Stakeholder-student interactions in engineering education: involving busy experts in project-based courses

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PROCEEDINGS

CHALMERS CONFERENCE ON TEACHING AND LEARNING 2023

CHALMERS
UNIVERSITY OF TECHNOLOGY

PROCEEDINGS CHALMERS CONFERENCE ON TEACHING AND LEARNING 2023

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Table of Content

About Chalmers Conference on Teaching and Learning

KUL, Chalmers Conference on Teaching and Learning, is held yearly and started in 2011. The aim is to contribute to the quality of the entire educational activity at Chalmers, i.e., undergraduate education, postgraduate education, and collaboration, by promoting collegial conversation about learning and teaching.

KUL offers an opportunity for the exchange of experience regarding program and course development and is an arena for pedagogical development and qualification. The idea is that the Keynote and other sessions should contribute to the collegial conversation and inspire further exchange, also between the annual conferences.

Summary in brief for KUL2023

Date: April 3, 2023

Venue: Lindholmen Conference Center, Gothenburg, Sweden

Number of participants: 144

Number of conference contributions: 27

Number of contributing authors: 57

Number of plenary sessions: 2

Number of parallel sessions: 18, over four or five parallel sessions

Average rating: 4.1 out of 5 (41% response rate).

News: Moved from January to April. Simplified process for conference contribution and introduction of proceedings.

Challenges: Information for Chalmers employees before the conference.

Keynote speaker Annoesjka Cabo, Academic Director of the Teaching Academy at TU Delft, discussed "The Art of Connecting" in her speech, delving into strategies for making innovation in engineering education effective.


Delft

Committees, groups, and roles

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Keynote KUL 2023

Annoesjka Cabo
TU Delft

Director of Education in the faculty of Electrical Engineering, Mathematics and Computer Science, and as Academic Director of the Teaching Academy, TU Delft

Title of Keynote speech
“The Art of Connecting”

Subtitle
“How to make Innovation in Engineering Education work”

Abstract
Inspired by the ever-changing world and society around us, Engineering Education is up for constant innovation, transformation, and adaptation.

The challenge is how to enable, enhance, and shape this at our universities. Another question is how to ensure the innovations actually work and are adopted in the local context.

At TU Delft, a new Initiative has started, which aims to design a space to co-create Engineering Education for the future based on research and evidence.

In this speech, Annoesjka Cabo will introduce the Initiative and the underlying vision. The audience will be actively involved in discussing possible ways forward from their point of view.

PAPERS

WORK IN PROGRESS

ROUND TABLE

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PAPERS

How to Better Teach Computer Networks to First Year Engineering Students Post-pandemic, A Case Study *

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9 september 2023

Abstract

The COVID-19 pandemic has significantly impacted the higher education sector, leading to changes in the way courses are taught. In this study, we explore how the transition from remote learning to in-person classes can be leveraged to enhance teaching and learning in the post-pandemic era. Specifically, we present a case study that evaluates the implementation of post-COVID changes in a large computer networking course. We demonstrate that a switch from remote to physical labs, along with an increase in active learning and spaced practice, can yield positive results. Our findings indicate that while the overall impact on performance may be limited, the time spent on lab activities and student satisfaction improved in our case study.

Sammanfattning

COVID-19-pandemin har haft en betydande inverkan på högre utbildning, vilket har lett till förändringar i hur kurser lärs ut. I denna studie undersöker vi hur övergången från distansundervisning till undervisning på plats kan utnyttjas på ett klokt sätt för att förbättra undervisning och inlärning i en post-pandemisk miljö. Vi presenterar en fallstudie som utvärderar implementeringen av post-COVID-ändringar i en stor kurs om datornätverk. Vi visar att en övergång från distans till fysiska labb, tillsammans med en ökning av aktivt lärande och tidsfördelad repetition, kan ge positiva resultat. Våra resultat visar att även om den övergripande effekten på prestationen inte förbättras, så blir labbaktiviteter effektivare och tar kortare tid och studentnöjdheten ökar i vår fallstudie.

Keywords: *post-pandemic education; computer networks; active learning; spaced practice.*

1 Introduction

As a consequence of the unforeseen recent COVID-19 pandemic, many if not all higher education courses had to abruptly transitioned from an in-class model to being held online (Adedoyin & Soykan, 2020). Two years after its outburst, the reverse move is being implemented as courses forced-held online are returning to their on-campus version (Greenhalgh, Katzourakis, Wyatt & Griffin, 2021). Teachers can take advantage of this shift back to in-person learning as an opportunity to reflect on their teaching and learning strategies and learn from their experiences during the pandemic. In this context, this case study proposes to investigate the implementation and outcome of pedagogically designed post-pandemic changes in an introductory networking course given at Chalmers University of Technology. Our study focuses on the following research question "How can we better teach computer networks post-pandemic for first-year engineering student?"

*Presented at Chalmers Conference on Teaching and Learning 2023, KUL2023

Motivation & Scope: Several studies have presented lessons to learn from the pandemic and the increase use of digital or hybrid education, cf. Fayed och Cummings (2021); Rapanta, Botturi, Goodyear, Guàrdia och Koole (2021); Zhao och Watterston (2021). However, for labs, relevant material appear lacking concerning the shift from remote to newly created physical content when the opposite move is well documented, see e.g. Corter, Esche, Chassapis, Ma och Nickerson (2011). This motivates the present study, focusing on student understanding of the cogs behind networking protocols and driven by measurable objectives. The challenging task of quantifying improvement in student understanding is avoided on purpose, but our reflections do provide some meaningful insights on the matter. The study aims to provide guidance for a better load-balance of student learning time in the post-COVID era. In particular, reducing the time spent on labs for equivalent *Learning Outcomes* (LO) reduces student frustration from being blocked on unnecessary hardware issues. Only compulsory course elements are used in the study. Due to lack of data, comparing changes with pre-covid times is out of scope of the present study.

Method & Objectives: To answer our research question, we implemented and evaluated several updates in the course activities taking advantage of the shift from online to on-campus or hybrid education. Updates were designed following three main pedagogical approaches: *Active Learning* (AL) (Freeman m. fl., 2014), *Practice Test / Spaced Practice* (PT/SP) (Dunlosky & Rawson, 2015) and *Peer Instructions* (PI) (Biggs, 1999). AL is used to activate students during all the course activities and in particular during the lectures. PT/SP is used in weekly exercises format for balancing students and *Teacher Assistants* (TA) time and improve learning. PI aims for students with different understanding level to help each other with known mutual benefits. After identifying specific areas of improvement that could benefit from on-campus education, we guided the design of the updates by the following three objectives. **[O1]** Setting-up new physical labs after pandemic years, with novel parts involving interactions between student groups to promote PI and AL. The update encourages different lab groups to "synchronize" with faster groups being led into helping out slower groups. **[O2]** Making useful in-class exercise sessions, with the adoption of a new format to better foster live PI between students, aiming to enhance a weekly training following a PT/SP approach. The sessions are designed to scale through using automatic grade reporting for groups. **[O3]** Switching to in-class quizzes during lectures, and evaluating AL between covid (online) and post-covid (in the classroom) lectures.

Evaluation & Results: Feedback was collected through an end of course evaluation survey and an additional short survey to gather lab-specific feedback, sent during the last study week on *Canvas*, the local *Learning Management System* (LMS). We evaluate the updates using a mixed-methods approach combining qualitative methods with semi-empirical data. Based on the collected data (from surveys, quizzes and LMS statistics), student feedback and the teacher's reflection, the proposed updates did succeed in reaching the set objectives. In particular, our case study highlights several interesting leanings when returning our computer engineering courses to campus-based education.

2 Methodology

Background The studied course is an introductory computer networking course held in 2022, part of the 5-year computer engineering curriculum with ca. 200 students. LO cover how packet switching networks and the Internet work around the most popular networking protocols. Due to the pandemic, the course was held entirely online in 2020 and 2021 following a traditional format (lectures, exercises and labs) coupled with an online exam. Quizzes during lectures were introduced in 2020 to enhance AL following Felder och Brent (2016) and Christie och De Graaff (2017). In 2021, automatically graded exercises held in the LMS were introduced to let the students practice asynchronously with the content.

Figure 1: Content of the student lab box[2].

Figure 2: Students in a collaborative lab.

Figure 3: Quiz views in the LMS for short questions: (a) before submitting, (b) after submission (score per question) and (c) after the session (guided solution).

Labs (O1) PI and collaborative labs were developed in the context of switching back to physical labs after the disposal of old hardware. New basic networking equipment[1] were acquired as presented in Figure 1. The physical labs[2] were mostly following the same content as the remote labs (half performed using the students network card, and half done in simulators). Additional parts were added to take profit of the on-campus setting to enhance collaborations between several lab groups up to the entire classroom (cf. Figure 2). The additions focus on including one problematic aspect which engages the group as a whole according to the concept of collaborative PI (Magin, 1982).

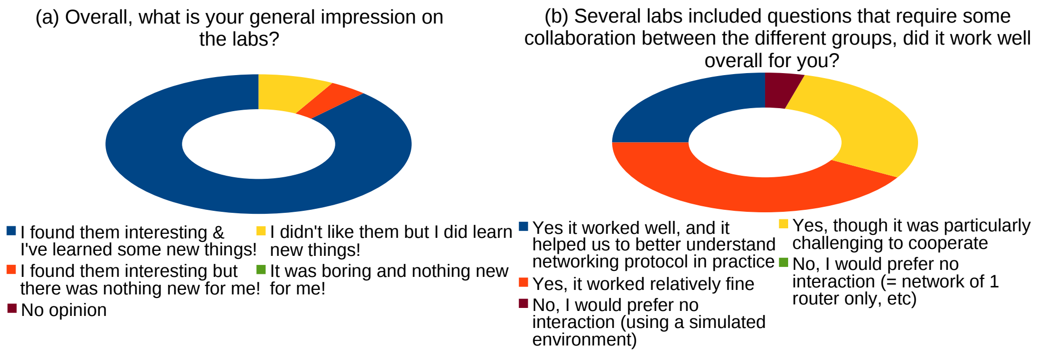
Exercises (O2) Conforming to proven experience (Crouch & Mazur, 2001), PI is best fostered in group exercises. Weekly exercise sessions aimed to review concepts from the lectures (short questions part) and apply the notions in concrete settings (problem part). The sessions were held on campus using automatic grading within the LMS and a TA helping students in solving the exercises and providing correction at the end of the session. Every student was allowed to submit and could see in return her/his correct and wrong answers (leveraging the different views in the LMS, cf. Figure 3). A grade was automatically calculated for each group based on individual submissions, and all exercises together provided up to 10% of the exam points as bonus points. The duration of the sessions and the difficulty of the problems made it essential for the students to collaborate in order to reach higher scores in the allocated time. Thus, the purpose was twofold: (1) to give an incentive to students to try the exercises on a weekly basis, and (2) to promote PI.

[1]On Figure 1: Raspberry Pi400 "keyboard/computer" (1), Pi4 (2), 5-ports switch (3) and 3-ports router (4).
[2]All labs manuals are available at `http://www.cse.chalmers.se/~duvignau/datakom/`.

Lectures (O3) To activate students after 10-15 minutes of lecturing time, quizzes are used for AL in the physical lectures. Each AL question relates to the previous lecturing point (usually, the most important element to understand). We use statistics extracted from the quiz application (mentimeter) as basis for our analysis. Our evaluation allows a reflection if the return to on-campus education triggered any challenges that should be addressed.

3 Results

Figure 4: Student feedback on (a) general labs impression and (b) the collaborative parts.



O1: Collaborative labs Table 1 summarizes the aggregate answers to the lab-specific survey. Concerning student satisfaction and learning (cf. Figure 4), a large majority (88%) of the students found the new labs interesting and assess that they have learned new concepts through them. For most students, the collaborative parts worked well or relatively fine with some students reporting better understanding of network protocol in action but also some challenges in collaborating on those parts. The total number of lab re-submissions was almost halved between 2021 (online labs) and 2022 (physical labs). Concerning completion time, students reported an average of 4h (matching the intended target), but we note large differences between the labs and among student reported answers. Contrary to previous pandemic years, no excessive lab duration was reported in the final course evaluation. Most students reported a difficulty adapted to an introductory networking class. TA also reported less hours spent on grading the labs as part of the check was done during the physical sessions. Student feedback (SF) praised the labs in the course evaluation:

SF: *The labs were great, and it was fun to learn-by-doing. [...] this was also fun because it definitely deepened my understanding of how networks work.*

SF: *I have to say the labs in this course have done a really good job of building more of an understanding and intuition for the concepts covered.*

SF: *I think the labs were great. The labs give a more practical view and understanding of the theoretical knowledge.*

SF: *I enjoyed the labs. They made me understand the material better, and it felt like what we learned during them was something you actually could have use for outside of school.*

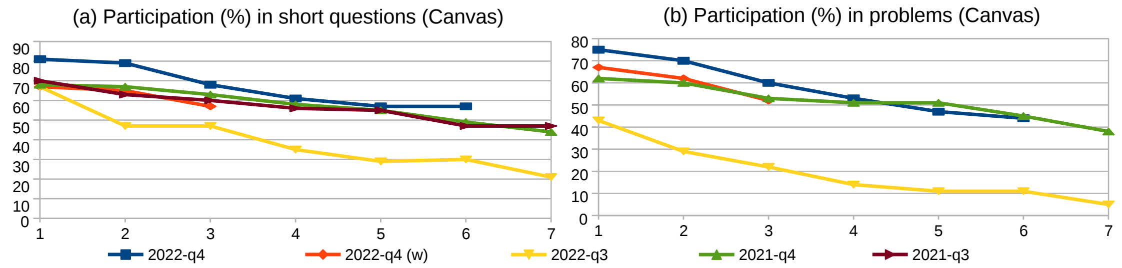
Table 1: Summary of the new labs with student reported time and difficulty (2022).

Lab	# of tasks	# of questions	# of coop. tasks	Average duration (h)[a]	Average difficulty 1-5[a]	# of resub. 2021	# of resub. 2022
1 – HTTP/DNS	7	24	0	3.67 ± 1.24	3.08 ± 0.56	8	3
2 – TCP	8 + 1	23 + 2	1	4.5 ± 1.2	3.17 ± 0.72	5	2
3 – Routing	7 + 2	25 + 2	5 + 2[b]	4.13 ± 1.26	2.89 ± 0.95	6	5
4 – Switching	10	30	5[c]	4.05 ± 1.1	3.11 ± 0.92	3	0
5 – SDN	7	22	0	3.59 ± 1.27	2.81 ± 1.06	7	6

[a] ± Standard Deviation. [b] Tasks require 4 lab groups. [c] Tasks require the entire classroom.

O2: Efficient in-class exercises Participation in online quizzes within the LMS has risen in 2022 by 10 pts on the first sessions; cf. Figure 5, observe that the student cohort is different in quarter 3 (Q3). The updates have been successful at bringing students at the exercise sessions despite having an exam in a different format. By tracking participation on a weekly basis, we observe that students have better spaced their practice. Individual scores obtained by the students were in line with previous years.

