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PROCEEDINGS

CHALMERS CONFERENCE ON TEACHING AND LEARNING 2024

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Chalmers University of Technology, 5 of April 2024

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Kursenkät


CHALMERS

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.

These proceedings gather the works of Chalmers teachers that typically emerge directly from the classroom. They provide insight into the lived experiences of teachers who actively seek to refine their practices and reflect on their pedagogical challenges.

Hence, the contributions offer examples of the scholarship or teaching and learning (SoTL) and suggest avenues for subsequent educational development research.

The contributions presented here are aimed to serve as valuable starting points for dialogue, inspiration, and ongoing collegial learning.

Summary in brief for KUL2024

Date: April 5, 2024

Venue: Chalmers Conference Center, Johanneberg, Gothenburg, Sweden

Number of participants: 154

Number of conference contributions: 26

Number of contributing authors: 57

Number of plenary sessions: 21

Number of parallel sessions: 17, over four or five parallel sessions

Average rating: 4.1 out of 5 (32% response rate).

Committees, groups, and roles

Conference committee

- Samuel Bengmark, MV (chair)
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Conference Administration

- Anna Bergius (Internal Communications), conference administrator and web manager

Keynote KUL 2024

Mats Cullhed
Uppsala University
Educational developer at Uppsala University

Title of Keynote speech
Controversial Intelligence

Subtitle
Integrating Generative AI in Higher Education

Abstract

If one part of generative AI is all about curiosity-driven, and often enjoyable exploration of how far it can take you, a more troubled aspect concerns its integration into the structures and cultures of academic teaching and learning.

I will discuss some of the short- and long-term challenges regarding, e.g., assessment and critical thinking, and suggest some ways through which faculty and students can shape learning environments, where generative AI may contribute to, rather than threaten, academic values and standards.

PAPERS

WORK IN PROGRESS

ROUND TABLE

WORKSHOPS

PAPERS

Authorized Cheat Sheets as Study Aids in Continuous Assessment

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May 2, 2024

Abstract

The availability and widespread of open-source AI tools posed a challenge to open-book or take-home types of examination. The solution is mostly found in classroom-based, computer-aided and proctored central examinations. However, these might hinder the analytical thinking and learning abilities of students, encouraging memorizing instead of synthesizing information. To balance the trade-off, authorized Cheat Sheets (CSs) can serve as a middle ground between open and closed-book types of examination. This paper investigates the introduction of authorized CSs in combination with continuous assessment in a course, and the focus is on understanding how these CSs evolved over the course and what can be concluded from this change to further improve their value for students. The findings contribute to identifying strategies employed by the students for preparing authorized CSs, culminating in insights for developing guidelines on preparing authorized CSs as study aids to assist students during continuous assessment.

Sammanfattning

Tillgången till och spridningen av öppen källkod för AI-verktyg har utmanat traditionella provformer som examination med tillgång till kurslitteratur eller hemtentor. Lösningen har oftast varit att ersätta dessa med klassrumsbaserade, datorstödda och övervakade centrala prov. Dessa prov kan dock hämma studenternas analytiska tänkande och lärande, och i stället uppmuntra till memorering snarare än att syntetisera information. För att balansera denna avvägning kan auktoriserade hjälpmedel (Cheat Sheets, CS:er) fungera som en medelväg mellan examination med eller utan tillgång till kurslitteratur. Denna artikel undersöker införandet av auktoriserade CS:er i kombination med kontinuerlig bedömning i en kurs, med fokus på att förstå hur dessa hjälpmedel har utvecklats under kursens gång och vad som kan dras för slutsatser från denna förändring för att ytterligare förbättra deras värde för studenterna. Resultaten bidrar till att identifiera de strategier som studenterna använder för att förbereda auktoriserade CS:er. Insikterna används för att utveckla riktlinjer för auktoriserade CS:er som studiehjälpmedel för att stödja studenterna vid kontinuerlig bedömning.

Keywords: *Cheat sheet; Crib sheet; Continuous assessment.*

1 Introduction

Cheat Sheet (CS) refers to the use of supplementary materials during exams, falling somewhere between fully closed-book and open-book examination formats. The researchers interested in the topic explore various aspects, including the relationships between these materials, student performance, and psychological factors such as test-taking anxiety. Hamouda and Shaffer (2016) conducted an extensive literature review summarizing studies related to CSs, which can be referred to for further details on this topic.

It is often the case that the production of CSs is not controlled, and students are free to choose how to approach it (Song and Thuente, 2015). In this study, we first observe how the CSs evolve over the course duration over four assessment occasions, and then discuss and conclude on the strategies employed by students. Based on this investigation, we aim to understand how we can advise students on preparing the CSs for their educational benefit. Therefore, the question is: How can the preparation of CSs be guided in a manner that enhances students' learning?

2 Literature Review

Research on CSs encompasses several key questions. It investigates the impact of CSs on scores (e.g., Dickson and Miller, 2005, Dickson and Bauer, 2008, Funk and Dickson 2011, Hamouda and Shaffer, 2016); it examines the comparative effects of CSs versus open or closed-book exams on students' performance (e.g., Erbe, 2007, and Gharib, et al., 2012); it looks into the psychological effects of using CSs as exam-taking anxiety (e.g., Erbe, 2007, Gharib et al., 2012). Research also investigates the content of CSs (e.g., de Raadt, 2012, and Hamouda and Shaffer, 2016).

Various parameters are used to describe CSs including layout and content features. Layout features include density and organization, the alignment of content order with course material, the inclusion of headings, subheadings, and color-coding (e.g., Ludorf and Clark, 2014 and Hamouda and Shaffer, 2016). Content features include the incorporation of examples in CSs, abstract representations, and examples of answers (de Raadt, 2012), the amount of detail, the presence of formulas and meta-content, correctness, completeness, and distinction between verbal and numeric information (e.g., Gharib et al., 2012, Edwards and Loch, 2015, and Ludorf and Clark, 2014). Hamouda and Shaffer (2016) introduced the parameter of overall quality, bridging together layout and content features.

The key requirement for a CS is typically its size, while when it comes to the content of the CS, there is a lot of freedom. Typically, students are instructed what paper format to use and can note down anything they believe will help them during the exam. (Gharib et al., 2012) Training for students regarding the content of their CSs is seldom (Song and Thuente, 2015).

3 Case Description

The Bachelor's level course, which sets the case setting in this study, is equal to 7,5 credits and is run through 8 weeks. The expected workload of this course is 20 hours per week. This workload includes all course activities such as lectures, group work, exams, or self-study. The course is divided into two equal parts, each worth 50 points. In one part, students collaborate to solve a case, while the other part consists of assessments. These assessments are represented by four equal parts, each worth 12,5 points, occurring every one to two weeks throughout the course. Every assessment covers those one or two weeks of the course content. Once an assessment is completed, the students are not assessed on the same content again (apart from applying their knowledge in the case study that they solve throughout the whole course). Some weeks emphasize theoretical concepts, while others focus on calculation-based exercises (Table 1).

