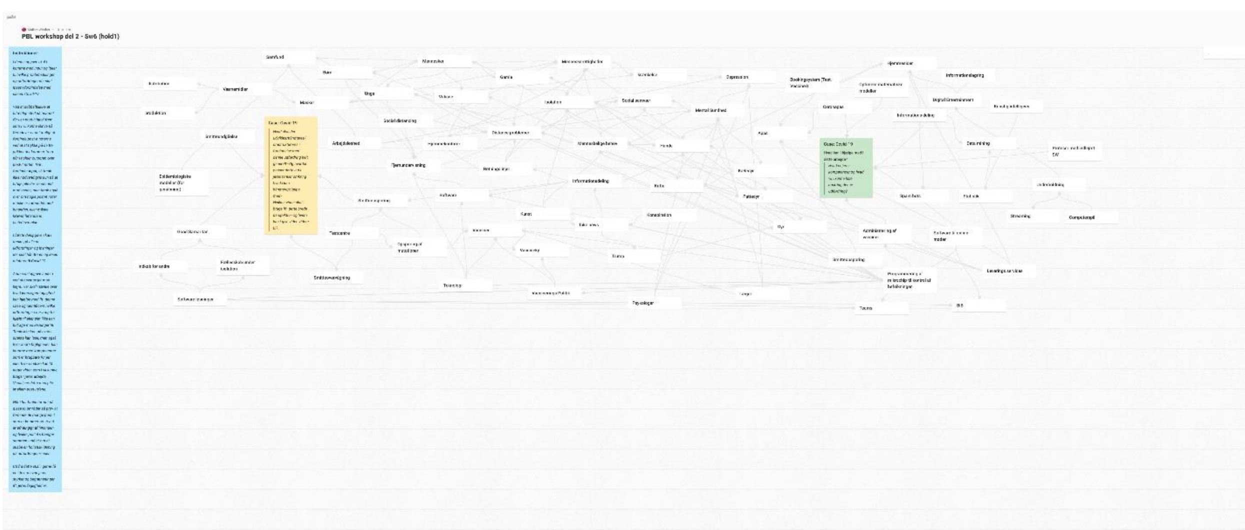
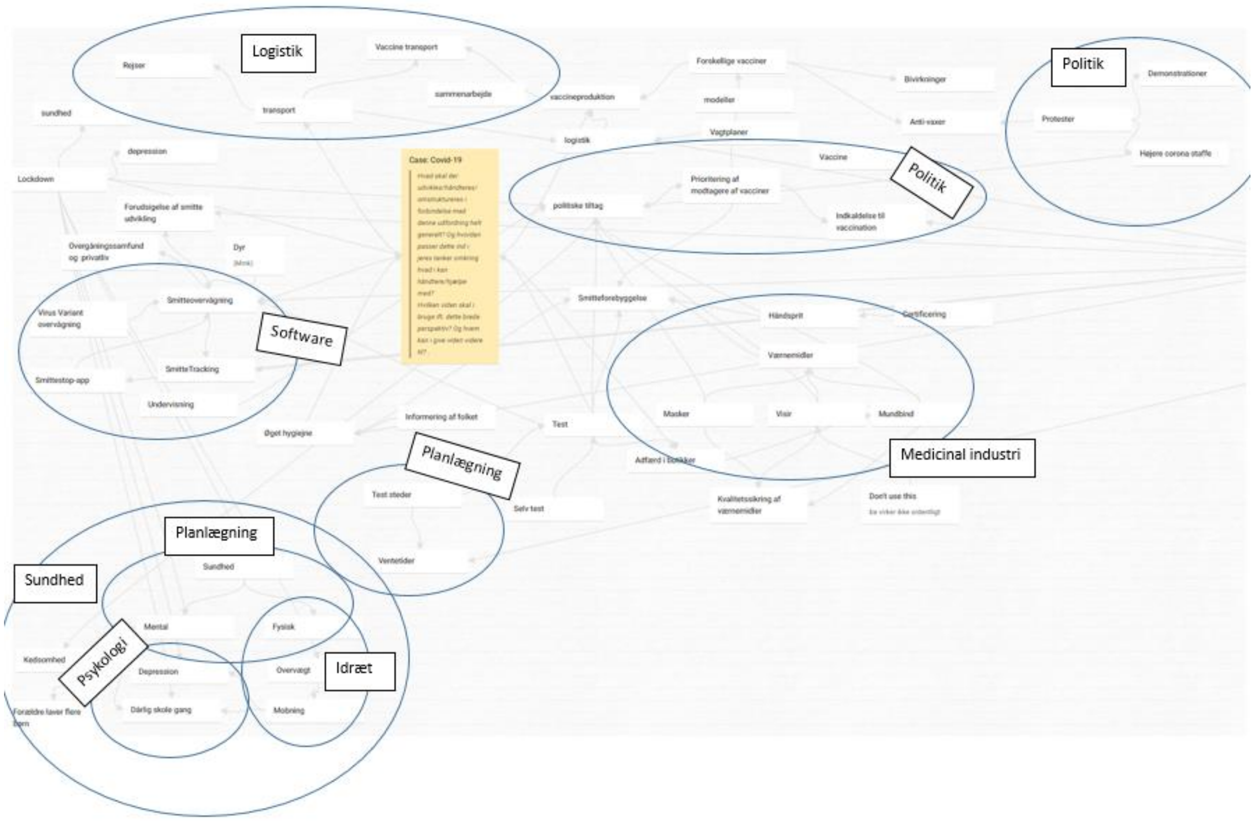
Appendix 1



Appendix 2



Appendix 3


Logistik
Rejser
Vaccine transport
sammenarbejde
transport
sundhed
depression
Lockdown
Forudsigelse af smitte udvikling
Overgåningssamfund og privatliv
Dyr
Case: Covid-19
Forskellige vacciner
vaccineproduktion
modeller
logistik
Vagtplaner
Bivirkninger
Anti-vaxer
Vaccine
Politik
Demonstrationer
Protester
Højere corona staffe
Prioritering af modtagere af vacciner
politiske tiltag
Indkaldelse til vaccination
Politik
Smitteforebyggelse
Håndsprit
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Virus Variant overvågning
Smitteovervågning
Software
SmitteTracking
Smittestop-app
Undervisning
Øget hygiejne
Informering af folket
Test
Masker
Visir
Mundbind
Medicinal industri
Planlægning
Test steder
Selv test
Ventetider
Kvalitetssikring af værnemidler
Don't use this
Planlægning
Sundhed
Sundhed
Mental
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