Figure 5: Participation in (a) short questions, (b) problems and at week 3 for 2022 (w).



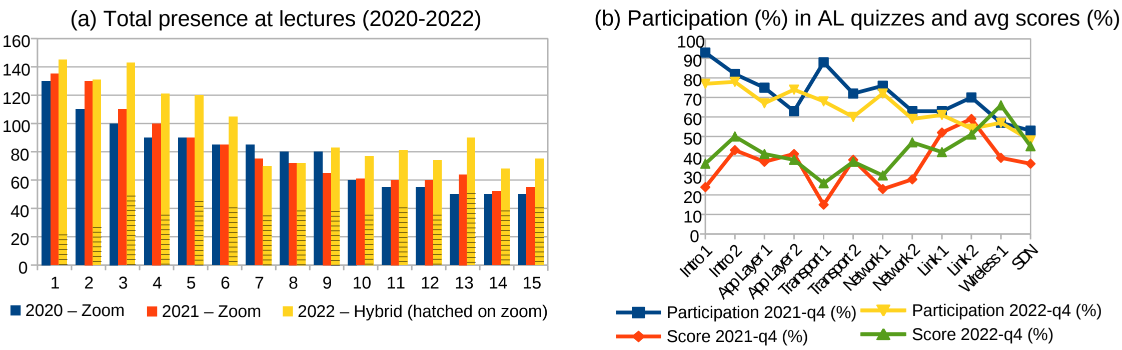
O3: AL in physical lectures We note that the hybrid format brought slightly more students to the lectures (cf. Figure 6). When analyzing the fraction of students taking part in AL quizzes, we observe similar trends in 2021 and 2022. We only note a -6% difference of student taking part in the quizzes which may be due to some students preferring not to switch focus between their lecturing notes and their mobile phone in physical versus a remote environment. Students have often praised the quizzes used in lectures for providing break, maintaining their focus and helping with teaching and learning, e.g.

SF: *I liked that during the lectures questions on the currently covered topics were asked in a quiz. This assisted in the learning of the course's contents.*

SF: *The quizzes during lectures kept me alert and motivated me to stay focused.*

SF: *The [...] quizzes especially since they force you to be focused and present during lectures.*

Figure 6: Presence in lectures and participation in AL quizzes (%) along AL scores (%).



4 Discussion and Conclusions

Our results advocate that well-designed on-campus activities can make student time more efficient with a workload more spread throughout the study period, reduce student frustration and raise student satisfaction, with comparable learning scores to the online setting (assessed by exam, lecture quizzes and exercises). The collaborative physical labs worked well and were more efficient. As an instructor, the teacher did notice PI taking place between more advanced groups and slightly slower groups. Using synchronization points did encourage PI behaviors among students but their challenging nature makes us advise to limit them to e.g. 4 lab groups. Concerning the exercise sessions, the format did favor PI that was observed during the exercises and succeeded in bringing more students to the sessions and making them evenly space their training practice. At last, let us note that the overall impression is quite positive by the students at the course evaluation survey with mostly positive feedback (with an average of 4/5).

To conclude, we presented a case study on teaching computer networks post-pandemic. Such a case study gives concrete insights for enhancing student learning experience in a post-COVID context and showcases tools and methods with proven experience and supported by empirical data. In this context, we orchestrated a shift from using remote labs to physical labs, adapted the exercises format to promote peer instructions and reflected on how to further improve active learning during lectures. We show here that despite computer networks being the very infrastructure that made remote and hybrid education feasible during the pandemic, a physical environment for labs and exercises does help to improve student learning on how networks work.

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Monitoring and supporting students in their learning – Example of a flipped online and hybrid course *

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21 October 2023

Abstract

This paper describes and evaluates an open advanced computational nuclear reactor physics course for students and professionals, offered in a flipped online and hybrid format. The preparatory phase consists of reading a handbook, watching short, pre-recorded lectures, and answering online quizzes. This is followed by a week-long set of synchronous, interactive sessions, during which the students discuss and reflect on various problems/questions and complete several hands-on assignments. Student participation, performance and satisfaction were analyzed. It is demonstrated that, thanks to the course design, high student engagement, performance and satisfaction are achieved. Significant differences in engagement and performance can nevertheless be noticed depending on whether the students participate in the synchronous activities onsite or remotely.

Sammanfattning

Den här artikeln beskriver och utvärderar en öppen, avancerad beräkningsbaserad kurs i kärnreaktorfysik för studenter och yrkesverksamma, som erbjuds i en flipped online- och hybridformat. Förberedelsefasen består av att läsa en handbok, titta på korta, förinspelade föreläsningar och besvara online quiz frågor. Detta följs av en veckolång serie av synkrona, interaktiva sessioner, under vilka studenterna diskuterar och reflekterar över olika problem/frågor och genomför flera praktiska uppgifter. Studenternas deltagande, prestation och tillfredsställelse analyserades. Det visades att högt studentengagemang, prestation och tillfredsställelse uppnås tack vare kursens utformning. Signifikanta skillnader i engagemang och prestation kan dock märkas beroende på om studenterna deltar i de synkrona aktiviteterna på plats eller på distans.

Keywords: *flipped classroom; active learning; hybrid teaching; online learning.*

1 Introduction

Advanced courses outside the regular curriculum or for professionals are often given as intensive "workshops" or "summer courses". Limited to very few onsite students, the condensed, on-site format of such courses often focuses on traditional lecturing. The high pace of the courses and the limited use of active learning techniques result in poor student participation and engagement, and thus in poor learning. Online and hybrid learning environments eventually provide more accessibility and flexibility, but are often characterized by low engagement and high drop-out rates (Eriksson et al., 2017).

*Presented at Chalmers Conference on Teaching and Learning 2023, KUL2023

Thus, there is an ongoing need to share and evaluate learning designs – in particular hybrid set-ups – that attempt to mitigate the weaknesses of online and traditional courses and foster their strengths. In the Horizon 2020 GRE@T-PIONEeR project (https://great-pioneer.eu), several advanced courses in computational nuclear reactor physics are offered as flipped online and hybrid courses. The course design mainly builds on the extensive literature about active learning (Freeman et al., 2014) and the flipped classroom approach (Stöhr & Adawi, 2018). Drawing on constructivist and social-constructivist perspectives on learning, the flipped classroom concept emphasizes the role of active learning as a better means to construct knowledge compared to traditional lecturing (Poh et al., 2010) and the importance of scaffolding by teachers and peers. Learners are typically encouraged to watch video lectures or read texts as preparation for class, and classroom time is dedicated to more active forms of learning, such as peer instruction or collaborative problem solving (Stöhr & Adawi, 2018). The flipped (or inverted) classroom method has been subject to extensive research with review papers published (e.g., Bishop & Verleger, 2013; O'Flaherty & Phillips, 2015; Karabulut-Ilgu et al., 2018) summarizing existing evidence of its effectiveness for learning, its benefits and challenges for both teachers and students.

In this paper, we aim to contribute to this field by evaluating one of the developed courses. The course, titled "Core modelling for core design", was simultaneously offered as an online course and a hybrid course. Our research questions are:

(1) What are the overall results and differences between the online and hybrid learning paths in the flipped course in terms of student activity and performance?
(2) How satisfied are participants with the flipped course design?

The course is based on the continuous development and assessment of different pilot courses by the authors during the last years (see, e.g., Demazière, 2020; Stöhr et al., 2020). The asynchronous learning phase of four weeks consists of reading a set of handbooks, watching short, pre-recorded lectures, and answering online quizzes. In case participants complete a sufficient fraction of the preparatory work, they are admitted to a week-long set of interactive synchronous sessions that they can attend on-site or remotely and that consist of both individual and group work. The work mostly revolves around answering quizzes, discussing various problems/questions and working on different assignments. Support from the teachers is offered during both the asynchronous and synchronous phases. When opting for remote attendance, the course is thus a 100% online course. In the case of onsite attendance to the interactive synchronous sessions, the course is hybrid.

2 Methodology

The asynchronous (online) learning phase took place between November 25, 2022, and January 8, 2023 (exceeding four weeks because of the Christmas holidays). The synchronous (online and onsite) learning phase took place between January 9 and 13, 2023. Four extra weeks were also given to the participants to complete the synchronous activities.

In terms of course set-up, the following measures were implemented:

- To be accepted to the synchronous sessions, the participants should have watched at least 50% of the pre-recorded videos and taken at least 50% of the online quizzes.
- To obtain a course certificate, the participants should have got at least 50 points (out of 100 possible points).

All activities undertaken by the students were monitored through a Moodle-based Learning Management System (LMS) and were used for grading, during both the asynchronous learning phase and the synchronous interactive phase. The points were associated with the asynchronous quizzes (with a weight of 25% to the total number of points) and all synchronous activities (with a weight of 75% to the total number of points). Most of the points were automatically assigned by the LMS, whereas some activities required manual grading.

The paper adopts a quantitative course evaluation approach. The learning analytics data (see, e.g., Ferguson, 2012) generated by the LMS were the basis to conduct analyses of activity completion (the extent to what learners engaged in the activities) and performance (the extend to what the results of the learning activities was correct). Moreover, a course evaluation survey (see, e.g., Marsh, 1987) was distributed among students gather learner reactions to the course set-up containing six statements about learner satisfaction with a 5-point Likert scale and two open questions, where participants named with up to three things they liked and disliked about the course and which were analyzed thematically.

3 Results

Out of 59 applications received to attend the course, six were discarded, as the upper limit for each course was set to ca. 50 participants. 12 participants had chosen an onsite participation to the synchronous sessions, the remaining 41 opted for the full online version of the course. Out of those 53 accepted applications, 31 participants qualified for the synchronous sessions (12 onsite and 19 online). An analysis of the student participation, performance and satisfaction is presented below in an aggregated manner.

3.1 Analysis of student participation

Student participation was measured via the completion rate on the asynchronous elements (videos and asynchronous quizzes) and on the synchronous elements (synchronous quizzes and all other synchronous activities) – see Tab. 1. In this Table and the following ones, the results are presented separately for the student who chose the synchronous onsite option (12 students) or the online option (41 students). Furthermore, for the online option, the students were differentiated depending on whether they qualified for the synchronous sessions (19 students) or not (22 students) (see the course description in section 2).

Table 1: Mean values of the completion rates [in %] on the asynchronous and synchronous elements (with standard deviations given in parenthesis).

	Asynchronous activities		*Synchronous* activities	
	Videos	Quizzes	Quizzes	Activities other than quizzes
Students who chose the *onsite* synchronous attendance (12 students)	91.4% (±16.3%)	80.7% (±29.2%)	99.2% (±2.9%)	86.7% (±11.9%)
Students who chose the *online* synchronous attendance and *qualified* for it (19 students)	93.5% (±12.4%)	90.6% (±13.1%)	82.1% (±26.8%)	58.6% (±26.5%)
Students who chose the *online* synchronous attendance and *did not qualify* for it (22 students)	16.5% (±28.9%)	2.1% (±6.8%)	Did not qualify	Did not qualify

As Tab. 1. demonstrates, a high completion rate on the asynchronous elements for the onsite and online qualifying students can be noticed, with even the online cohort slightly outperforming the onsite. On the other hand, the online participants who did not qualify had a very low completion rate, explaining why they were not accepted to the synchronous activities. For the synchronous elements, the onsite students were significantly more engaged than the online qualifying students. The difference between those two cohorts is even more significant for the synchronous activities other than the quizzes.

3.2 Analysis of student performance

Student performance is reported in Tab. 2. It is measured by the average value of the grades for each of the categories of graded activities (irrespective of whether those activities were taken or not). The final grade is also reported in this Table. The final grade was estimated with a relative weight of 25% on the asynchronous quizzes and a relative weight of 75% on all synchronous activities.

Table 2: Mean values of the grades on the asynchronous and synchronous elements (with standard deviations given in parenthesis). All data were renormalized to 100 points representing the maximum number of points on each of the categories of the activities.

	Asynchronous activities	*Synchronous* activities		Final grade
	Quizzes	Quizzes	Activities other than quizzes	
Students who chose the *onsite* synchronous attendance (12 students)	76.5 (±16.5)	79.4 (±11.3)	61.3 (±11.6)	76.2 (±8.9)
Students who chose the *online* synchronous attendance and *qualified* for it (19 students)	72.4 (±16.1)	44.9 (±22.7)	44.2 (±17.5)	55.7 (±10.6)
Students who chose the *online* synchronous attendance and *did not qualify* for it (22 students)	1.4 (±3.9)	Did not qualify	Did not qualify	Did not qualify

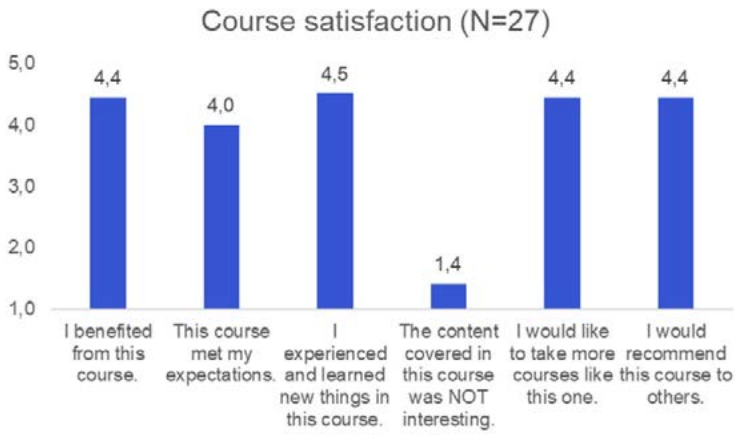
As shown in Tab. 2, whereas the success rate on the asynchronous elements does not differ between the onsite and the online qualifying students, the onsite students perform much better on the synchronous activities than the online ones. As activities that were not taken were also counted in the grades, the lower grades on the asynchronous elements for the online qualifying participants is also the result of a significantly lower participation on the synchronous activities other than the quizzes – see Tab. 1.

Nevertheless, most of the online qualifying participants (17 out of 19) got a grade larger than 50 points and thus passed the course, whereas all onsite participants (12) passed the course. The lower grades for the online qualifying participants are considered to be attributed to the LMS providing immediate update on the grades when an activity is completed. As it is believed that the online participants combine their synchronous participation with other duties (job, other studies, family, etc.), they most likely tend to simply pass the course, i.e., to get a grade of just 50 points. The onsite participants, on the other hand, by the nature of their onsite attendance, are more dedicated to the synchronous activities.

3.3 Analysis of the student satisfaction

As illustrated in Fig. 1, participants expressed very high satisfaction with the course on all items used in the course evaluation. All positively formulated statements reached an average agreement of 4 or more on a 5-point Likert scale, supplemented by the negative statement that had high disagreement (1.4).

Figure 1: Mean values of agreement with statements regarding course satisfaction (1…strongly disagree 5…strongly agree).