Table 1. Assessments' description

Assessment	General information	N of questions	Type of questions
1	4 lectures covered. Duration 1hr 15 min	12	short essay, multiple choice, multiple answer, matching, true/false, fill in the blanks
2	3 lectures covered, Duration 1hr 30 min	7	Majority calculation based, the rest matching and multiple answer
3	2 lectures covered, Duration 1 hr 30 min	7	Calculation based and other types equally balanced
4	1 lecture and 5 academic papers covered, Duration 1 hr 30 min	10	short essay, multiple choice, multiple answer, matching, true/false, fill in the blanks

The students do not need to pass each assessment, but they must take every assessment regardless of their total score. In the end, they have a 40% threshold to pass the course's theoretical part which is measured by the sum of these four assessments. This approach enables them to compensate for a lower score in one of the assessments with a higher score in another.

The course is run in parallel with another course structured in a more traditional way culminating in an exam at the end of the course, which is an important aspect allowing the continuous assessment to fit well in the schedule.

The idea of continuous assessment was introduced to the course in 2020 together with Covid-19 pandemic and the compulsory switch to distance education. For the first two years, the continuous assessment was run from a distance. The assessments were composed of multiple choice, multiple answers, matching, calculations, or short essay-type questions. Then, the students were allowed to use the learning material freely when answering the assessment questions. However, they were receiving the questions in a shuffled order, and they were not able to backtrack the questions. Hence, they were asked to take their time, answer one question at a time, based on their own knowledge and with the help of the available sources, and then submit their answer. By limiting the backtracking option, the risk of copying answers between the students was reduced as they were working on different questions at every moment. The total assessment duration was also limited so the students were focused on producing their own answers. Although all information sources such as slides, the course book, and online sources were available to the students, the assessment results indicated varying performance across students and within different assessments. The students provided feedback stating that having all sources available was reducing their amount of stress to prepare for an assessment, but it was not enough to answer all questions correctly as the questions required knowledge about the different concepts or analytical abilities to combine learnings from different lectures. Hence, they confirmed that without studying the course material, it was not possible to get higher grades from the assessments.

After two years, all course activity was returned to the real-life format including the assessments. During the third year, the assessment format was kept but the assessments were run in the classroom. The students brought their computers and used the same digital interface to answer the questions. All sources were still open. The teacher team was observing them during the assessments as they were not allowed to copy from each other or discuss with each other.

The CSs analyzed within the scope of this study are from the fourth year of the continuous assessments in this course. The fourth year of the course was challenged by the introduction of open-source AI tools. The availability of such tools made it impossible to allow the students to have all sources open because these tools can answer most of the the potential assessment questions. Normally, even if the information sources were available, the students kept learning by searching for information, remembering concepts from the lectures, referring to related concepts, or combining information. However, with AI tools this learning opportunity was no longer feasible. To tackle the AI challenge, two big changes were introduced to the assessment system. The first one was the assessment interface – a safe exam browser was introduced as the digital interface instead of the course management platform. The safe exam browser runs in a system that blocks all the other web pages and allows the user to work only on the exam browser. This eliminated the use of online AI tools. The second change was the introduction of the individual CSs and replacing the open book/open-source structure of student support with an A4 CS. The open book/open-source structure was causing the students to look for a certain slide from lecture presentations on their computers, information online from the internet or a certain page in the book. During the former in-class assessments, it was observed that this created disturbance and stress. For those students who had studied the material already, it was not difficult to find what they were looking for. But for other students, speed searching became the main capability during in-class assessments. Hence, CSs were introduced to limit the available support during an assessment to 1xA4 page (both sides) but still keep the supporting material and eliminate the need to memorize formulas or definitions. However, with this replacement, CSs became also a source of studying before the exams because students needed to prepare them ahead instead of just bringing a book or printed slides.

4 Data collection and analysis

The student group was composed of third-year bachelor students, marking the final year of their program, from both the home university and a few on an exchange program. In total, 49 students were enrolled in the course, and all of them were required to undergo mandatory continuous assessments. The students of the main program had not been previously exposed to preparing or using CSs.

The students were suggested to create CSs four times during the course, preceding every occasion of the continuous assessment. Starting from assessment 2, some students opted not to utilize the opportunity to prepare or to bring a CS to the assessment. CSs were collected and then used for analysis, with rare exceptions when students preferred to retain their copies but allowed the teachers to take a photo of their CSs. Several CSs were not collected for various reasons. It came to our attention that sometimes students forgot to bring their CSs and had to prepare a second one shortly before the assessment; there was no opportunity to distinguish such CSs in this investigation. A total of 163 CSs were collected and analyzed: 36 from Assessment 1, 37 from Assessment 2, 45 from Assessment 3, and 44 from Assessment 4. For assessments 2 through 4, the submission time was recorded (the specific moment when students considered their work on the assessment finished).

The only requirements for the CSs were that they fit within one A4 sheet and that they contain the student's own work. However, after the second assessment, one of the teachers engaged in a 10-minute interaction with students. During this interaction, the teacher shared previous research findings about the impact of CSs on students' performance (described earlier in the Literature Review). On the same occasion, a 3-question questionnaire among students was conducted to understand what they found most effective for themselves and how their CS preparation methods had evolved from the first to the second CS they created. The results of this questionnaire were provided to the students before the third assessment. Students' perceptions about their experience of preparing and using CSs were also collected after the course was over.

In such research where user generated primary data is used, the General Data Protection Regulation (GDPR) considerations are of utmost importance. In this study, the Data Security Department at the university was consulted to ensure that the data is treated ethically and that there are no violations in its use.

The CSs were coded for further analysis. The data coding scheme emerged throughout the work, inspired by both the material at hand and the previously described examples from academic literature. For every code, each CS was assessed by manually placing each exemplar into emerging groups and comparing each subsequent one to the ones previously assigned to the groups, to ensure consistency within every group.

The *density* of the CSs was described on a scale from one to seven. A score of one indicated a sparse layout (resulted in a single example containing a single table); a score of four indicated a well-organized, well-readable format like a typical academic paper; a score of seven described densely packed CSs with tiny fonts. This analysis required a comparative approach, as some CSs, for example, utilized tiny fonts, but occupied only one side of the A4 page.

Next, the *method of production* was described, distinguishing between handwritten and typed. CSs ranged from fully typed with no handwritten elements to those entirely handwritten with some falling in the middle of the two.

Further, the *use of color and other formatting elements*, such as headings and subheadings, was considered. Regarding headings, the scale ranged from one to three, with one representing a simple text format and three indicating the presence of two or more levels of headings. The color coding was analyzed using a scale from zero to four, representing different degrees of color utilization: a score of zero represented an absence of color (except for colorful screenshots). A score of two reflected a consistent use of color throughout the text. A score of four indicated extensive and diverse use of color throughout the document.