The thematic analysis of the participants answers to the open questions about what they liked and disliked about the course is presented in Tab. 3. Among the positive aspects of the course, the active learning activities and other course materials were particularly often mentioned, as evidenced through comments like:

"The self-learning activities were great. All the handbook parts, videos and quizes brought lots of information and helped me to learn."

This was followed by the quality of the instructors and the course structure and organization, but the importance of interactions and support was also stressed in statements like:

"Everybody (teachers and students) was eager to help when it was needed."

Among the negative aspects, participants were especially concerned about the amount of content that was covered in a relatively short period of time. Further, technical issues during the first run of the course were also often raised as an issue.

Table 3: Thematic analysis of course participants' answers to the questions about things they liked and disliked about the course (*N*=27, numbers in brackets indicate number of participants mentioning this theme).

Participants liked	*Participants did not like*
Practical Exercises / Tools / Codes / Software (16)	Time Constraints and Pace (17)
Course Materials / Handbooks / Slides / Sources (11)	Content and Instruction (13)
Well-explained Topics / Quality of Teachers (9)	Technical Issues and Software (11)
Organization / Course Structure / Preparation (9)	Course Structure (6)
Networking / Interactions with Students and Professionals (6)	Workload and Assignments (5)

Inclusive Atmosphere / Support from Teachers and Students (5)	Course Format and Recommendations (4)
Flipped Classroom / Teaching Methods (3)	Instructor-related Issues (3)
Flexibility / Pace / Online Learning (2)	
Real-world Applications / Industry Relevance (2)	
Multidisciplinary / Diverse Backgrounds (2)	

4 Discussion and Conclusions

Our results demonstrate that the flipped course, provided both as online and hybrid, has been successful in terms of participation, engagement, completion rates and learner satisfaction. An overwhelming large fraction of the participants who completed the preparatory work and were actively participating in the synchronous sessions successfully passed the course (100% for the onsite attendees and 89% for the online qualifying attendees). As result of the thematic analysis, we attribute this to the many activities and continuous formative feedback the participants received, so that they were able to understand their mistakes, learn from those, and successfully complete the various assignments. This was achieved by course design, as the asynchronous work followed by the synchronous quizzes gradually prepared the students for the more involved activities. Those activities also represented the core of the interactive sessions and, correspondingly, a large fraction of the graded activities. The successful completion of those activities was made possible via close supervision from the teachers of both the onsite and online students. Interactions between students and teachers occurred during the entire duration of the course, both during the asynchronous and the synchronous phases, through the various interaction channels that were implemented (chats, forums, messaging, quizzes with instant feedback, active quizzes, discussions, coding assignments, input deck writing and audio/video interactions). The continuous feedback the students receive on all learning activities through the LMS, beyond their formative nature, also allow the students to see their progression towards passing the course, adding an extra ingredient for motivating them to complete the tasks. This is clearly visible for the online students especially, as they work hard to obtain the necessary 50 points to pass the course. Thus, this study confirms the advocated learning benefits of the flipped classroom method and the online/hybrid learning design provided broader access for learners compared to traditional in-class teaching while keeping a high retention.

However, there were significant differences between onsite and online participants, indicating that online learners adopted a more strategic learning approach to keep up with the course content. Additionally, we saw from the thematic analysis that the high workload of the course may have made it challenging for learners to balance it with other duties. Thus, the proposed course format is best suited for learners who are mature enough to take responsibility for their learning, i.e., students at the master level and above with well-developed self-regulated learning skills (Stöhr et al., 2020).

Based on the positive outcomes observed in the course, we plan to reoffer the course during the next academic year, with potential modifications to better support the needs of online learners. For example, apart from eliminating the technical issues of the first run, additional scaffolding could be provided to help learners regulate their learning despite a high workload.

5 Acknowledgements

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Does a flipped classroom approach help? – Experiences from a project-based engineering course *

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Abstract

Many project-based courses start with theoretical background lectures. However, the application of this knowledge in the students' projects is often limited. This paper explores the research question: Does a flipped classroom approach improve the connection between theoretical lectures and the practical project? The method consists of converting four conventional lectures into a flipped classroom approach and posing surveys to the students. Furthermore, the teachers reflect on the outcomes in comparison to previous years. The results show that the exercises after the pre-recorded flipped lectures are appreciated by the students. However, the quality of their final project reports and observations during supervision meetings do not show clear results. As the project was carried out in 2021 during the pandemic, the results might be overshadowed by the impact of the remote teaching situation. Finally, the continued work on the flipped classroom approach led to high quality reports and improved course evaluations in 2023.

Sammanfattning

Många projektbaserade kurser börjar med teoretiska bakgrundsföreläsningar. Tillämpningen av dessa kunskaper i studenternas projekt är dock ofta begränsad. I den här uppsatsen undersöks forskningsfrågan: Förbättrar en flippad klassrumsmetod kopplingen mellan teoretiska föreläsningar och det praktiska projektet? Metoden består av att omvandla fyra konventionella föreläsningar till en flippad klassrumsmetod. Utvärdering görs med hjälp av enkäter till studenterna. Dessutom reflekterar lärarna över resultaten i jämförelse med tidigare år. Resultaten visar att övningarna efter de förinspelade flippade föreläsningarna uppskattas av studenterna. Kvaliteten på deras slutliga projektrapporter och observationer under handledningsmötena visar dock inga tydliga resultat. Eftersom projektet genomfördes 2021 under pandemin kan resultaten överskuggas av effekterna av den avlägsna undervisningssituationen. Det fortsatta arbetet med flippad klassrumsmetoden ledde till högkvalitativa rapporter och förbättrade kursutvärderingar i 2023.

Keywords: *flipped classroom; project-based learning; life cycle engineering; pedagogical project.*

1 Introduction

Project-based courses have been gaining popularity with the aim to address engineering megatrends, such as education for sustainability (Sukackė et al., 2022). Project work has been an important part in teaching life cycle engineering at many different universities (Viere et al., 2021). The course Life Cycle Engineering (BOM250) at the Department of Architecture and Civil Engineering (ACE) also uses a project-based learning approach. The

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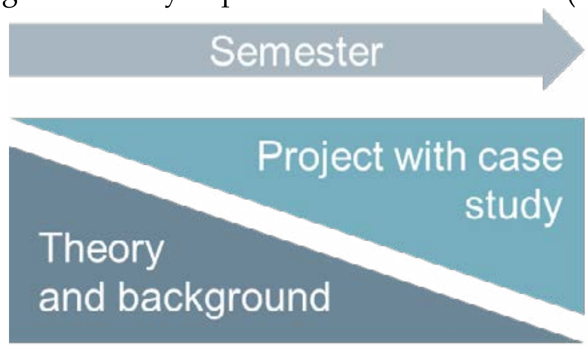
course has been taught for eight years and about 50 civil engineering students on the master level take the course every year. The main task is to calculate the environmental impact of a building or an infrastructure project, e.g. a bridge, using LCA. This project work is conducted in groups of four to five students and the written project report makes up 50% of the final grade. The rest the course consists of lectures on the theory needed for the project, software tutorials, and of small exercises. The exam at the end of the course makes up the other 50% of the grade.

As in most LCA course for engineers (Cosme et al., 2019; Mälkki & Alanne, 2017; Viere et al., 2021), the emphasis slowly shifts from the theoretical background towards the practical case study throughout the semester (see Figure 1). The problem is that not all students are able to apply the theoretical background presented in the lectures during the project. There seems to be a gap, which can be noticed in supervision meetings when teachers are asked to explain basic concepts again. Furthermore, in the written reports misunderstandings of the theories can be noticed.

Figure 1: Shifting from theory to practice over the semester (Cosme et al., 2019)



The aim of this project is to test if the use of a flipped classroom approach for teaching the theoretical background can improve the connection to the project phase. The main research question (RQ) is: Does a flipped classroom approach improve the connection between theoretical lectures and the practical project?

This question can be further divided into:

> RQ1: Does the availability of short videos on specific aspects of LCA support students in using information from the lectures in the project?
>
> RQ2: Which exercises given to the students after watching the videos are suited to support them in remembering and applying the theoretical aspects?

The results presented in this article are based on a pedagogical project carried in the beginning of 2021 during the pandemic. The discussion also reflects on the continued development until 2023.

2 Background

The building and construction sector is responsible for about 40% of global greenhouse gas emissions and 50% of the resource demand. Therefore, future architects and civil engineers have the potential and responsibility to contribute to the environment. Life Cycle Assessment (LCA) is a method of assessing the environmental impacts related to the manufacture and use of a product or a service. According to Burnley et al. (2019), LCA is an effective way of encouraging engineering students to develop and apply a wide range of transferable skills. Mälkki & Alanne (2017) provide an overview of published LCA studies in education including the teaching and learning methods. Most of them include lectures, a project, and group work. In a recent paper, Viere et al. (2021) analyse twenty-eight studies published on the experience on teaching LCA in higher education and conclude that project work is very common and an important element of teaching LCA.

Project-based learning (PjBL) is a systematic teaching and learning method, which engages students in complex, real-world tasks that result in a product or presentation to an audience (Chen & Yang, 2019). The aim of PjBL is to support students in creating knowledge based on a given problem or challenge (Beneroso & Robinson, 2022). As such, it follow a constructivist (Hein, 1991; Yilmaz, 2008) education approach. According to a meta review by Chen & Yang (2019), PjBL has a medium to large positive effect on students' academic achievement compared with traditional lectures. Guo et al. (2020) review the reported results in the literature more specifically for different subjects in higher education and argue that more evaluation studies are needed. Nevertheless, they recommend more educators to adopt PjBL because it promotes students' innovation competence and supporting their autonomy during learning tasks.

When teaching LCA for engineering students, the project is usually to conduct an LCA of a typical product and present the results to a hypothetical client. In the course BOM250, the students can choose between an apartment building and a bridge. The teachers in the course facilitate the project in supervision meetings by asking and answering students' questions. In addition, the lectures at the beginning of the course provide the foundation to start the project group work. Furthermore, software tutorials support students to learn the LCA software needed to carry out the case study in the project. Cosme et al. (2019) describe the benefits of using this three-fold approach of theory, software, and project for teaching LCA. While they describe the case studies and the different software used in detail, the information on the lectures is limited. There is a lack of information on strategies to link the lectures on the theoretical background knowledge with the project.

In a flipped classroom, the traditional in-class instructional time and out-of-class practicing time is switched (Lage et al. 2000). The information transmission component is moved out of class time. Students prepare for class by individually engaging with resources, such as videos or texts that cover the content of the traditional lecture. The intention is to free face-to-face time for creating meaningful learning situations for in-class interaction between students and teachers (Lundin et al. 2018).

Castedo et al. (2019) compared a student group of an engineering bachelor program using a flipped-classroom methodology with a group taught with traditional lectures. According to their results, the flipped-classroom methodology has a direct impact on student learning (or grades), especially for students with a high degree of involvement. One reason could be that from a cognitive load perspective, self-paced preparatory work might better manage working memory than traditional lectures (Clark, Nguyen, & Sweller, 2005).

However, the flipped classroom approach also comes with challenges (Akçayır & Akçayır, 2018), such as additional time for teachers to prepare videos, insufficient video quality or students fail to schedule time for preparation. Furthermore, students tend to prefer in-person lectures to video lectures (Bishop & Verleger, 2013). Abeysekera and Dawson (2015) see potential issues of student motivation as flipped classroom approaches wager the success of in-class activities on the likelihood of students completing their pre-class assigned work. According to the authors, this leads to the perennial problems of student preparation: how do teachers know if students have prepared, what they know and if the preparation was useful?

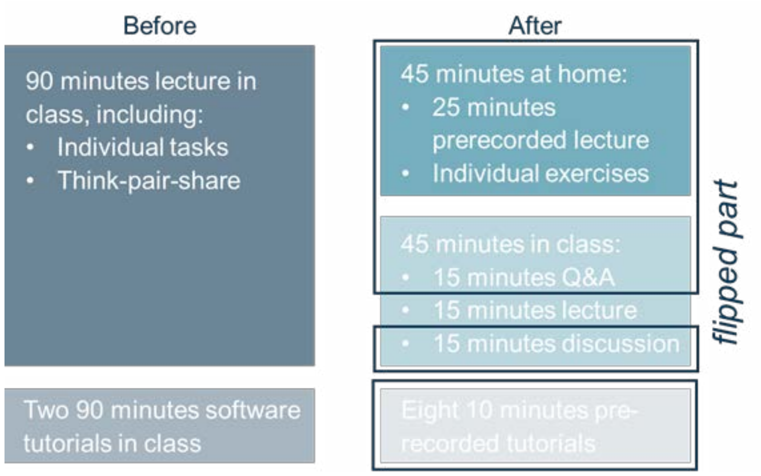
3 Methodology

New course structure

The overall course structure followed the one of the previous years. After two general introductory lectures a lecture on LCA was given online to introduce the four steps of LCA. Each of the steps was covered in detail in four consecutive partially pre-recorded lectures. The original 90 minutes lecture were split in half (see Figure 2). The first half was covered by a pre-recorded video with an average length of 25 minutes and a small exercise afterwards. The exercises were intended to prepare the students to fully benefit from in-class work. The students could choose, if they watched the video and completed the exercise during the scheduled lecture time or beforehand. This was mainly to avoid that the students feel like they had to work more, which is mentioned by Alebrahim and Ku (2020) as one reason to potential students' resistance towards a flipped classroom approach. The pre-recorded lectures were uploaded three days in advance. The second part of the lecture started by answering students' questions and summarizing the results from the exercises. A presentation on the theory not covered in the pre-recorded video followed, which usually took about 15 minutes. In the remaining 15 minutes, the students discussed questions covering both parts of the lecture and the application of the content to their project in breakout rooms. This allowed for social interactions between the students.

In addition, software tutorials that were previously given live in a computer room where pre-recorded. The students were asked to voluntarily upload screenshots of the final results after completing each of the tutorials so that the teachers could check if it was carried out correctly. There were no consequences if students did not complete a tutorial.

Figure 2: Structure before and after introducing a partially flipped classroom



Exercises

For each lecture, small online exercises were developed that allowed the students to repeat and apply the content. Those exercises were voluntary and there were no consequences if they were not completed. To answer RQ2, the form of the exercise varied (see Table 1). Exercises 3 and 4 were based on individual quizzes to be filled out right after the lecture aiming at remembering – the *Knowledge* step of Bloom's taxonomy (Bloom et al., 1956). The students received the feedback about the correct answers immediately afterwards through the computer. As such, a behaviouristic learning theory was followed (Mödritscher, 2006). Exercises 1 and 2 consisted in applying an important aspect of the pre-recorded lecture to another example. As such, they aimed at the *Application* step in Bloom's taxonomy and followed a constructivist learning theory. Exercise 1 had a social component, because students were asked to write their answer in a discussion forum and comment on at least one answer of another student. As such, the students provided and received formative feedback from each other.