In addition, the *type of content* was considered, distinguishing between text and tables/figures. A score of zero indicated an absence of tables and figures, while a score of two represented the presence of three or more such elements.

5 Results

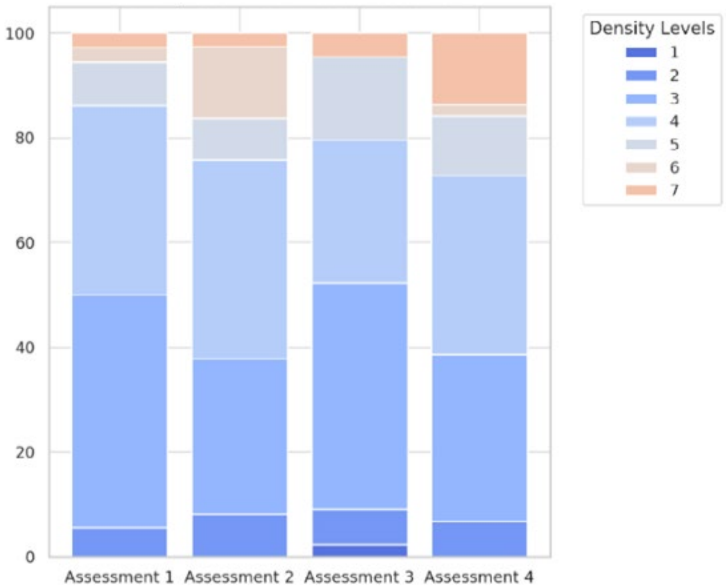
Cheat Sheets Variation

Table 2. General description

Parameter	Assessment 1	Assessment 2	Assessment 3	Assessment 4
Time, average	-	74 (82,13%)	48 (53,48%)	42 (46,34%)
Time, median	-	75	46	41
Time, standard deviation	-	13,69	13,96	19,10
Density, average	4	4	4	4
Density, standard deviation	1,01	1,25	1,19	1,43
Density, median	4	4	3	4

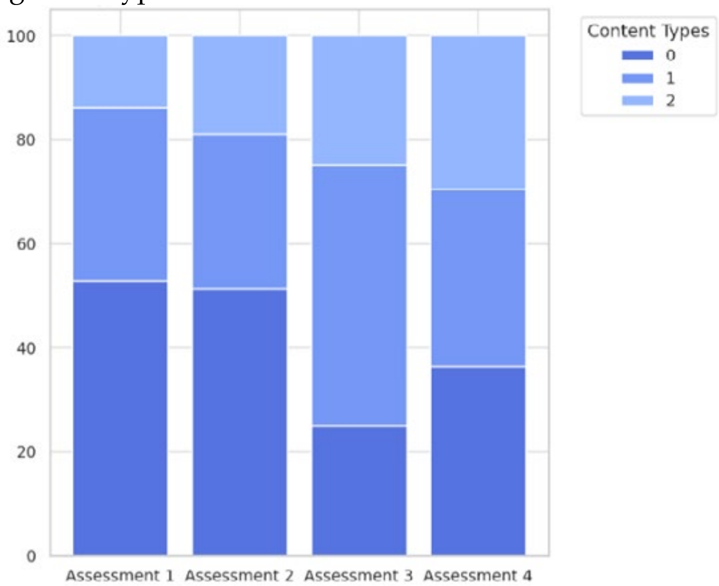
The average time spent on the assessment recorded for Assessments 2, 3, and 4 shows a decrease as the assessments progress. Specifically, the time decreased from 74 minutes on average in Assessment 1 to 42 minutes in Assessment 4. Similarly, the median time dropped from 75 minutes to 41. While the standard deviation of the time students spent on Assessments 2 and 3 was quite similar (13,69 and 13,96), it increased to 19,1 in Assessment 4. This increase may be attributed to various factors, possibly linked to students' varying ambitions for achieving their desired scores as they came to Assessment 4 with the knowledge of how the score for the assessment can affect their final score.

Figure 1. Density Distribution Across Assessments



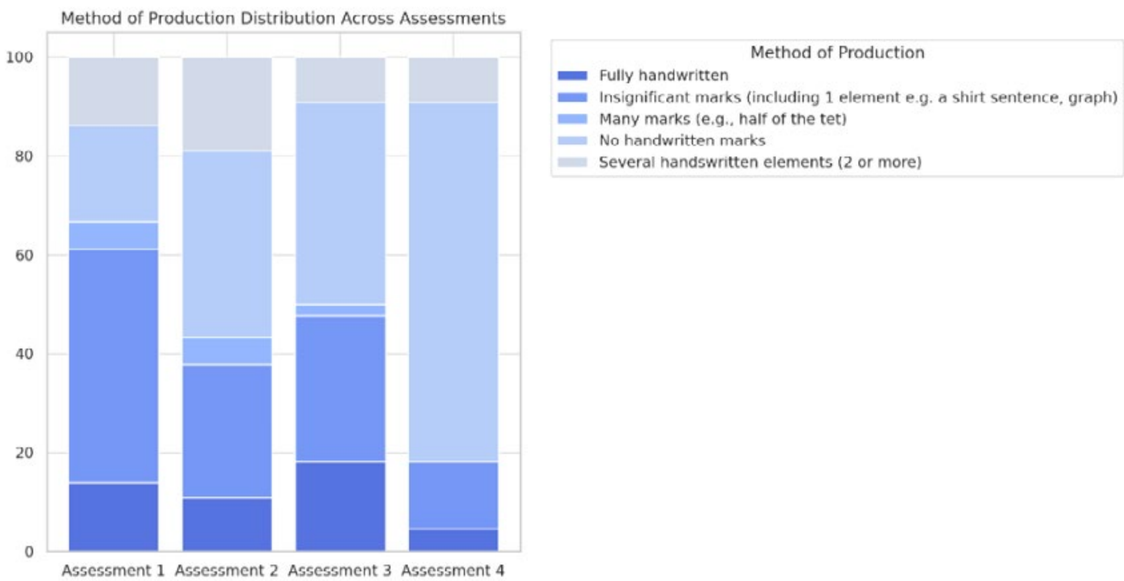
Regarding density, in Table 1 and Figure 1, it is observed that the average density had remained constant at 4, with the median following the same tendency, except for Assessment 3 where it dropped to 3. The standard deviation in density was lowest for Assessment 1, suggesting that many CSs were similar (looking somewhat resembling an academic paper in appearance and type of text). However, standard deviation increased for subsequent assignments, indicating a higher variation and a more diverse approach among students in deciding how much material to include. There is a clear distinction when it comes to the density of the CS between assessments 1 and 3 when compared to 2 and 4. One possible explanation is the different "complexity" of the assessments. Depending on the topic coverage, some tests included more verbal content than the other tests containing more mathematical problems and thus requiring more calculation skills. Regardless of this complexity, all four tests were solvable within the provided time and no complaints were received about the duration of the tests. However, in some cases, for instance at the last test, some students handed in their answers quite early as they had enough points already from the first three tests to pass the course. Hence, without any ambitions for a higher grade, they settled for a minimum point from the final test. In relation to that, another interesting analysis could be to explore the relation between density and duration it took for students to complete the assessment because the ambition level can also be a determining factor in CS density.