Table 1: Overview of lectures and exercises

Lecture	Exercise	Exercise format	Learning theory
1 Goal and scope	Define a functional unit	Discussion in forum	(Social) Constructivism
2 LCI	Draw a flow chart	Apply to another example	Constructivism
3 LCIA	Quiz	Multiple choice quiz for repetition	Behaviourism
4 Interpretation	Quiz	Multiple choice quiz for repetition	Behaviourism

Means of evaluation

According to Abeysekera and Dawson (2015), a difficulty of the flipped classroom is the question how teachers know if students have prepared and if the preparation was useful. To answer RQ1, it was focused at a) comparing the quality of the final reports to previous years and b) observations during the supervision meetings. The level of questions received during the supervision meeting usually provide an indicator for the level of understanding of the students.

To gather data for RQ2, the students were asked to fill out a small anonymous online survey to rate the usefulness of the different exercises during the course on a scale from 0 – not useful to 3 - very useful. In addition, the supervision meetings were used to check if questions are posed that have been answered during the exercises. As the final exam grades are anonymous, it was not possible to use those to compare the grades of students who completed the exercises with those that did not.

4 Results

Online survey on exercises

The results from the online survey are shown in Table 2. On average 89% of the students completed the exercises. However, only 57% of the 49 students were also present in the second part of the lecture and answered the poll. In general, the students seem to have found the exercises useful. The results do not indicate that the exercises using a behaviourist approach (Exercises 3 and 4) were preferred over the constructivist exercises (Exercises 1 and 2) and vice versa.

Table 2: Survey results (response rate refers to the percentage of students that attended the lecture afterwards and answered the poll)

Exercise	Completion rate	Response rate	Not useful (0 points)	Less useful (1 point)	Quite useful (2 points)	Very useful (3 points)	Average points
1 Goal and scope	90%	49%	0%	4%	88%	17%	2.3
2 LCI	88%	65%	3%	9%	63%	25%	2.1
3 LCIA	96%	71%	0%	3%	57%	40%	2.4
4 Interpretation	82%	43%	0%	5%	62%	29%	2.1
Average	**89%**	**57%**	**1%**	**5%**	**67%**	**28%**	

Teachers' observations

Two supervision meetings were held with all student groups by the examiner and me. In general, the questions received during these meetings seemed to be on the same or a lower level than last year. Based on the observations during the first supervising meeting, Exercise 1 did not support in understanding the concept of a functional unit. One reason might be that the formative feedback between the students and the teacher's brief discussion of wrong answers was not sufficient. Direct comments from the teachers in the discussion forum to explain wrong assumptions might have helped. Exercise 2 of drawing a flow chart seemed to have worked better as a support because many groups used them as a basis for the discussions within the group.

Written reports

According to the examiner who has been involved in the course for the last eight years, the written reports had the same quality as the last years on average. No group failed the group work during this year, which has happened before.

5 Discussion and Conclusions

Reflections on the research questions

In general, the students seemed to have appreciated the small exercises. Considering that these were voluntary, an average completion rate of 89% seems to be very high. However, only 57% answered the survey on average. Based on this feedback, the answer to RQ1 can be assumed to be yes. However, the results from the observations and questions received during the supervision meetings and also the quality of the final reports do not give any indications that the availability of short videos did support students in using information from the lectures in their projects.

The survey did not show any clear preference towards one type of exercise and therefore no clear answer to RQ2. The results can be interpreted in such a way that all exercises were equally suited. In the author's opinion, the two exercises following the constructive theory and using examples closely related to the final project supported the application better and are more important than testing memorizing the lecture content in quizzes.

In an attempt to interpret these results, it has to be considered that only flipping parts of the original lecture content (50-80% out of a conventional 90-minute lecture) did not free as much time in class for teacher-student or student-student interaction. A fully flipped approach might have shown different results. Nevertheless, the flipping freed some time for discussions between the students in breakout rooms to increase social interaction. This seems to have been an important aspect in the remote teaching phase during the pandemic. However, it was not reflected in the evaluation for this study.

The response rate to the survey was limited. It could be assumed that the students who in general are more interested in the topic are the once that filled out the survey - therefore leading towards a positive bias in the evaluation. Furthermore, the teachers' observations did not follow a specific method or protocol. The author informally discussed with one other teacher. As such, the evaluation of the reports is subjective.

Finally, the teachers observed that the remote working situation hindered the group work in general. For example, students in one group still did not know all their group members' names two months into the course. This probably had the biggest impact on the quality of the group work making it difficult to compare with previous years.

Reflections three years later

Three years after the first implementation of the flipped classroom approach and back to on-site courses as before the pandemic, the same approach is still used. The more complex constructive exercises were moved to the time in class and replaced by multiple-choice quizzes at home with automatic correction following the behaviourist theory, an approach also recommended by Bishop and Verleger (2013). The students seemed to appreciate the quizzes very much according to the course evaluation done at the end of the semester. In the course evaluation, many students highlighted the value of the pre-recorded lectures for exam preparation while a few mentioned they would prefer conventional lectures in class. The pre-recorded software tutorials provided the biggest benefits in the first year. In a final poll, 92% of the students preferred the pre-recorded tutorials over live tutorials. Since then, the software tutorials were further extended, and they were highly appreciated again in 2023. Compared to the previous years, both the quality of the final reports and also students' rating of the course in the evaluation has increased in 2023. The rating for the overall impression of the course reached an average of 4.3 in 2023 compared to 3.9 in 2022 and 2021. This can be interpreted as indication that working with this course in the pedagogical project and continuing to work on it afterwards has finally improved its quality.

Outlook

With the increasing interest on the industry in LCA, the course Life Cycle Engineering is likely to continue in the future. The number of students can be expected to rise. This will pose challenges in grading written reports but further highlight the benefits of pre-recorded software tutorials and automated quizzes. The plan is to increase the number of quizzes to allow teachers to get more insights into the student preparation in an efficient way, which according to Abeysekera and Dawson (2015) is a core challenge in a flipped classroom approach. After three years, it is time to update and probably re-record the lectures entirely. This provides the opportunity to completely flip the four lectures. Furthermore, the time schedule will be adapted to better fit the flipped classroom approach. The remaining four lectures in the course will remain in the conventional format.

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Group assignments improve an online course *

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Abstract

We study the effects of a set of group assignments in an introductory mathematics course taught online. An analysis of the assignments that students turned in, of peer reviews and of answers to a questionnaire about the students' experiences with the group assignments shows that the aims that the instructors had set for the assignments were fulfilled to a great extent. More specifically, the students appreciated social contact, they felt that they learned meaningful course content, and the socio-mathematical norms promoted in the assignments, where discussion and communication are rewarded, were accepted by the students. The answers also indicate frustration towards peers who are not participating actively, difficulties discussing material without having time to process it alone first, and difficulties communicating mathematics online.

Sammanfattning

Vi studerar införandet av gruppuppgifter i en inledande matematikkurs på distans. En analys av inlämnade uppgifter och kamratrespons samt av svar på en enkät om studenternas upplevelse av grupparbetet visar att de mål som lärarna hade för uppgifterna uppfylldes i stor utsträckning. Analysen visar att studenterna uppskattade den sociala kontakten, att de kände att de lärde sig meningsfullt kursinnehåll och att de sociomatematiska normer som uppmuntras i uppgifterna, där diskussion och kommunikation premieras, accepterades av studenterna. Svaren rör också frustration gentemot kurskamrater som inte deltar aktivt, svårigheter med att diskutera material som man inte hunnit bearbeta själv och svårigheter med att kommunicera matematik online.

Keywords: *group assignments; online teaching; mathematical discussion; socio-mathematical norms.*

1 Introduction

In this paper, we analyze the impact of a series of group assignments in mathematics, given in an online precalculus course. The goals of the assignments, besides working on course content, were to establish contact between students, to encourage mathematical discussion, and to support students transitioning into university studies by acquiring new ways to work with mathematics.

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1.1 Socio-mathematical norms

The construct of socio-mathematical norm, as developed by Erna Yackel and Paul Cobb, originates in a sociological perspective on mathematical activity (Yackel & Cobb, 1996). It describes expectations that steer what students and teachers in a specific context consider to be mathematical work, worthwhile questions, valid answers, or quality in argumentation. Norms differ at different school levels and we expected students coming from secondary school to think of mathematics as computing, to expect that any problem can be solved within a few minutes, to judge that a good solution is one that matches an answer at the back of the book, and to underplay the role of communication. Introducing norms for university mathematics, we wanted them to recognize both computing, reasoning and communicating as valuable mathematical activities, to work on problems together and to see reflection and representation of mathematics as important work.

1.2 Group work in education

Earlier studies have shown that students benefit from group work, developing both collaboration skills and academic knowledge (Hammar Chiriac, 2014). Group work encourages the students to share ideas, explain and clarify, and together students can construct new knowledge. The students' perception of group work relates to both the task and social aspects. Studies have found that group work improved individual problem solving skills and that discussing ideas with others improved self confidence and developed social skills (Clohessy & Johnson, 2017). Hansen (2006) points out that for successful group work, it is important to have clear goals and a clear role distinction among the group members. Non-active students (free-riders) have a negative impact on the students' perception of group work (Hammar Chiriac, 2014; Hansen, 2006). One documented strategy for group work, Process-Oriented Guided Inquiry Learning (Moog & Spencer, 2008), emphasizes teamwork, communication and problem solving by giving students functional roles such as Questioner, Moderator, Illustrator, or Connector. The roles can be formulated differently, the important aspect being that each participant contributes meaningfully.

1.3 Research questions

In order to study to what extent our goals of contact, mathematical discussions and transitioning to university mathematics were met, we formulated two more specific research questions:

- What difficulties and benefits did students experience in relation to the group assignments?
- What views of socio-mathematical norms do students exhibit in their reports?

Few research studies consider online group work. This study brings new knowledge on how online group work can contribute to developing socio-mathematical norms.

2 Methodology

2.1 The assignments

The project was carried out in an online section of the technical foundation year (Tekniskt Basår), which prepares students for engineering programs. Group work sessions were held once a week throughout the 7-week course in the video meeting platform Zoom. After a lecture and a problem session, three hours were scheduled for group work on the same topic. The assignments consisted of open problems and discussion questions. For instance, one assignment was to discuss what it means to simplify a mathematical expression and decide which expressions are simplest in different contexts. In another assignment, students created a grading template and graded some made-up student solutions to a proposed exam question. Groups of four or five students were formed each week, based on presence at the session. The format was inspired by Process-Oriented Guided Inquiry Learning, with instructions for roles and the group process described in detail to form a routine, and to help students focus on discussing the content more than the form. The group assignments were optional and offered bonus points towards the exam. After each session, groups handed in a summary of their results and of what they had learned from the discussion. Each student then read two other groups' reports and wrote peer feedback. For economic reasons, the teacher read the reports only superficially, without grading or offering feedback.

2.2 Data and analysis

After the course, the students were asked to answer an anonymous survey about the group assignments. Our data consists of assignment reports and peer feedback for Fall 2022, as well as free-text answers from the surveys for Fall 2021 and Fall 2022 for the following items: "Comments on participation", "Comments on setup", "Comments on assignments", "Comments in general". Participation in group assignments during Fall 2022 ranged from 47 students the first week to 34 the last week. In total, 54 of 78 registered students participated at least once. The 2022 survey was answered by 28 of the 78 registered students, of whom 25 had participated in at least 6 group assignments. The 2021 survey was answered by 46 of 174 registered students in the course and 38 of these had participated at least 6 times.

To analyze the survey data, we used an inductive, qualitative content analysis (Elo & Kyngäs, 2008). The data was coded to reflect the main themes of each of the students' comments. Then similar answers were grouped into categories that emerged from the list of main themes. Assignment reports and peer feedback were scanned for comments revealing socio-mathematical norms, which we found in most of the weekly reports from each group.

3 Results

3.1 Student perception of the assignments

Survey answers fell into three main categories – organization, social interactions, and assignment content.

Some students write that group work was time consuming, discussions took too long and the group assignments were too frequent. Many students state that they could not contribute, because they had little time to prepare and think about the new material since the lecture. Students mention bonus points as an important motivation to participate. Some students found the roles unnecessary, and at the end of the course, some groups did not use them. They also mention that it was hard to write the report and at the same time focus on participating in the discussion and that they had difficulties with group discussions online and writing mathematics on Zoom. Furthermore, students wished for intervention and feedback from the teacher. They also suggest that requirements be enforced by the teacher, preventing reports of low quality from giving bonus points.

Generally, the students are positive about contact with other students, especially in a distance course, although one student comments that it is not the university's responsibility to provide students with social relationships. Students mention several social aspects of the learning process, e.g. "cooperating makes me more engaged", "interesting to see how others were thinking", "the discussions made us think through the subject more deeply", "relieving to see that I was not the only one who was unsure about a concept". Several students mention differences in group dynamics: "How interesting the exercise was depended on the group, if the group was engaged, the exercise was interesting." One student comments "if we had time to get to know each other's strengths and how we cooperate, the group work would have been smoother". The biggest problem, which many students mention, is the lack of commitment (turned off the camera, were silent, left early, etc.) by some participants.

The exercises must be chosen wisely, to give opportunities for discussion: "it is most rewarding to discuss when there are many angles to attack the problem from", "in exercises with Geogebra (a mathematical software), the discussion and the solution got better, it became clear and visual". Students also state that some exercises were hard to understand and that more help in the beginning would have been appreciated. The last assignment, which was directly connected to an exam question, was very appreciated. In the 2021 survey, students commented about peer feedback being mostly "good job!", "nice pictures!" and not very constructive. One student concluded that reviewing was the best part of the assignments, "Seeing their solutions and viewpoint on problems that I had wrestled with was really rewarding".

3.2 Socio-mathematical norms

In their group reports, the students were required to comment on what they found difficult and what they had learned. The expressed views of how they worked with the assignment indicate a wide acceptance for the type of socio-mathematical norms that we tried to instill. Most answers describe mathematical activity as learning, discussing, understanding, e.g. "We learned how different values of coefficients and constants determine how the graph looks" or "The discussion led us into the algebra formulas for squares, conjugates and cubes and how they are used to factor polynomials". The output of mathematical work here is not numerical facts that can be checked on an answer sheet, but more general forms of learning: "Something we didn't know before was that an equation with three variables is drawn like a plane in 3D", "The group got to learn an example of how Thales' theorem can be used". Comments also show openness for different methods and an appreciation for how differences can stimulate the group: "You can get to the same answer even if you use different methods", "Luckily, we had different thoughts and answers, which gave discussion and more learning", "We took a few examples to explain to each other".

4 Discussion

Online education, and in particular synchronous group work online, is relatively new. Only in the last few years has it become a common practice, and little research is available. Most results in our study are in line with the findings of studies on face-to-face group work, with the added value of coming in contact in an online context, as well as some drawbacks concerning technical challenges of video meetings, e.g. difficulties in showing mathematical thoughts to each other. The students' perception of online group work confirms the findings from earlier research on group work: comments regard both content and group-related aspects, students believe that they can learn from each other and group composition plays an important role. Students are annoyed by non-active participants in the group and bothered by timing aspects (Hammar Chiriac, 2014; Hansen, 2006).

Students of 2021 complained that most peer feedback was not instructive. We expanded the instructions in 2022 to giving constructive but nice feedback, e.g. by pointing out how the results of their own group differed. This seemed to have an effect, as more of the feedback in 2022 was productive and well thought out. This is an indication of how sensitive the results can be to details in the setup and instructions. Many students argued that the roles were superfluous, but having observed group work, both face-to-face and online, we still think that the mere existence of roles helps structure the conversations and pressure students into richer participation.

The fact that student comments are aligned with the desired socio-mathematical norms and views of mathematics does not automatically imply that the students' views have changed completely. It does, however, show a willingness to adhere to new norms in a specific context and that the assignments that we formulated gave rise to the type of attitudes and behaviors that we strove for.

The methodology followed, using both survey data, observation and student assignments, gives a composite picture, rich in details. Note, however, that in all our material, students who participated most assiduously in the group assignments are overrepresented. As is the case in many online courses, a large proportion of students were less active. Another source of data would be necessary to hear from less engaged students and understand their needs better.

5 Conclusion

Based on this study, we recommend similar learning activities in other courses, both online and on campus. All in all, group assignments are met positively by students, with high participation rates, a positive attitude towards social interactions and focus on course content as well as positive adjustments in students' expressed attitude towards mathematical work. While the content of each assignment was tightly connected to course content, the thoughts behind the choice of questions and the format for the assignments can inspire instructors in other contexts, in mathematics or other subjects, especially at the introductory level. Group assignments play a special role in online courses, as a unique opportunity for social contact, but the format also offers opportunities in face-to-face studies.

We have learned that assignments need to be carefully worded to give detailed instructions for both the group work and reporting process and easily understandable exercises, especially when the format is new to the students. The instructor should also think through how students should be rewarded for participating, to encourage participation while minimizing free-riders. Stating explicit expectations (e.g. that the students should be in an environment where they can participate fully without being distracted, and that peer feedback should be constructive) is one measure to reduce free-riding. Some teaching time should be available to help students onto the right track in discussions, but detailed reading of the assignments is not necessary.

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Stakeholder-student interactions in engineering education: involving busy experts in project-based courses *

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Abstract

Project based learning (PjBL) is increasingly used in engineering courses as a student-centred approach for designing and improving solutions for real-world problems. A key feature of PjBL is the interaction between the problem "owner" and the students who work with the given task. Previous literature documents these interactions primarily from the perspective of students and teachers, leaving us ignorant of the stakeholders' experience. Undertaken within a larger development process of creating an entirely new project-based Bachelor course at Chalmers, the aim of this study is to better understand how to work with city official as stakeholders and owners of the complex real world problems in the course. The process entailed negotiations with the city government officials, ensuring their participation and engagement in the course. Qualitative data collection provides the basis for comparing expectations of stakeholders, students, and teachers with outcomes. Three components ensured long-term stakeholder involvement: relevant projects; clear rules of engagement for student-stakeholder interaction and; a final conference where students present results to stakeholder.

Sammanfattning

Projektbaserat lärande (PjBL) används i allt högre utsträckning inom ingenjörsutbildningarna som ett studentcentrerat arbetssätt för att hitta relevanta lösningar på verkliga problem. Här undersöks interaktionen mellan tjänstemän inom Göteborg stads förvaltningar i deras professionella roll som experter och "ägare" av problem, och studenter på kandidatnivå. Interaktionen sker inom ramen för en kurs i innovation och hållbarhetsomställning där läraren sätter tydliga ramar för att säkerställa experternas deltagande och engagemang i kursen, med syfte att öka kursens kvalitet och studenternas lärande, samt en god erfarenhet för de inblandade. Studien använder kvalitativ metod för att jämföra studenters, experternas och lärarnas förväntningar med utfallet. Studien dokumenterar även experternas upplevelse av interaktionen, vilket saknas i tidigare forskning. Experternas inblandning säkerställdes genom tre komponenter: relevanta projekt, en tydlig ram för hur studenter och experter interagerar, samt en slutkonferens där studenterna presenterar sina resultat för experterna.

Keywords: *stakeholder interaction; Project Based Learning; sustainability challenges; student-led innovation.*

*Presented at Chalmers Conference on Teaching and Learning 2023, KUL2023

1 Introduction

The conference formats have different expectations and criteria, such as word limits, that must be followed. These can be found on `the website for KUL2023`. The chapters in this template are suggestions, not mandatory.

In this text follow the APA7 guidelines. For example, if the names of the authors are mentioned in the text the citation should look like Hardaker, Richardson, Lien och Schumann (2004). Otherwise it should look like (Chavas & Shi, 2015).

1 Introduction

The challenge in focus is the ambition to prepare engineering students for professional roles by introducing Project Based Learning (PjBL) with a complex real-world challenge "owned" by government stakeholders. This comes with many opportunities, but also the need to negotiate the terms of agreement. Stakeholders are very time constrained and for them to be willing to commit resources to the course, and to do so over time, we need to ensure there are values for them in doing so. Based on previous literature detailing the goals of stakeholder involvement in PjBL, the aim of the study here presented was to enhance the quality of the stakeholder involvement in a new Bachelor level course at Chalmers University of Technology, Sweden, given for the first time in 2022.

1.1 Literature and proven experience of student-stakeholder interactions in PjBL

Existing studies identify multiple constraints for successful stakeholder involvement in university education. Time constraint is a common concern. For stakeholders to be willing to commit resources to the course, and to do so over time, teachers need to ensure there are values for them in doing so. Similarly, studies suggest that we can expect negative reactions from students who get frustrated by the limited interaction and prefer real internships to limited industry interactions in a project (Lima, Mesquita, & Flores, 2014). Students also commonly experience a high work load and need to assume a role as active learners and leaders of their own projects (Mills & Treagust, 2003).

There exist some rich and detailed accounts of processes and values. Ranger and Mantzavinou (2018: 166) provides a relevant example of the use of human-centred design thinking in product development in a course at MIT, US. "Teams of students with diverse backgrounds are paired with international stakeholders and industry partners to tackle real-world prosthetic technology needs […]." The authors describe the course structure and stakeholder interaction. While the time contribution from companies is limited, they provide the "problems" for students to work on. During the course, companies offer students the possibility of a visit and are willing to offer feedback when needed. Partners were also involved as interviewees in the stage of background research. The authors do not detail the time demand and it is unclear if there were some boundaries negotiated, or if the needs-driven interaction could spill over and become a problem for industry partners.

Soares et al. (2013) and Lima et al. (2014) describe how they scaffold student-company interactions in a multi-course setup at the University of Minho, Portugal. Companies participate at the beginning of the semester and present the problems to students. They then negotiate terms of interaction with each student team and visit three times during the course period for presentations. The authors highlight challenges with students spending too much time at the companies, and a heavy coordination burden for teachers with so many actors.

Literature suggest certain values are associated with this methodology that creates a "learning environment closer to the professional practice." (Soares et al., 2013) As emphasised by Lima et al. (2014), students get to apply a combination of technical and "transversal" competences, i.e., time management, project management, inter-personal communication, and autonomy. Professional competences includes a range of abilities, but some seem to be considered generic to engineering practice (De Los Ríos-Carmenado, López, & García, 2015), no matter the specific field[1].

Specifically related to the interaction with stakeholders, the closeness to professional practice is reported to work as an important motivator for students. Students are also expected to acquire deep knowledge from the experts by working in a context where theory is put into a real context and where their soft skills and generic competences are sharpened (Lima et al., 2014). In these cases, the PjBL methodology and work with real problems aim to support creativity and initiative. In the Soares et al article, 85% of students are reported to have a positive opinion of the interaction with the company, but they expressed much more negative views of how performance was evaluated (noted as a challenge also by Alves et al. (2016)) and the level of support from teachers. Ranger and Mantzavinou (2018) do not report student evaluations but only state that the response has been overwhelmingly positive.

Taken together, the insights that inform the course setup of the stakeholder-student interaction are: the need to shape the terms of interaction through clear communication; creating rules of engagement; ensuring the relevance of projects such that stakeholders find it valuable; and ensuring that students gain new insights, knowledge and skills from their interactions with the experts. In terms of knowledge gaps, none of the articles include an evaluation of the *interaction* from the companies' perspectives, only that of students and teachers. This suggests that data collection should also aim to capture the stakeholders' experience.

1.2 Project description

The study was carried out as part of the ongoing course development process of the new bachelor course in the Global Systems program, *Innovation and sustainability transitions*. The author is the main teacher of the course. The course had an introduction phase of two weeks, followed by a six-weeks project. The course trained students in carrying out a short

[1] De Los Ríos-Carmenado et al. 2015 (p. 185) describes the generic competences as: capacity and will to learn, solid knowledge of the basic natural sciences and the deep knowledge of some technology area, besides the general human values. "Moreover, the engineer has to be prepared for permanent learning as well as being capable of communicating and team-working."

research project on how societies manage transitions in a specific sector that is facing pressures, in the face of uncertainty.

The student projects deal with the water situation for Gothenburg, with multiple stakeholders from the city of Gothenburg (Kretslopp och vatten, Miljöförvaltningen, Stadsbyggnadskontoret and Stadshuset). The stakeholders are all somehow involved in managing the city's water infrastructure in times of accelerating climate change, and they are faced with the need to manage current challenges, but also plan for a future of mounting pressures on the city's infrastructure. Decision taken today have long-term consequences and involve large societal investments, but uncertain climate change projections pose a real risk that investments turn out to be inadequate or inappropriate as preconditions change. This means that city planners and decision makers must make decisions in the face of uncertainty.

The students worked on problems identified by the teachers in dialogue with the main city stakeholders and were tasked with addressing this specific problem in the light of water resource management being a complex system and the future (100+ years) holding great uncertainty and change. Topics given were related to sea level rise, heavy rains during different seasons, drinking water quality, changes in ground water and the role of water as a resource in the city landscape. They formulated a specific, narrow problem and developed a proposal for addressing the issue.

The learning objectives of the course were formulated around key scientific concepts and the use of these in analysis and reflection around the specific water-related challenges at hand: specific approaches and methods for working with complex systems and sustainability challenges; and application of practical skills related to project management, communication, and teamwork necessary to complete a project that involves external stakeholders.

Interactions with stakeholders were set up ahead of the course in a process of negotiation, managing expectations, building trust and agreeing on objectives. The author ensured stakeholders there would be a clear rule of engagement[2] and limit to the time and work burden for city officials, who then agreed to participate. During the course period, interactions were planned and took place through guest lectures, assigned contact persons for each student group, interviews, a Q&A session and, where stakeholders agreed to it, follow up meetings. Stakeholders also joined a boat ride with students, and many attended the final conference where they gave feedback on the presented projects.

1.3 Study questions

Based on insight from the literature review, the study questions were, first, how do we scaffold the student-stakeholder interactions given the very real time constraints? Second, what are the values obtained through stakeholder interactions in PjBL seen from the

[2] Students were given the contact's details and an instruction around when and how to make contact. They were also told that they could not contact other people in the municipality before speaking to the assigned person.

perspectives of students, teachers, and stakeholders? In response to these questions and the broader aims of the course, the author formulated three objectives to achieve in the first version of the course:

Objective 1) To establish a clear agreement on roles and responsibilities, and set rules for engagement, such that we avoid conflict or that stakeholders drop out.

Objective 2) To ensure that stakeholders see value in participating and are willing to commit resources also in the future.

Objective 3) To ensure a valuable learning experience for our students in working on their projects.

2 Method

The study applies qualitative methods. Data collection involved multiple steps:

Before the course started, the author documented the expectations, set the aim and three objectives, with notes from teacher meetings, stakeholder meetings and email communication.

A literature review of journal articles and conference papers on the topic of PjBL in collaboration with industry or stakeholders in engineering education.

During the course period (September to October) we collected data on the student experience, through: the Mentimeter tool, asking for expectations they had for the course; a dialogue with student representatives; continuous interactions between students and the supervisors that also addressed stakeholder interactions; observation during final conference; and specific questions in the course survey regarding stakeholder interactions. We also documented stakeholder feedback during the course and final conference.

This process of data collection allowed for comparison between expected outcomes and actual experience. The data was analysed after the end of the course and course evaluation. The author organised the data along three dimensions – temporal (compiled before, during or after the course); actor perspective (stakeholder, teacher, or student); and research question. Within these dimensions, the abductive content analysis (Graneheim & Lundman, 2003) involved identifying recurrent themes, assessing their prevalence and then triangulating between data sets and actors for complementarity and divergence (Nightingale, 2009). While organising and summarising data in a report, the author returned to original data to double check interpretation. The students' answers in the course survey show the degree to which students agree or not around points of critique and free text comments were plenty, which helped with interpretation.

3 Results and discussion

In relationship to the three objectives explained above, all were met, but the student experience leaves room for improvement. In terms of experience, among the three groups of people involved – students, teachers, and stakeholders – the external stakeholders are most positive regarding the outcome of the course. While both students and teachers saw many areas for improvement, the stakeholder were positively surprised, possibly due to the initially low expectations stakeholders expressed ahead of the course. They did not expect to learn anything relevant from student projects but saw a chance to recruit students in the future. They stated that the rules of engagement had worked and that the work burden had been acceptable. At the final conference, the attending stakeholders expressed surprise at the quality of presentations. One of the senior engineers stated in the conference's panel discussion that the course was unique and offered a great value in that students got to experience projects of this kind already at bachelor level, something she hoped that they appreciated. Another senior engineer told the author she appreciated the new and different perspectives brought by the students.