Figure 2. Type of Content Distribution Across Assessments



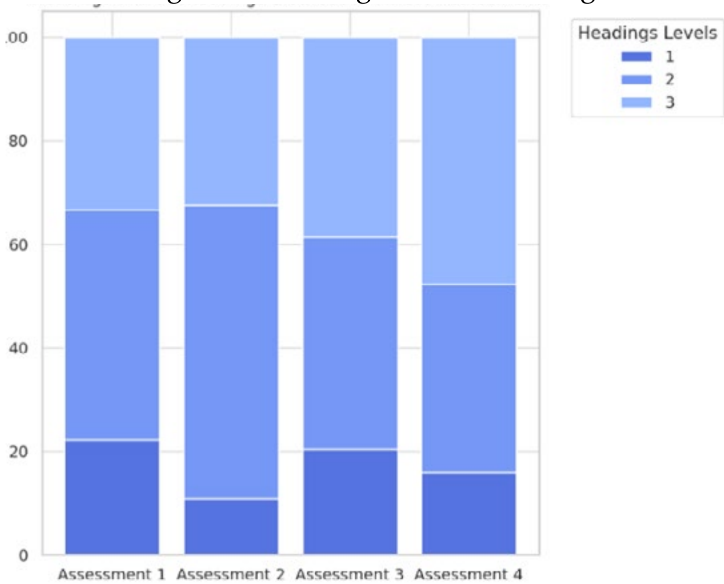
In Figure 2, 0 represents the absence of tables/graphs; 2 represents having three or more of them. It is apparent that students began incorporating more visuals over time, yet 25-35% of students opted to maintain the use of pure text still in Assignments 3 and 4. Gradually, the number of students using more visual elements in their CSs increased from 5 to 13. In contrast, the percentage of students using basic content was decreasing over time.

Figure 3. Headings and Subheadings Distribution Across Assessments



Examining the method of production reveals a significant shift in fully typed CSs across assessments. In the first assessment, there were 7 fully typed CSs (no handwritten marks), contrasting sharply with the final assessment, with a more than four-times increase to 32. However, when combining fully typed CSs with those featuring insignificant handwritten marks, the variance becomes less pronounced across all assignments, fluctuating between 24 and 38. In terms of CSs that are fully or largely handwritten, 6 to 9 students opted to handwrite their CSs for the first three assignments, while only 2 chose to do so for the final one.

Figure 4. Headings and subheadings



In Figure 4, 1 means no subheadings are present, whereas in 2 and 3, one and two or more levels of subheadings are present, respectively. The majority of students opted to incorporate at least one level of subheadings, and frequently, two levels, to structure their CSs.

Students' feedback

Intervention after Assessment 2

33 students commented on the CSs during the intervention. Reported changes in approach to producing CSs between the first and second assessments varied among individuals. Some respondents did not notice any significant changes. Several individuals reduced the amount of text. Some reported a reduction in the size of the second CS, associated with the fewer lectures and chapters included in the second assessment. One person stated not creating the second CS at all. Another participant reported shifting their focus to important keywords rather than presenting "a wall of text". Another individual reported a switch from handwritten to computer-typed CS, and a few individuals mentioned using more formulas in the second CS than in the first one. Some enhanced the structure by using PowerPoint, colors, bullet points, and shorter sentences in the second CS.

Course evaluation after the course

13 to 15 students answered the question regarding the CSs in the centrally held course evaluation questionnaire. Many respondents expressed positive sentiments about CSs, mentioning that the CSs worked surprisingly well and helped in managing short periods between assessments. Some individuals had mixed feelings, mentioning that they did not need to use them extensively. Some respondents suggest improvements, such as being clearer about what is allowed on CSs. Others suggested using bullet points instead of full sentences and emphasized the importance of reading through materials and highlighting essential information.

6 DISCUSSION & IMPLICATIONS

The primary implication of this study is that in settings similar to those described in this case – specifically, a continuous assessment examination within a bachelor course heavily focused on concepts and theories – the CSs are popular among students if permitted by the teachers and are being used as a study aids. We consider it as meeting the purpose of introducing such an opportunity for the students, therefor, an effective study aid. Our investigation into student strategies for creating CSs revealed a correlation between the density of these CSs and the time students dedicated to assessment (the time they used until they considered the assignment complete and ready for submission). While time spent is not claimed in the study as a direct indicator of a student's performance, it might indicate a student's own perception of being ready with the assessment and comprehension of the material, especially considering that the majority of in most cases students submitted the assessments before time ran out. Here we assume that the complexity of the different tests was comparable. Therefore, it is considered beneficial to offer students the opportunity to create a CS as a study aid for such assessments. Additionally, it was observed that the density of content began to vary as students gained more experience in preparing their own CSs. Notably, the densest CSs led students to spend more time on the assignment before deciding it was ready for submission. Based on this observation, we assume that students with less dense CSs spent more time preparing and elaborating on their material, and therefore felt ready with their assignment sooner, while students with denser CSs had to analyze their material more during the examination and were therefore less prepared. We therefore suggest that guidelines could address the density of CSs, advocating for avoiding the use of minimal fonts (avoiding high density of CSs) for the students to use the assessment time more effectively. Additionally, students frequently employed a tree structure when organizing content in their CSs, often dividing the text into one or two and even three levels. This consistent strategy suggests its effectiveness in structuring information for both preparing for the assessment, and information retrieval during the assessment and shall be encouraged in future implementations.

The use of fully handwritten CSs and the ones with handwritten marks had reduced over the course in comparison to fully typed exemplars, which is counterintuitive from a learning perspective. The idea of reworking one's own material into CSs was one of the goals of introducing such aids, and therefore, despite this tendency, it should be discouraged in future implementations. Notably, for the first three assignments, students actively used colors, meta-text, marks, and underlying and highlighting methods, but significantly reduced their usage in the last iteration, for Assessment 4. This reduction might be related to the fact that many knew that they did not need to work extra as they had estimated grades and settled with what they had estimated. Additionally, students spent a lot less time on average on the last assignment which may be another indicator of the same. To further encourage learning, the use of handwritten CSs and marks in any of their versions shall be encouraged, as well as redesigning the grading scheme to avoid such a situation where students may choose not to prepare properly for the last assessment.

Within the study, the content of the CS in terms of being complete copies of slides or reproduced material in the student's own words was not systematically assessed due to its complexity and the lack of resources required to undertake such an analysis. Such analysis would necessitate a more automated method to assess such parameters, which could provide deeper insights into the evolution of the CSs and potentially reveal interesting findings about what actually works best (or does not) with CSs.