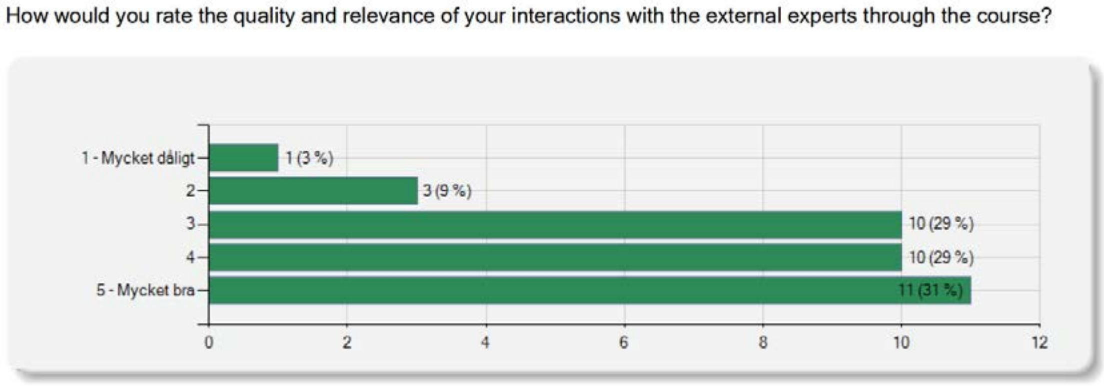
For the teacher team, there are many small changes and modifications to make. This was, however, expected for an entirely new course. Most students (68%) had a positive overall impression (based on the course survey and oral feedback) and much appreciated the chance to work with real world problems and get access to senior experts as problem "owners". A quote illustrates the positive feedback some students gave: "*The interaction/ cooperation with Gothenburg City made the issues we were working on feel important and it was nice to feel like we actually could contribute.*"

However, one third of the students who answered the survey express an overall negative impression of the course (similar to the result found in (Soares et al., 2013)). Although that is due to other factors than the project and stakeholder interactions (e.g. finding the work load too high, having complaints around schedule, type of assignments or the grading scheme) there's a small group of students who clearly did not enjoy the project format or the interaction with stakeholders. Based on analysing written comments, considering previous literature and follow up conversations with the student representatives and program director, we may understand this as being overwhelmed and unprepared for a course that is demanding and unconventional, and that requires skills some or most students lack as these (e.g. project management and team communication) had not been practiced in any previous course in the program. As one student wrote: "*My group has been incredibly confused during the entire course. We didn't understand what to do or what we were doing (…) we were SO confused*". Some groups experienced challenges with experts who did not have time for them. This was expected based on insights from literature (Lima et al., 2014), but it was not foreseen that some experts' profile would be a poor match.

The course survey (Figure 1) result shows a largely positive experience of interactions with experts. In the final course evaluation meeting, the four student representatives also expressed that this interaction provided a unique value and experience that really helped prepare them for professional life. However, for a few (four) students, the interaction with experts was a largely negative experience, which shows in figure 1 where "1-mycket dåligt", means that they rate the interaction as very bad.

Figure 1. Student answers to course survey question about stakeholder interactions.

17. How would you rate the quality and relevance of your interactions with the external experts through the course?



	Mean	Median
How would you rate the quality and relevance of your interactions with the external experts through the course?	3.8	4.0

Encountering the professional realm – where there is no culture of sugar-coating feedback on unfinished ideas – creates somewhat a chock for some of the students who lack such exposure. A couple of groups felt discouraged by experts not supporting their proposed solutions. Some students were frustrated when experts gave different feedback. A student quote illustrates this emotional response to critical questions and comments: *"I felt like the persons from Göteborg Stad [did]not contribute very much in the final conference. They came with bad energy and only gave negative feedback to our projects. However, it was very fun to listen to other group's presentations!"*

A key strategy is to further clarify and communicate the rules of engagement, but also prepare students mentally for the encounter with the professional world. We need to clarify the skillset we think they will develop, rather than possess ahead of the course, and explicitly state the link between learning outcomes and the practical and stakeholder aspects of the course. For an entirely new course, neither students nor teachers know what to expect. This makes it very hard to set expectations right. In the final conference, stakeholders expressed that they were positively surprised suggesting they will come into the course with positive expectations around what the students can achieve. As teachers, we now also have an idea of how far the students can develop the projects, and students will have a reference point which may not be overly positive but at least quite realistic.

3.1 Relevance

Chalmers and the City of Gothenburg have expressed an ambition to collaborate around challenge-driven higher education, but achieving such collaborations in practice is not a given. The experience documented in this study helps illustrate the value and potential setups of such collaborations. The study details key issues that need to be addressed for such partnerships to work in practice and identifies some risks and challenges from the perspective of students, teachers, and stakeholders. This contributes to a wider discussion around the future role for PjBL with real-world cases and stakeholders at Chalmers University of Technology.

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WORK IN PROGRESS

Småskaliga live case för att integrera livslångt lärande och arbetslivsanknytning*

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Abstract

A model of live-cases is developed for educational collaboration and work-integrated learning. The model can be implemented in existing university education and lifelong learning (LLL) courses and allows engineering students and LLL students from healthcare to work together on a real-life problem. The small-scale live-case model is resource-efficient as it is strongly delineated in time (duration: one week), further it is unique in focusing not only the students' but also the practitioners' learning.

Sammanfattning

I detta projekt utvecklas en live-case-modell som stödjer utbildningssamverkan och arbetsintegrerat lärande inom ramen för existerande universitetsutbildning och kurser för livslångt lärande (LLL). I denna modell får ingenjörsstudenter och LLL-studenter från vården arbeta tillsammans med ett verkligt problem från LLL-studenternas organisation. Den småskaliga live-case-modellen är resurseffektiv eftersom den är starkt avgränsad i tid (varaktighet: en vecka), dessutom är den unik då den inte bara fokuserar ingenjörsstudenternas, utan även praktikernas (LLL-studenternas), lärande.

Keywords: *case-base learning; life-long learning; live-case.*

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1 Introduktion

I ett ständigt föränderligt arbetsliv behöver inte bara framtida (dvs studenter) utan även nuvarande medarbetare (yrkesverksamma) utveckla sina kompetenser. Följaktligen har mycket fokus i samhället i allmänhet, och universiteten i synnerhet, lagts på stöd för kurser inom livslångt lärande (LLL) (Aspin och Chapman, 2000). För att möta dessa behov har vi utvecklat en modell för live-case som skapar integration mellan LLL-kurser och befintlig universitetsutbildning. Modellen kallas SMILLA (Småskaliga live case för att integrera livslångt lärande och arbetslivsanknytning) och genomförs inom området kvalitetsutveckling i vården.

I ett live-case arbetar studenterna med en extern organisation för att lösa ett verkligt problem (Burns, 1990; Elam och Spotts, 2004) vilket har visats ha positiva effekter för lärande, både när det gäller att förstå kursinnehåll och att utveckla kommunikations- och interaktionsförmågor (Roth och Smith, 2009). De deltagande organisationerna rapporterar också positiva erfarenheter som tillgång till nya idéer och problemanalyser (Roth och Smith, 2009). De stora skillnaderna mellan SMILLA och andra live-case är: 1)att modellen är resurseffektiv (varaktighet en vecka) medan dokumenterade live-case ofta är relativt terminslånga projekt, och 2)att modellen fokuserar individuellt lärande både för studenter och för de enskilda yrkesverksamma, medan dokumenterade live-case fokuserar fördelar på organisatorisk nivå (Smeds et al., 2023). Syftet är att undersöka om SMILLA kan skapa resurseffektivitet genom att samordna utbildningsaktiviteter inom ramen för existerande universitetsutbildning och LLL-kurser.

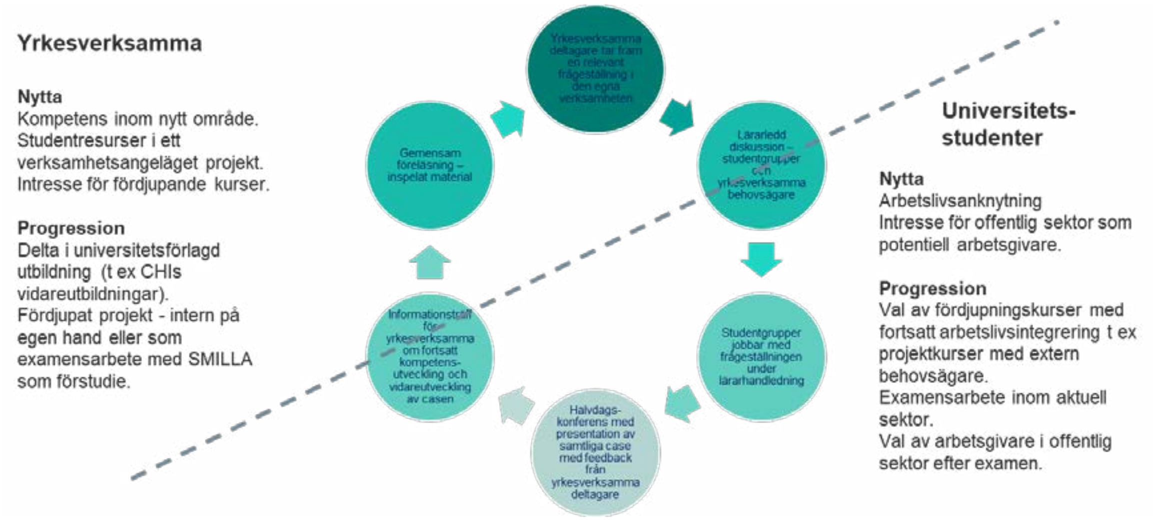
2 Metod

SMILLA utvecklas inom ett Vinnova-finansierat projekt som inkluderar tre pilotomgångar av modellen samt arbete för att identifiera kritiska faktorer för långsiktig utbildningssamverkan (LLL). Denna artikel fokuserar det första pilotprojektet av SMILLA-modellen och följs upp ur studenters, yrkesverksammas och lärares perspektiv. Före piloten har ett antal fokusgrupper med Chalmerslärare med erfarenheter av liknande projekt samt möjliga arbetsgivare inom vården genomförts. En före-enkät har genomförts med studenterna för att etablera en baseline och för att undersöka intresset att jobba inom hälso- och sjukvårdssektorn, enkäten har sedan genomförts igen efter live-case-veckan. Ytterligare studenterfarenheter har samlats in via kursutvärdering och studenternas reflektionstexter. Yrkesverksammas erfarenheter har samlats in i en fokusgrupp efter case-veckan. Vidare kommer LLL-kursen utvärderas i en kursenkät. Lärarperspektivet har beaktats och dokumenterats via reflekterande fokusgrupper.

3 Live-case-modellen

I SMILLA (Figur 1) samverkar studenter på mastersprogrammet Quality and Operations Management (MPQOM) med yrkesverksamma som läser en LLL-kurs i kvalitetsutveckling. LLL-kursen läses på kvartsfart parallellt med de yrkesverksammas arbete (för mer detaljerad beskrivning hänvisas till Smith et al. (2019)) och är uppdelad i tre moduler (ca 6 undervisningsdagar per modul) där den första är en introduktion till verksamhetsutveckling (principer, arbetssätt och verktyg) som liknar delar av den programobligatoriska introduktionskursen på MPQOM.

Figur 1: SMILLA-modellen



Praktiskt genomförs modellen i följande steg. Steg 1: båda studentgrupperna tar del av samma inspelade föreläsningsmaterial och caseinstruktioner. Steg 2: de yrkesverksamma tar fram problembeskrivningar under handledning (bakgrund till problemet, tentativ problemformulering och eventuellt bakgrundsmaterial). Steg 3: de skriftliga problembeskrivningarna lämnas över till studenterna första dagen i en fokuserad utbildningsvecka och lärare involverade i både LLL-kursen och masterskursen har handledning med studenterna. Steg 4: under veckan läser studenterna materialet, intervjuar den yrkesverksamma, samt arbetar med att utveckla problemformuleringen med input från föreläsningar, litteraturseminarium och gästföreläsning från vårdsektorn. Steg 5: studenterna presenterar analyser och förslag för de yrkesverksamma och för de involverade lärarna som ger muntlig feedback. Steg 6: de reviderade problemformuleringarna diskuteras i LLL-kursen som en bas för deltagarnas egna förbättringsprojekt.

4 Diskussion och slutsatser

Erfarenheterna från pilotuppföljningen visar att studenterna har upplevt det värdefullt att få ta del av praktiska exempel och träffa potentiella arbetsgivare. Flera studenter upplever att deras kunskaper har fungerat bra att omsätta i praktisk nytta i en för dem relativt okänd kontext; ”Förut trodde jag att jag inte skulle kunna jobba inom vården, vad kunde jag ha att erbjuda? Jag har nu insett att det finns många områden där jag som ingenjör kan erbjuda min hjälp och expertis.” De yrkesverksamma betonar studenternas goda förmåga att snabbt sätta sig in i ett komplext problem och att synliggöra potentiella vägar framåt från ett externt perspektiv. Som främsta fördelar lyftes bland annat: ”Referenserna de hänvisade till kommer göra vårt arbete lättare!” och att ”integrera "ingenjörstänk" med klinisk erfarenhet”.

SMILLA fungerade väl ur de tre perspektiv (student, yrkesverksam, lärare) som utvärderades och upplevdes som stödjande för lärande hos både studenter och yrkesverksamma. De yrkesverksamma ser nyttan och möjligheterna att lära från studenterna vilka ser nyttan av sin kompetens i ett, för flertalet, okänt fält (offentlig sektor). Sammantaget upplevs SMILLA som ett resurseffektivitet sätt att samarbeta i, och samordna, utbildningsaktiviteter existerande universitetsutbildning och LLL-kurser.

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Interpersonal presence in an international digital research environment *

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Abstract

Active learning is a more effective teaching method than traditional lecturing. It involves assigning tasks to students instead of just having them listen passively to a lecturer. An important aspect in active learning is social interactions and we present a case study investigating the impact of social interactions in online supervision, at the bachelor's and master's level, and discuss strategies for overcoming challenges in recreating the dynamics of a physical setting. Our findings suggest that intentional efforts to foster interactions between students and mentors at universities in different parts of the world, along with external stakeholders, enhance online education. Additionally, increased student internationalization, engagement and satisfaction can be achieved.

Sammanfattning

Aktivt lärande är en mer effektiv undervisningsmetod än traditionell undervisning. Det innebär att man tilldelar uppgifter till studenterna istället för att de bara lyssnar passivt på en föreläsare. En viktig aspekt inom aktivt lärande är social interaktion och vi presenterar en fallstudie som undersöker effekterna av social interaktion vid handledning av kandidat och masterstudenter online, samt diskuterar strategier för att övervinna utmaningar med att återskapa dynamiken i en fysisk miljö. Våra preliminära resultat tyder på att medvetna ansträngningar för att främja interaktion mellan studenter och handledare vid olika universitet i olika delar av världen, samt externa intressenter, leder till förbättrad utbildning online. Vidare tyder våra resultat på att en ökad internationalisering, engagemang och tillfredsställelse bland studenterna kan uppnås.

Keywords: *Online learning; Internationalization; Student engagement; Student support; Active learning*

1 Introduction

Active learning is a teaching method that outperforms traditional lecturing by actively engaging students in tasks rather than relying on passive listening to a lecturer (Felder & Brent, 2016). Interpersonal interactions, as highlighted by Croxton (2014) and Swan (2002), have been shown to facilitate the learning process and increase student satisfaction within active learning environments. In the context of research supervision, where interaction is often isolated from an active classroom environment, we recognise the need to introduce a framework for active learning strategies to enhance the learning experience for students. While acknowledging the value of personalised guidance, we also aim to foster a broader

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range of social interactions and promote internationalization even in a digitalized educational setting. By integrating active learning principles into our supervision practices, we aspire to cultivate a supportive and interactive learning environment that encourages dialogue, knowledge sharing, and multidirectional communication. This transition entails not only embracing external and global collaboration but also adapting to a digital format that facilitates these broader social interactions.