7 CONCLUSIONS

While CSs were introduced as part of continuous improvement associated with the course, based on student feedback analyzed by teachers, and not directly due to the rapid appearance and spread of generative AI, the CSs became timely aids for continuous assessment instead of the previously used open book format. Several implications were drawn based on CSs' analysis, suggesting guidelines on how to instruct students to prepare CSs to enhance their learning. The implications include recommendations to encourage students, while preparing their CSs, to be reasonable with the size of the font and to carefully consider what material to include on the CSs and what to leave out. This can be practically achieved by limiting the density (font size). A tree structure of notes is naturally chosen by many students and is therefore considered a convenient way to structure and access material. Finally, the use of colorful pens or handwritten notes, if not a fully handwritten CS, is also encouraged as a means to elaborate on the material prior to the examination. This approach encourages students to work on their material more before the exam, making them more familiar with it during the actual examination.

To conclude this paper, we would like to share a quote from one student that reflects their perception of their own experience with CSs, which ultimately (perhaps without students' awareness of it) led them to the level of preparedness for the assessment expected by the teacher team following the introduction of CSs: "*Barely used any of it (CS)… Did not feel I needed it*".

We prepared a basic exploratory analysis of how the variables behave across the assessment. In further research we can apply quantitative methods to understand what these relations could reveal. How long the students took to finish the exam is a variable that can mediate the effects of CS production. We plan to explore how the duration of the exam is affected by the method of production of the CS. In addition, further interesting results can be driven by studying when the students prepare their CSs before assessments and the relationship between their preparation time and their final results.

References

De Raadt, M. (2012, January). Student created cheat-sheets in examinations: Impact on student outcomes. In *Proceedings of the Fourteenth Australasian Computing Education Conference* (Vol. 123, pp. 71-76).

Dickson, K. L., & Bauer, J. J. (2008). Do students learn course material during crib sheet construction?. *Teaching of Psychology*, 35(2), 117-120.

Dickson, K. L., & Miller, M. D. (2005). Authorized crib cards do not improve exam performance. *Teaching of Psychology*, 32(4), 230-233.

Edwards, A., & Loch, B. (2015). A preliminary categorization of what mathematics undergraduate students include on exam "crib sheets". In *Conference on research in undergraduate mathematics education* (pp. 47-51).

Erbe, B. (2007). Reducing test anxiety while increasing learning: The cheat sheet. *College teaching*, 55(3), 96-98.

Funk, S. C., & Dickson, K. L. (2011). Crib card use during tests: Helpful or a crutch?. *Teaching of Psychology*, 38(2), 114-117.

Gharib, A., Phillips, W., & Mathew, N. (2012). Cheat Sheet or Open-Book? A Comparison of the Effects of Exam Types on Performance, Retention, and Anxiety. *Online Submission*, 2(8), 469-478.

Hamouda, S., & Shaffer, C. A. (2016). Crib sheets and exam performance in a data structures course. *Computer Science Education*, 26(1), 1-26.

Ludorf, M. R., & Clark, S. O. (2014). Help sheet content predicts test performance. *Essays from Excellence in Teaching* Volume XIII, 60.

Song, Y., & Thuente, D. (2015, October). A quantitative case study in engineering of the efficacy of quality cheat-sheets. In 2015 *IEEE Frontiers in Education Conference* (FIE) (pp. 1-7). IEEE.

Implementation of Flipped Classroom in a Master-level Chemical Engineering Course: Lessons Learned from our Experience

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26 July 2024

Abstract

Motivated by reported benefits of the "flipped classroom" methodology, we attempted to implement flipped classroom in the "exercise sessions" of our master-level chemical engineering course. We are not experts in any pedagogical field, and during our first two attempts we experienced difficulties teaching in a way which motivated higher levels of active student participation. Based on our observations and feedback from students, we believe that our third attempt was more successful. Here we summarise the differences in how we designed the exercise sessions of our course from 2022 to 2024 and explain our thoughts about why we observed a more active classroom atmosphere on our third attempt. We also reflect on the lessons we think we can use in our future teaching.

Keywords: flipped classroom, active learning, student participation

Introduction

"Flipped classroom" is a teaching methodology where students prepare for time in the classroom by reading texts and watching video lectures so that in-class time can be devoted to problem-solving and interactions between students and teachers. Research on flipped classroom has been conducted for general cases (Bishop & Verleger, 2013; Buhl-Wiggers et al., 2023), and specifically for engineering education (Lo & Hew, 2019; Kerr, 2015; Karabulut-Ilgu et al., 2018).

The authors of this proceeding attempted to apply the concept of flipped classroom to their teaching of the course "Advanced Chemical Engineering and Process Analytical Technology" (ACEPAT). This is an elective course attended mainly by master students in the programme "Innovative and sustainable chemical engineering", but students from other courses are permitted to join. The course focuses on "unit operations" (steps in industrial processes) and methods of analysing these operations. To fully understand the course material, students must think about physical phenomena at length scales from the molecular level up to chemical production plants. We expect students to have a basic knowledge about physical chemistry, mass transport, thermodynamics, and process engineering before beginning the course. The problems we ask our students to solve are often multi-step and require drawing knowledge from a combination of topics to reach a solution. We need to interact with our students to identify gaps in their understanding and decide which aspects of the problems we ought to focus on to make efficient use of classroom time. Otherwise, there would not be enough time to cover the theory behind all steps of every problem. Collaboration between students is beneficial because students are likely to have complementary strengths and weaknesses which help them solve problems in teams (Michaelsen & Sweet, 2008; Smith et al., 2009). The importance of teacher-student and student-student interaction was the basis of our motivation to implement the flipped classroom format in our course, which we attempted in 2022, 2023, and 2024.

Despite our best intentions, we had difficulties implementing flipped classroom in a way which helped students experience its benefits. We struggled in 2022 and 2023 to achieve a high level of student participation, which will be described in the "observations" section. In the 2023 course, we planned to collect data for a pedagogical study. However, these efforts were abandoned because we needed to prioritise adjusting our teaching plans over data collection. Although we have not yet received student evaluations for 2024, we believe that we had a more active and engaged class for this version of the course. We believe that the elements of flipped classroom we have implemented have led to an improvement in the frequency and depth of student engagement, but we also acknowledge that some differences in student behaviour could be caused by having a different group of students each year.

We would like to share an account of the problems we encountered, our observations on how students responded to the different versions of the course, and our interpretations about why some ideas worked and others did not. We hope that we can add to the discussion by presenting a non-expert perspective on how teaching methodology applies to a particular context: A master-level engineering course with a class of 10-15 students from various academic backgrounds.

Descriptions of changes made to "exercise sessions"

Several aspects of the ACEPAT course have changed since 2021. The course in 2021 (not flipped classroom) consisted of lectures, exercise sessions, experiments in the laboratory, and a seminar delivered by an engineer at AstraZeneca. The "exercise sessions" focused heavily on calculation-based problems from the textbooks. In these exercise sessions, the teaching assistant (a PhD student) would write out each step of the calculations on the chalkboard over a period of several hours, which generally involved no student interaction. From 2022 onward, we used a flipped classroom model for the exercise sessions. Although there were some changes throughout all areas of the course from 2021 to 2024, we will focus our analysis on the exercise sessions, which is where the most significant changes were made. There were 3 to 5 exercise sessions scheduled each year which were between 1.5 hours and 3 hours long. There was typically a 10-minute break after each hour.

2022: student presentations

As a replacement for the exercise sessions in 2021 the students were divided into groups of 3 or 4 and were assigned a problem from the textbook. Each group was assigned a presentation time when they would explain the relevant theory, equations, and solutions for each problem. All groups of students were asked to attempt the textbook problems that would be featured in the next student presentations before coming to class. There were 9 groups of 3 or 4 students each. With a total of 33 students, this was a significantly larger class than the next two years. Attendance was required for the groups giving presentations that day, but strongly encouraged for all students.

2023: exercise sessions with calculation examples

The 2023 version of the course had only 10 students. Student presentations were eliminated. Instead, students were assigned textbook problems which they were required to submit to Canvas (a web-based learning management system). During the exercise sessions, the class alternated between working together to solve the textbook problems and answering conceptual questions on Mentimeter. Students were informed that the Mentimeter questions corresponded to “conceptual” questions of the exam, while the textbook problems corresponded to “calculation” questions on the exam. Students were asked to read sections from the textbook and view a video lecture before coming to each of the exercise sessions. Attendance was not mandatory, but encouraged.

2024: problem-solving with increased discussion with students

We had 12 students in 2024. This year, the “exercise sessions” were less focused on the students working on problems, and more focused on using conceptual questions to generate discussion between students and the instructor. Students were asked to prepare for each session by reading assigned sections of the textbooks and viewing video lectures. New textbooks were chosen for covering most of the course content based on feedback from student representatives of previous years. We aimed to promote a conversational atmosphere by formulating a series of interesting conceptual questions which felt relevant both to the exam and to understanding of the chemicals industry. These conversations were guided by the instructor, but adapted based on student questions. Students were encouraged to be open about the areas they had the most difficulty understanding. The instructor often asked clarifying questions like “what do you mean specifically when you use that term?” or “is this statement always true, or sometimes true?” because understanding the relationship of topics like mass transport and equilibrium with chemical processes requires precise language. Since some students are not accustomed to being “interrogated”, the instructor repeatedly emphasised that students are not being criticised when they are being questioned, but that the questions are intended to help guide their thinking and that student input is highly appreciated. We also spent a few minutes of each of the exam sessions to clarifying exam expectations. This may have the effects of reducing students’ feelings of uncertainty (Michaelsen & Sweet, 2008) while also motivating the students by reminding them about the direct relevance that the problems have to the exam.

Observations and Interpretation

Our judgement of the effectiveness of the three exercise session formats is bas on observations of student participation during the exercise sessions and our discussions with students. In 2023, we planned to combine students' Mentimeter responses, exam results, and evaluation survey responses to add a quantitative element to our analysis, but we decided against aiming for a quantitative analysis. One reason was that the small class size of ten students would mean that the sample sizes would be quite small, but the main reason was that we wanted to make adjustments to our course as it went on based on student feedback, and these adjustments took priority over the maintaining an "experimental" plan.

2022 exercise sessions

The students were not as engaged and willing to participate in discussions as we had hoped. We observed that students appeared nervous, and were therefore more focused on avoiding mistakes and completing the assignment rather than involving their classmates in discussion. Participation from students in the audience was very rare, and almost all questions following the presentation were asked by the instructor despite students being encouraged to speak.

In hindsight, the behaviour of both the presenting groups and the audience were understandable. Developing an engaging presentation is time consuming, and the students were only given a grade of "pass" on the assignment for completion. Considering that the students have other assignments to focus on, it makes sense that they would focus on completion of the assignment rather than spending additional effort on plans to engage the audience. Although the audience was encouraged to attempt the problems being presented by each group before coming to class, it quickly became apparent that most students did not do this, as they did not answer exercise-specific questions from the instructor when asked, but were more likely to answer general questions. It is also possible that the students in the audience would avoid asking questions to the presenting group so that they would not make the presentation more difficult for their classmates.

Even if these assumptions are incorrect, we still do not think that student presentations are an effective format to teach calculation exercises. This is because solving calculation exercises is not a very flexible task, so it limits the scope of the discussion that the students could have about it. Perhaps student presentations could be effective in a case where students explain their decision making on a self-directed project, but presentation textbook problems ultimately felt unnecessary. Students spent most of their in-class time watching presentations rather than problem solving. For these reasons, we decided to change the exercise sessions for 2023 to increase the time that students spend engaged in problem solving or discussion.

2023 exercise sessions

Student participation in class significantly increased compared to 2022. We found that Mentimeter was useful for stimulating student participation because we could require all students to anonymously submit an answer to each question. The instructor stood at the front of the class and asked guiding questions related to the problems the students had attempted immediately before. The students seemed to be more motivated to ask questions when they are attempting to solve a problem which contains conceptual challenges. Although all students participated in the Mentimeter questions, about three students (out of ten) contributed most of the student participation in the discussions. It is unclear whether students who listened to discussions learned as much as the students who participated.

We observed that students did not appear to be focused on the textbook problems when time was given to the students to work together. In a student representative meeting, some students told us that the exercise sessions had too much switching back and forth between activities. The Mentimeter questions and the instructor's questioning were quite demanding, and students seemed mentally tired by the end of the sessions. The apparent lack of focus on the textbook problems may have been a result of students needing time to transition between tasks and preparing for the next round of Mentimeter questions. The initial reason for allocating time in class for solving textbook problems was so that students would have an opportunity to ask questions or work with the instructor. Once we saw our plan in practice, it seemed that we tried to incorporate too many tasks in too little time. Therefore, we changed the exercise sessions in 2024 to focus more deeply on a smaller number of tasks.