At our institutions, including the National Radio Astronomy Observatory and University of Virginia in the United States, and Chalmers University of Technology in Sweden, students engage in interpersonal interactions with researchers and research groups within the field of astronomy during their thesis work. We are now conducting a pilot study to explore how we, as supervisors, can expand the digital learning environment to facilitate social interactions and student engagement at the bachelor's and master's levels, to generate incentives for students to learn. We place the students at the centre of the learning environment, and encourage them to take an active role in the research process and to make meaningful scientific contributions. John, Caniglia, Bellina, Lang och Laubichler (2017) describe the integration of ”knowing”, ”acting”, and ”being” as a competence-based curriculum, where ”competence” means successfully performing tasks and solving problems by applying knowledge, skills, and attitudes (Wiek, Withycombe & Redman, 2011).

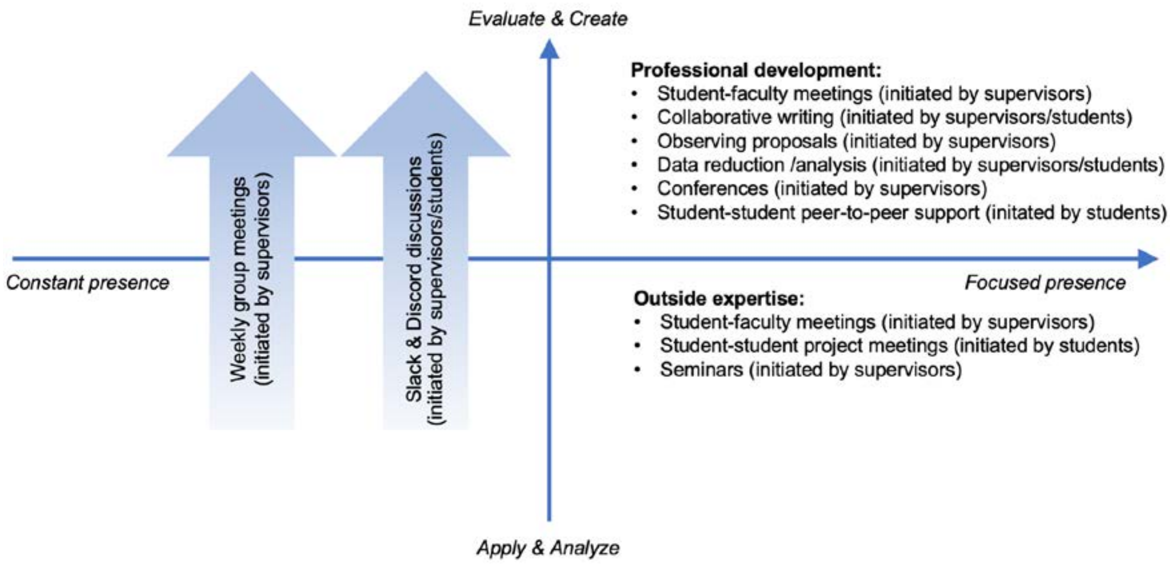
This approach aligns well with our research framework. We hope to provide opportunities for students to collaborate with people from other universities, nations and cultures through international research collaborations. The central questions we ask are; *i*) How can social interactions and engagement be fostered in a digitalized educational setting, particularly in the context of distance supervision in research? *ii*) How can international research collaborations be effectively facilitated through the use of digital technology, and what are the potential benefits of such collaborations for students' academic experiences and skill acquisition?

2 Methodology

To address these questions, we adopt a framework inspired by the approach described by John m. fl. (2017), which emphasises the establishment of clearly defined roles for supervisors, co-supervisors, and collaborators. Furthermore, we acknowledge the importance of personal, professional, and cultural backgrounds for all involved parties and we define digital social presence as a shared experience among the participants in the digital learning environment. Finally, we distinguish between constant presence and focused presence, to ensure that students receive the appropriate level of guidance and support throughout their learning journey.

Along with group dynamics and interactions, project formulation serves as a guide for the research experience of a student or a group. To optimize learning, we recognize that planning and selecting appropriate methods are critical skills for any project work, and students should play an active role in these aspects. Moreover, students should be capable of collaborating with various stakeholders in the project, demonstrating teamwork, working with different groups both nationally and internationally, and presenting their work. These objectives align with the revised Bloom's taxonomy framework (Anderson & Krathwohl, 2001). Our supervision activities (Fig. 1) do not fall into a single category in the Bloom's taxonomy framework. However, they can still be placed on a continuum from practical application and analysis skills to more abstract thinking. To categorise our supervision activities, we have opted for an approach that spans from developing skills and competence (such as selecting appropriate methods) to nurturing judgement and approach (including collaboration skills both locally and internationally) or falling some-where in between. In the case of weekly meetings and online discussions, our objective is to guide students through a deliberate progression along Bloom's taxonomy throughout the supervision period, with the aspiration that this approach will engage higher-order thinking both individually and during collaborative sessions.

Figure 1: Conceptual illustration of the learning environment that promotes digital social presence, with supervision activities categorised based on their relevance to the overall goal, and with the roles of responsibility indicated in parentheses. The vertical axis represents progression through Bloom's taxonomy, from practical application and analysis skills at the bottom to higher-order thinking at the top. The horizontal axis represents the differentiation between constant and focused presence.



3 Outcomes and feedback

We collected feedback through exit interviews with verbal input and an anonymous feedback form. Quantifying the outcomes posed a challenge due to the relatively small sample size in this case study (∼20 students and 3 mentors). Nevertheless, our aim is to evaluate these outcomes more comprehensively in the future as we continue to gather feedback and data to assess our supervision activities and make necessary adjustments.

Based on the feedback obtained throughout the study, we have observed that students are motivated by international, diverse research groups, and the opportunity to gain hands-on experience with research, as well as exposure to academic discussions. We have also observed that motivation is important for engaging students such that they can accurately evaluate STEM career paths, and meanwhile productively contribute to the research group mission. We have also seen that when students take initiative to continue the social presence, even when it is not required for any credit or evaluation, and when they encourage other students to follow a similar path, they consider it a positive experience.

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ROUND TABLE

Pragmatic Research on Educational Practice *

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Abstract

During a round table discussion at a collegial conference on teaching and learning, a focus group with 12 teachers from a technical university discuss challenges with studying their own teaching practice. Furthermore, a concept called PREP – Pragmatic Research on Educational Practice, with the goal of engaging engineering educators in studying, documenting, and sharing their initiatives to improve teaching practices, is introduced and discussed. Among the main obstacles to researching their own teaching practice, the participants pointed to a lack of time, know-how, and motivation. They expressed that there is potential in the collegial part of PREP and the time efficiency of using what can be studied during a course. The role of PREP studies, in relation to regular educational research, is also discussed, and that PREP may be perceived as a devaluation of educational science was problematized. Some participants felt that it was very likely that they would participate in a PREP group next academic year if given the opportunity.

Sammanfattning

Under ett rundabordssamtal på en kollegial konferens om undervisning och lärande diskuterar en fokusgrupp, med 12 lärare från ett tekniskt universitet, utmaningar med att studera sin egen pedagogiska praktik. Vidare introduceras och diskuteras ett koncept kallat PREP – Pragmatic Research on Educational Practice, med målet att engagera ingenjörsutbildare i att studera, dokumentera och dela med sig av sina initiativ för att förbättra undervisningsmetoderna. Bland de största hindren för att beforska sin egen undervisningspraktik pekade deltagarna på brist på tid, kunnande och motivation. De uttryckte att det finns potential i den kollegiala delen av PREP och i tidseffektiviteten att använda det som kan studeras under en kurs. PREP-studiernas roll, i förhållande till vanlig utbildningsforskning, diskuteras också och att PREP kan uppfattas som en devalvering av utbildningsvetenskapen problematiserades. Några deltagare ansåg att det var mycket troligt att de skulle delta i en PREP-grupp nästa läsår om de fick möjlighet.

Keywords: *higher education; pragmatic research; teaching practice*

1 Introduction

This paper reports on the results of a focus group discussion concerning the value of using a collegial process for studying one's teaching practice. The focus group was organized as a round table discussion at an engineering education conference. The first aim of the round

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table discussion was to discuss what opportunities and obstacles engineering educators see in studying their teaching practice. The second aim was to introduce and discuss a program called PREP - Pragmatic Research on Educational Practice (Bengmark, 2022). This program is meant to engage engineering educators in studying, documenting, and sharing their initiatives to improve teaching practices. The authors had tried and developed the PREP program for a period and wanted to investigate the relevance of this program for other engineering educators.

2 The sample and the design of the round table discussion

From a research perspective, we view this round table discussion as a focus group discussion, a qualitative research tool involving the participants in structured discussions, allowing an in-depth exploration of participants' perspectives and experiences (Gibbs, 2012). The group consisted of 12 engineering educators active in various disciplines, making up a convenience sample as the participants voluntarily chose between parallel sessions during a collegial conference on teaching and learning at a technical university. Three participants had no prior experience conducting research connected to their teaching, three had presented educational research findings at conferences for teaching practitioners, and the remaining six had initiated studies but had never completed and shared educational research results with others.

A structured interview guide developed by the authors was used, containing multiple-choice and open-ended questions. For example, we asked *What prevents you from studying your own teaching practice scientifically?*, with a few choices to choose between and a line to add your own formulation. The participants were asked to respond to the questions individually, either digitally or on paper, before each part of the discussion. The moderators facilitated the discussion, encouraged participants to share their thoughts and experiences, and probed for further elaboration when needed. In the middle of the session, the PREP program was described by the authors using a PowerPoint presentation. The data from the focus group session consists of written answers and notes taken by the authors during the session.

3 Description of PREP and its relation to other methods

The rationale for devising PREP was to form a program that made it possible and worthwhile for many more higher education teachers to study their own teaching practices and report on the results. This led to the following three characteristics of a PREP study. First, it is pragmatic, using what the educators can see or do within one university course instance within the given limitations regarding time and organization and without compromising the course quality for current students. This normally means there are no control groups, and that it is not possible to eliminate conflating variables. Second, it is research-oriented, i.e. systematic, and shared for others to evaluate. Reporting about the teaching ideas and their effects is the main focus so that others can replicate or modify and share their results. Hence, a single PREP report does not constitute a research paper in the classical sense, but cumulative results from several PREP reports may reach the usual scientific credibility. Finally, PREP studies are all about educational practice and examine educational issues and ideas in their natural environment.

To support the pragmatic research process, PREP groups are formed consisting of a handful of educators teaching during the same period. The members conduct individual studies, possibly in different subjects and at different universities. They support each other by discussing their PREP studies and reporting on their progress, helping the members commit to their studies, and getting suggestions and ideas from the group. The group meets three times. At the first meeting, the kick-off, each member formulates what they want to do and study in their course and drafts some initial thoughts on how the effect could be measured. Other group members help with ideas, suggestions, or references. At the second meeting, mid-course, the members report on their progress and get help with ideas on how to continue from the other group members. At the third meeting, each member describes the data found and their interpretation of it, and then gets reactions on the analysis of the data from the group.

To facilitate the documentation, reports follow a template filled in online and stored in a searchable and public repository. The documentation of a PREP study emphasizes the description of the teaching activities, as these need to be understood by educators from other regional or organizational traditions for them to be able to reproduce the teaching activities. The threshold for publishing a study in the PREP repository is different from regular scientific journals. For example, unsuccessful or incomplete studies are welcome as there are lessons to be learned from why a study was not completed and also to diminishing problems with publication bias. Also, studies with unclear results are welcome, as the results may become clearer through replications.

There are other regular research methods where the researcher and the practitioner can coincide, such as design-based research (Anderson & Shattuck, 2012), design experiments and design research (Cobb, Confrey, DiSessa, Lehrer & Schauble, 2003), (Edelson, 2002) and action research (Ivankova, 2015; Noffke, 2009). In contrast to PREP, all these methods have the aim to live up to the standards of a regular educational science journal. Pragmatic research, in the PREP context, means taking advantage of what is already being done within the teaching practice even though it does not meet all the requirements expected of a full-fledged scientific study. Another concept of pragmatism in research can be found in the literature but is then related to underlying philosophical assumptions about the choice of method (Biesta & Burbules, 2003).

An approach that has great similarities with PREP is the Scholarship of Teaching and Learning, SoTL. It also aims to activate university teachers in developing their teaching by scientific analyses of practice and then sharing the results with peers Trigwell (2013). However, it has been a hard sell partly as it is seen as difficult to operationalize Boshier (2009). PREP offers a collegial for supporting and helping each other, as well as a forum for sharing results, also accepting reports on a less demanding format and level than what most expect when reporting on SoTL work.

4 The outcome of the round table discussion

The participants were first asked for permission to use their contributions to the round table discussion for scientific study, to which all gave their consent. The participants were then asked: What prevents you from studying your own research practice scientifically? The three main obstacles expressed were lack of time, motivation, and know-how on how to study your teaching practice.

After a short presentation on PREP, the remaining part of the discussion focused on if and how PREP could support the process of studying your teaching practice. That PREP is pragmatic and uses data that one can collect on the fly was highlighted by the participants as a way to reduce the time needed for a study. The collegial parts of PREP were discussed as a way to share know-how and to keep up motivation. The proposed documentation template for PREP studies was also discussed. The participants thought it would simplify documentation and suggested some improvements.

The value of PREP studies was discussed, and a concern was expressed that PREP is less scientific and hence could be perceived as a devaluation of educational research. In response, it was emphasized that individual PREP studies could not be equated with, and should not be seen as providing evidence to the same extent as, regular educational research reports. In educational research, there is always a need for collective efforts, involving several similar studies and replications reporting comparable results, to make scientific claims. As PREP studies are not as rigorous, there is a need for many replications pointing in the same direction, before there is reason to believe that there is where the claims are to be made.

One lesson learned from the seminar is that PREP can be perceived as provocative, and the idea needs to be communicated with care if it is to be accepted. Despite this, several participants, on a direct question at the end of the conversation, felt that it was very likely that they would participate in a PREP group next academic year if given a chance.

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WORKSHOPS

Advanced study techniques for university students *

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Abstract

The students starting at the Engineering Physics and Engineering Mathematics educations at Chalmers face challenges in terms of greatly increased workload and complexity of the subject matter compared to their previous education. Based on the experiences from teaching an introductory course in mechanics for nearly ten years (Ulf), the lack of efficient study techniques for a large number of students was identified. We have this year therefore offered the students a course in advanced study techniques (Daniel) tailored for university students, and also for their specific educations. We will here briefly describe the contents of the course and the preliminary impact on student learning.

Sammanfattning

Studenterna som börjar på utbildningarna inom Teknisk fysik och Teknisk matematik på Chalmers möter stora utmaningar i termer av kraftigt ökad arbetsbelastning och ämneskomplexitet jämfört med sina tidigare studier. Baserat på erfarenheterna från att ha undervisat en introduktionskurs i mekanik i nära tio år (Ulf) har vi märkt att en stor andel studenter saknar en effektiv studieteknik. Vi har därför i år erbjudit studenterna en kurs i avancerad studieteknik (Daniel) för universitetsstudenter och även anpassad till studenternas specifika utbildningar. Vi kommer här att kortfattat redovisa kursens innehåll och dess preliminära effekt på studenternas lärande.