2024 Exercise Sessions

Student engagement and participation were the highest in 2024 by a large margin. Students appeared more comfortable speaking in discussions, helped each other often, and frequently asked thoughtful questions. We noticed these differences immediately, as the students appeared more engaged even in the course introduction. Although we do believe that our 2024 exercise sessions were an improvement from 2022 and 2023, it seemed that there were also differences in how this group of students interacted with each other and with teachers which were independent of our teaching plans. For example, a group of students who are familiar with each other may be more willing to speak openly than a group of students who are meeting for the first time. It is also possible that the group's behaviour could be influenced by the personalities of individual students (Felder et al., 2002). Tendencies in the collective behaviour of a group of students could be considered an uncontrolled variable. Since student participation was already frequent, we decided not to use Mentimeter. We believe that Mentimeter can be a valuable tool for encouraging student participation. If students are hesitant to reveal their answers and justifications aloud, Mentimeter can help the instructor learn about the students' thoughts anonymously. However, Mentimeter has a disadvantage of interrupting the flow of conversation, since the Mentimeter questions are pre-planned. One of the main advantages of teacher-student interaction is that it allows the teacher to adjust their questioning in response to students' statements. Making these subtle adjustments in the teaching plan is more difficult when a linear Mentimeter presentation is followed. The anonymity of the Mentimeter responses makes it harder for the teacher to make connections between students' thoughts because the teacher does not know which responses were sent by which students. Since we observed that this group of students appeared comfortable asking questions and helping each other, we decided that the value of this person-to-person communication outweighed the advantages of Mentimeter.

In 2024, we observed an increased "thoughtfulness" of student questions, and much of the class discussions were focused on understanding the core principles which govern the processes, rather than focusing on completion of a problem. Again, these differences might have been related to the uncontrolled variable of the group's interaction tendencies. Although, it is also possible that the instructor was more effective communicator this year due to having more experience with the course. There was also additional time between 2023 and 2024 to develop more interesting problems which piqued students' interests. Our interpretation is that a mixture of these factors contributed to the improved classroom atmosphere in 2024.

Reflection

In many ways, our original plan to improve our course while carrying out a pedagogical study raised more questions than it answered. We chose not to continue collecting data for a quantitative analysis because we the need to fix problems with our teaching took priority over continuing previously made plans. For example, we planned to analyse student responses in Mentimeter, but we decided to stop using Mentimeter in 2024. Additionally, we planned to use responses to the course evaluation in our analysis, but the class size was unexpectedly reduced to one third of its size from 2022 to 2023, and we received only three responses (out of ten) on the course evaluation. The student representative meetings were, however, a very useful source of feedback.

Although we did not complete it, planning a quantitative pedagogical study was still an informative experience because caused us to think about the complex relationships between students, teachers, course content, and learning objectives. Throughout these years, we sometimes questioned the specific goals we had for our course. We also wondered about what we are supposed to be "doing" as teachers, and what we can offer students that would be difficult to acquire on their own. The shift to online courses due to Covid-19, the increased availability of educational materials on the internet, and speculation about the future role of artificial intelligence (Bearman et al., 2023) are putting pressure on universities to identify the benefits that can be uniquely offered by in-person teaching. Our experience suggests that two-way communication with students and the maintenance of an effective learning environment are important parts of the answer.

We had relatively small class sizes the past two years of our course (10 students in 2023 and 12 students in 2024) with students coming from Chalmers bachelor programmes, international bachelor programmes, and Erasmus. Some students studied topics other than chemical engineering in their bachelor. It was therefore necessary to teach flexibly from one moment to the next, responding to students' apparent level of understanding the material. A major advantage of in-person teaching with a small class size is that the teacher can communicate with students to identify the gaps in their understanding. The teacher can ask immediate follow-up questions to judge whether their explanations are having the desired effect. We perhaps underestimated the importance of these advantages when planning the exercise sessions in 2022 and 2023. Our first instinct was to focus on the "structure" of the in-class time, which seemed necessary due to the broad range of topics that needed to be covered. However, the focus on completion of the plan for the day rather than on taking time to deepen fundamental understanding may have created a classroom environment which felt more like an assessment than an opportunity for conversation.

Especially for small class sizes, personal interaction can provide significant advantages (Pollock et al., 2011) that are difficult to offer in any other setting. We aim to maximize these advantages by using the exercise sessions to identify the parts of the course material which are most challenging for students. We can then focus our efforts on conversing with the students about these topics. We also must maintain a classroom atmosphere where students feel comfortable asking questions and are encouraged to help each other. We believe that the more open and personal classroom atmosphere was the main factor that explains the increased student participation in 2024, and we hope to maintain this atmosphere in the future.

Conclusion

Although we initially had some difficulty teaching the exercise sessions for our course in a way which facilitated student participation in discussions, we were satisfied with what we observed in the exercise sessions in 2024. We believe that maintaining a personal atmosphere focused on discussion of the main ideas of the course was the approach that best took advantage of the small class size. We think that our positive experience of student participation was also dependent on the 2024 group of students having tendencies for group interaction which made them receptive to this format. If the students in next year's class are less receptive to open discussion, we could try to "get started" by using Mentimeter to keep the sessions moving. Hopefully, we could transition over time to the open, conversational format which we consider ideal for a small class size. Our attempt to include a quantitative aspect in our pedagogical study gave us insight into the difficulty of considering the many variables which effect students' educational experience. We feel that adaptability, whether it be adapting explanations of course concepts to a student's current level of understanding or making subtle adjustments to teaching style to fit a particular group of students, is an important skill to have for teaching a flipped classroom course. When class sizes and students' educational backgrounds vary from year to year, there may be no "optimal" teaching plan. We believe that the opportunity to connect with students, adapt to their needs, and develop an environment of open communication are some of the reasons that in-person teaching still holds an advantage over the alternatives.

References

Bearman, M., Ryan, J. & Ajjawi, R. Discourses of artificial intelligence in higher education: a critical literature review. *High. Educ.* **86**, 369–385 (2023).

Bishop, J. L. & Verleger, M. A. The flipped classroom: A survey of the research. *ASEE Annu. Conf. Expo. Conf. Proc.* (2013).

Buhl-Wiggers, J., la Cour, L. & Kjærgaard, A. L. Insights from a randomized controlled trial of flipped classroom on academic achievement: the challenge of student resistance. *Int. J. Educ. Technol. High. Educ.* **20**, (2023).

Felder, R. M., Felder, G. N. & Dietz, E. J. The effects of personality type on engineering student performance and attitudes. *J. Eng. Educ.* **91**, 3–17 (2002).

Karabulut-Ilgu, A., Jaramillo Cherrez, N. & Jahren, C. T. A systematic review of research on the flipped learning method in engineering education. *Br. J. Educ. Technol.* **49**, 398–411 (2018).

Kerr, B. The flipped classroom in engineering education: A survey of the research. *Proc. 2015 Int. Conf. Interact. Collab. Learn. ICL 2015* 815–818 (2015).

Lo, C. K. & Hew, K. F. The impact of flipped classrooms on student achievement in engineering education: A meta-analysis of 10 years of research. *J. Eng. Educ.* **108**, 523–546 (2019).

Michaelsen, L. K. & Sweet, M. The essential elements of team-based learning. *New Dir. Teach. Learn.* **2008**, 7–27 (2008).

Pollock, P. H., Hamann, K. & Wilson, B. M. Learning through discussions: Comparing the benefits of small-group and large-class settings. *J. Polit. Sci. Educ.* **7**, 48–64 (2011).