Keywords: *Study techniques; student learning; student health; mechanics.*

1 Introduction

The students starting at the Engineering Physics and Engineering Mathematics educations at Chalmers are very high performing students, and have often been the best students in their respective classes before coming to Chalmers. However, their natural aptitude for learning, together with the much lower level of their previous studies, have in many cases enabled them to excel without a structured approach to learning or any specific study techniques; studying the night before a test, or not studying at all, has been enough. Until now that is. The fail rates for the first two courses (Introductory mathematical analysis and Linear algebra) were 52% and 43%, respectively, in the 2022/23 academic year. This means that a sizable group of students, who have basically never failed a test before, now failed **both** starting courses in mathematics, which are essential for their education and subsequent courses. This naturally leads to a lot of stress and less enthusiasm for the studies, affects the students' psychosocial health, and is one important cause of the high dropout rate of 30-50% for these educations. Furthermore, some of the students who now struggle and might drop out are the ones with the highest amount of natural talent, and

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hence no previous need for study techniques, who of course have the potential to become excellent engineers.

There are efforts made to teach study techniques at essentially all Swedish universities, but mostly in the form of self-studies and often more of tips and tricks than a thorough and comprehensive method. Chalmers is one example, where one lecture is supplemented with 20 short videos (Liljeqvist, 2019). Our impression is that these kinds of efforts have very limited impact, which is supported by the fact that the videos just mentioned has on average been viewed 117 times over two years despite that they are intended for all of Chalmers' students.

To address all the negative consequences mentioned above a collaboration with Daniel Benjaminsson was initiated, who through his company UnQap specializes in teaching advanced study techniques to a wide range of students and professionals, to create what we believe is the most ambitious course in study techniques at any Swedish university. Since Daniel is a former student at Engineering Physics at Chalmers he has a unique insight into the problems faced by the students, and he also knows the subject matter they are learning and can hence fine tune the study techniques accordingly. The workshop at KUL consisted of a theory part and then exercises allowing the participants to try the advanced learning techniques for themselves.

2 Advanced study techniques

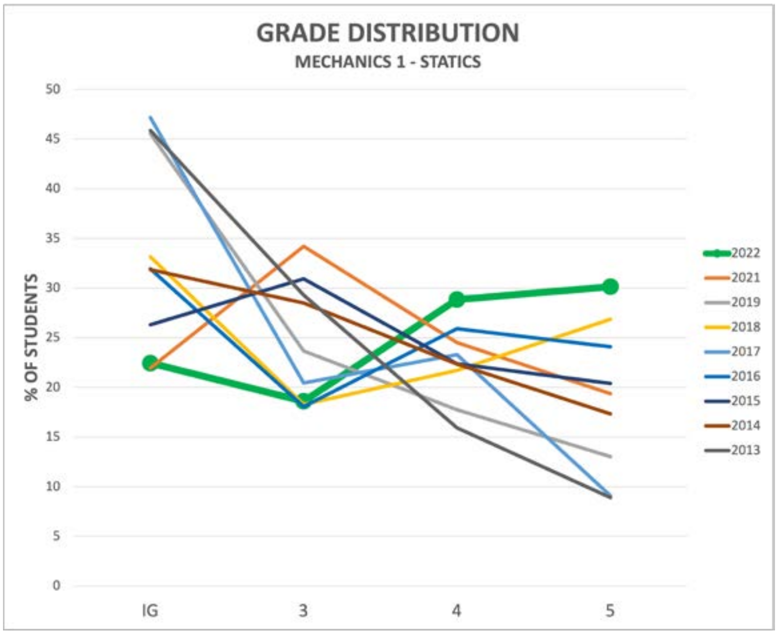
The introduced study techniques are in harmony with *constructive alignment* (Biggs, 2014), which is the preferred principle for course design and development at Chalmers. First, the learning outcomes of a course are analysed to identify what knowledge to focus most on, since time is limited and not all the contents in a course are of equal importance. Second, a large number of previous exams are briefly surveyed to make sure the identified focus areas are reflected by the exams, and also to sort the exam problems into specific learning outcomes for later study. Note that a student at this point do not know the subject, or how to solve the problems, but has a clear picture of what they are expected to learn and how the big concepts of a course are combined in exam questions.

The next task is to gather knowledge around the identified focus areas, which usually is achieved mainly through lectures, exercises and studying course literature. The tools and knowledge that the students gather throughout the course are then organized into a mind map (Buzan, 2006), which connects important concepts and problem solving techniques, thereby facilitating the students' *understanding* of the material. The last step is to memorize the mind map using the standard method of loci (Yates, 2011) combined with spaced repetition to convert to more long term memory (Mace, 1932). The study techniques were covered during a total of six lectures (2x45 min) before the exam reported below, and another five lectures in the following study period before the second exam.

3 Results

It is difficult to get hard evidence on the impact of this intervention, but there are some indications which together, we believe, paint a rather clear picture. First, due to ethical reasons, all students were allowed to participate so there is no control group. Approximately half the group, 70-80 students, did follow the course on study techniques. Exactly which students these were is not possible to determine since the course was open for all students. What we can do is to compare the grades for *all* students in the mechanics course between 2013 and 2022, the year of the intervention, excluding 2020 when there was an

Figure 1: Exam results before and after the intervention.



exam over Zoom due to Covid-19. The grades are presented in figure 1 and show a clear shift towards higher grades after the intervention, as well as a reduction of failed students as indicated by IG in the figure. In order to strengthen the argument that this is an effect of the intervention, and not due to the student group of 2022 being exceptionally strong, we also compare the grades for students in course Introductory mathematical analysis given in the study period before the mechanics course. The grades between 2011 and 2022 (excluding again 2020 due to Covid-19) are presented in figure 2, which shows that the student group of 2022 had both few high grades (4 and 5) and a high failure rate. It therefore seems unlikely that the strong results in the mechanics course was due to a stronger than usual student group. Further evidence for the efficacy of the study technique intervention is obtained if we compare the results for the re-exam for Introductory mathematical analysis given *after* the intervention, *cf.* figure 3. Note that the re-exam is given the year after the course started, so the 2023 re-exam is just after the mechanics course. Here we see that the student group which performed statistically well below average on the regular exam performed well above average on the re-exam. Since Daniel provided the students with tailored study technique material also for this course the intervention is a possible explanation for the improved performance at the re-exam compared to the regular exam.

Second, in the course evaluation the students were very positive, felt reduced stress and clearly supported continuing this intervention next year. A total of 73 students responded to the course evaluation and around 20 students spontaneously sent positive feedback via email. Below are a few examples, and a lot more can be found in the appendix.

- "The methods work fantastically well, the toolboxes [course specific mind maps] are also very nice to have since the first half of the year was a bit chaotic."
- "... They [the techniques] have made it easier for me to memorize many different things, and therefore I get less stressed that I'll forget a tool or concept during an exam. The learning techniques are also effective and save a lot of time."
- "I think the learning techniques have been very valuable, and I believe they will be helpful both in mechanics and in life in general."

Figure 2: Exam results in Introductory mathematical analysis.

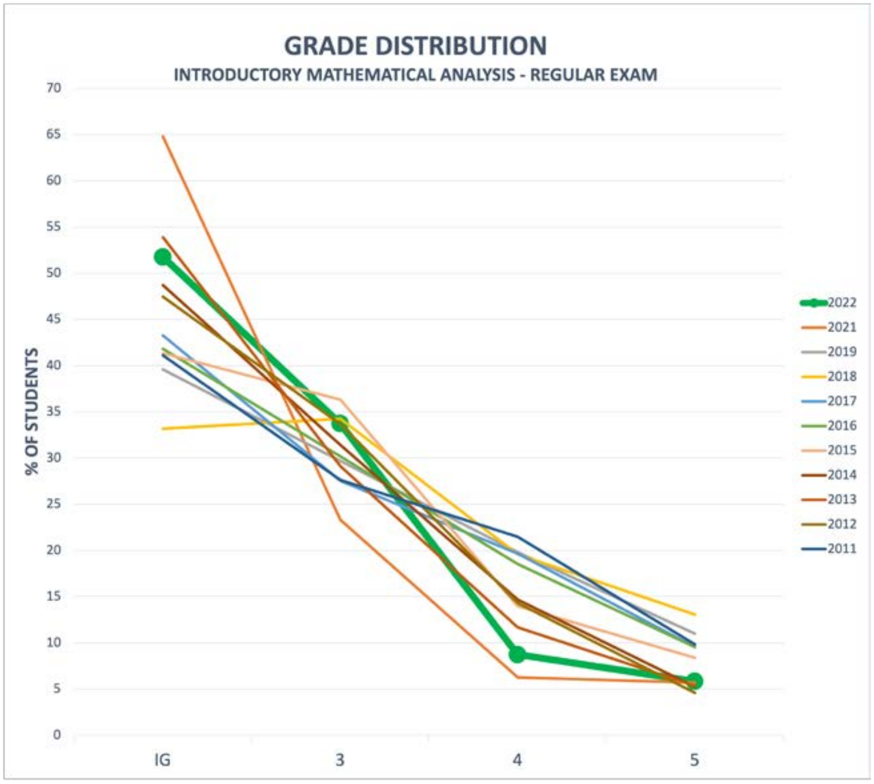
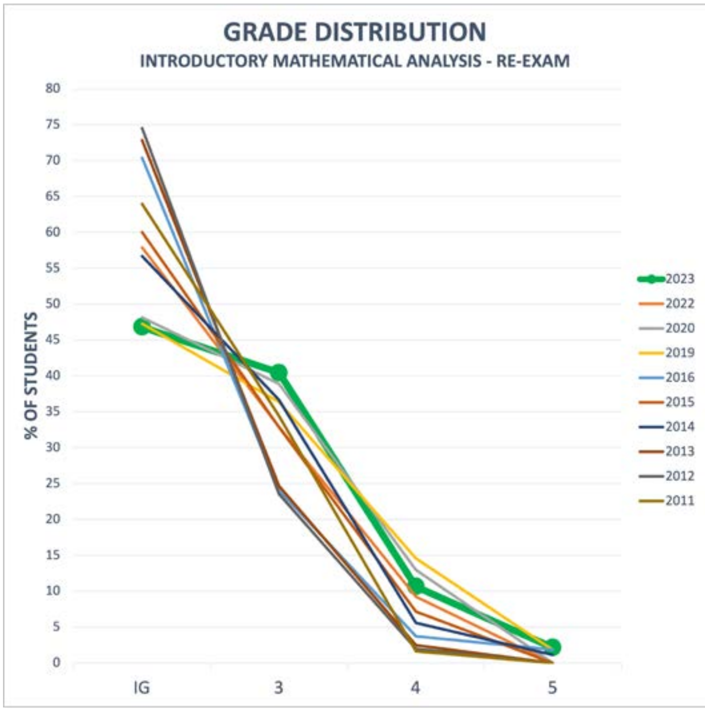


Figure 3: Results for the re-exam in Introductory mathematical analysis.



- “It feels like I have gained a better understanding now, and I feel confident about how to proceed with my future studies.”
- “I failed the first two exams and quickly realized that I needed to change my study techniques. Then you [Daniel] came with your concept on a silver platter, and I decided to go all-in. The result [in the following exams] was a grade 4 in linear algebra, a 5 (full marks) in mechanics, and a grade 3 with a margin in the continuation course of mathematical analysis.”
- “Very interesting content that has already helped me in my studies. It provides a comprehensive method.”

Third, at the workshop two students gave testimonials where they shared how, after failing both exams in the first study period (before the introduction of advanced study techniques) the taught techniques enabled them to not only pass the courses in the second study period, but to obtain high grades. Furthermore, it also allowed them to easily pass the re-exam for some of the courses they failed during the first study period. Having followed up these students almost a year after the first study technique classes begun this positive effect has persisted through time, one of them even saying “The studies are incredibly easy now.”. It should be stressed, however, that these students were not representative as averages for the student group, but should be viewed as a best-case scenario when fully committing to the techniques.

4 Discussion and Conclusions

Considering how effective this intervention seems to have been begs the questions why study techniques are not a natural part of what students learn at school. Spending just six lectures on learning effective study techniques can boost both student learning and psychosocial health, positively affecting the students’ future life and career.

A Feedback from the students

Below are some additional feedback from the course evaluation questionnaire.

- “We have received genuinely helpful and concrete tips on how to improve our learning instead of just hearing that we need to study more/have a good sleep schedule.”
- “First and foremost, I want to thank you [Daniel] for everything you have given and taught us during the study technique sessions. It means a lot!”
- “Extremely useful information described in great detail. We are also encouraged to test ourselves with the help of ready-made mind maps and examples. Moreover, we are encouraged to ask questions which motivates that you really want to learn and understand the techniques.”
- “I feel that I now have a much clearer picture of how I should structure my studies.”
- “It’s simply an excellent deep dive into learning techniques. From the other people who previously came and spoke about study techniques, it has been hard to get much out of it as they only had one lecture. These have been very good.”

- "... I also want to give feedback and say that it was really great that you made mind maps for us - it really helped to have a basis to start from. Especially in the continuation course [of mathematical analysis] when I had difficulty dividing things into categories, and I think I got a really good mind map in the end, largely because there was something to start from."
- "Thank you very much for both the mind maps and the feedback; it has really been helpful."
- "Thanks for an interesting course; it has been a great help!"
- "Very concrete examples and testing of application. Also helps with someone who "thinks" like a student and not like a professor."
- "An important subject that doesn't get enough focus in teaching."
- "Useful for any course, not just mechanics."
- "It's good to learn how to easily memorize; the mind maps created for the courses are very helpful!"
- "I think they [the lectures] are both interesting, fun, and it feels like you learn something useful. Good lecturer too. I also think you remember it well afterward. Good that you can easily ask questions, both in front of everyone and individually."
- "Very interactive with the students, and I like that we got to test making our own VIPS [memory exercises]. Above all, you always had the opportunity to ask questions, and it felt very relaxed."
- "Simply very good info, Daniel is awesome, and the study techniques and memory techniques are superb. Very good also to be able to email."
- "The setup was good and fun, everything was tied together well so it stuck [in memory] better. The subject was also good because it is interesting and useful."
- "You get drawn in very well, and you really got to see that it worked."
- "Good methods and committed teaching."
- "The toolboxes are very useful."
- "The lecturer's commitment was very entertaining, and the learning techniques are pretty powerful if you have the [memory] stories."
- "Interesting and useful methods and new perspectives."
- "Very educational and exciting."
- "Easy to understand the concepts. It seems helpful and works."
- "It's a good structure with interactive lectures. You get to learn fun and good stuff, so it feels very good and useful."
- "Good with information about the techniques, I've noticed that I don't have much technique. Especially mind maps, I've found, are good for increasing learning."

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