Smith, M. K. *et al.* Why Peer Discussion Improves Student Performance on In-Class Concept Questions. *Science* **323**, 122–124 (2009).

How can we motivate and engage our students to develop their technical writing skills?

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Abstract

Students at Chalmers University of Technology are often not as motivated nor engaged in developing their technical writing skills as they are their discipline skills and knowledge. This paper discusses the adjustments to a writing intervention aimed at addressing this issue. The students should develop how they discuss and integrate figures or tables in a text, *data commentary writing*. But they made minimal writing development progress and, significantly, showed little interest in doing so. Observations made during a new run of the course identified four specific teaching elements which contributed to increasing the students' motivation and engagement in developing their writing: the use of students' own writing for analysis and discussion, having dedicated time in class to addressing teacher feedback, including reflection tasks to help students internalize the new knowledge, and having closer collaboration between writing and technical instructors in the planning and teaching.

Sammanfattning

Studenter vid Chalmers tekniska högskola är ofta inte lika motiverade eller engagerade i att utveckla sina tekniska skrivfärdigheter som de är i deras disciplinfärdigheter och -kunskaper. Den här artikeln diskuterar justeringar av ett skrivinslag som försökte lösa problemet. Studenterna ska utveckla hur de diskuterar och integrerar figurer och tabeller i en text, *datakommentarsskrivning*. Men de gjorde ytterst små framsteg med att utveckla denna skicklighet och visade anmärkningsvärt litet intresse i att göra det. Observationerna gjorda under en ny kursomgång identifierade fyra specifika lärande inslag som bidrog till att öka studenternas motivation och engagemang i att utveckla deras skrivande: användning av studenternas egna texter för analys och diskussion, tid i klassrummet dedikerad till att hantera läraråterkoppling, inkluderande av reflektionsuppgifter för att hjälpa studenter internalisera den nya kunskapen, och närmare samarbete mellan skrivande och tekniska instruktörer i planeringen och undervisningen.

Keywords: *student motivation; commenting on data with tables and figures commentary writing; technical writing skills; manageable writing task; instructor collaboration.*

1 Introduction

While teaching communication skills at Chalmers University of Technology, I have observed that a significant proportion of undergraduate students exhibit a lack of interest and motivation in enhancing their written communication abilities, or at least they do not prioritize this aspect of their education. It is not uncommon for first-year students to claim that they have previously engaged in similar writing activities, indicating that they are under the impression that their writing proficiency is adequate for technical and academic writing contexts. They fail to recognize the integral relationship between the refinement of their writing skills and their technical disciplinary knowledge and that effective writing is instrumental in demonstrating their expertise within their technical field. In the second and third years of their studies, many students continue with this attitude. Generally, only when they must write their bachelor theses is the significance of writing proficiency and the need for guidance and support recognized. While it may be true for some that they already have strong writing skills, there is a group of students who would decidedly benefit from further development of these skills.

As part of a development project in one of Chalmers' teaching diploma courses, I took the opportunity to investigate and develop this student motivational and engagement problem within a course intervention focused on technical writing skills. It is a 1.5 credit intervention of a third-year 7.5-credit course, Applied control system design, in the Mechatronics Engineering program. The course is scheduled during the autumn term, which is delivered in English, allowing for exchange students to also attend the course. They take the course alongside the mechatronics students as well as a few electrical engineering students who can take it as an elective. In the intervention, two written assignments practicing a specific writing skill, *data commentary writing*, are produced: one is a short exercise; the other a longer, complete paper. For logistical reasons, the students write in groups of three.

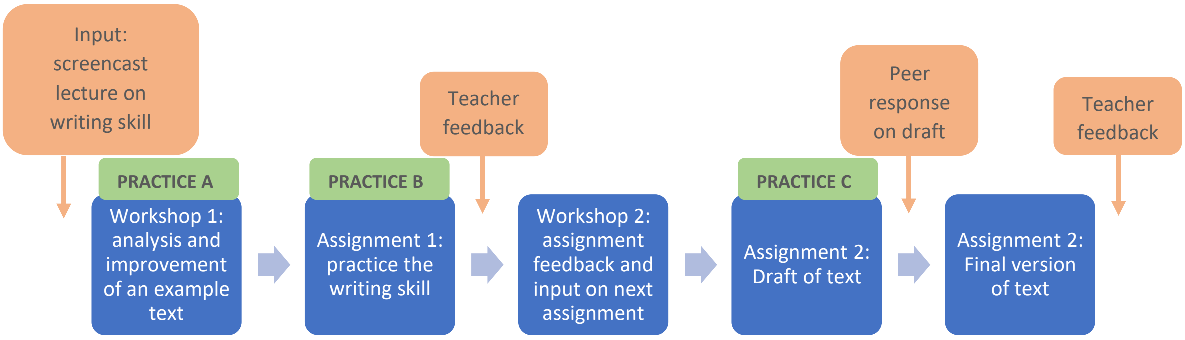
During the first run of the course, it was evident from the assignments, conversations with students, and classroom observations that student interest in developing their technical writing skills was minimal. The students believed they could write well enough. Despite this belief, all groups were required to revise both assignments because there was little change in their approach to the writing skill since the start of the intervention. The students passed the course but had not really transformed their writing approach.

This limited or unsuccessful learning was naturally a disappointment and frustration to me, but I understood that the students' lack of interest in trying to learn this skill was a determining factor and I needed to act on this. Therefore, I initiated my course development project, asking: *How can we motivate and engage our students to develop their technical writing skills?* This was a small-scale observational study of the changes implemented in a course tougher with a brief student survey. It should be noted that although the use of AI-generated text is relevant in the discussion of student motivation to develop their writing skills, at the time of the course development covered in this paper, the topic had not yet taken hold in scholarly debate as it has now, and consequently, this paper does not examine this aspect. This paper examines the correlation between motivation, engagement, and learning. The paper first gives an overview of the writing intervention's original design, and the type of technical writing skill involved. The next part discusses the importance of active learning and stimulating self-determination to induce student learning. The final parts summarize the changes that were implemented and the effect of four particular components. The paper ends by suggesting the next phase for this investigation, focusing on textual comparison.

2 The intervention and data commentary writing

The writing intervention was designed taking into account that skills can develop through practice (Felder & Brent, 2016). Figure 1 illustrates the multiple practice opportunities outlined in the intervention's study sequence.

Figure 1: Overview of the original intervention design



As seen above, the writing skills concept was taught outside the classroom first, and then a workshop followed where the students applied that input (Practice A) in a low stakes writing activity. Thereafter, the first assignment was performed, applying the knowledge again (Practice B). Written teacher feedback followed as well as a feedback overview session together with information about the next assignment in a second workshop. The intention was for the practice and teacher feedback to foster a transfer of knowledge and understanding into the next assignment (Practice C). Before completing the assignment, the students had one more opportunity to apply their knowledge, in the peer feedback occasion on the draft of the final assignment.

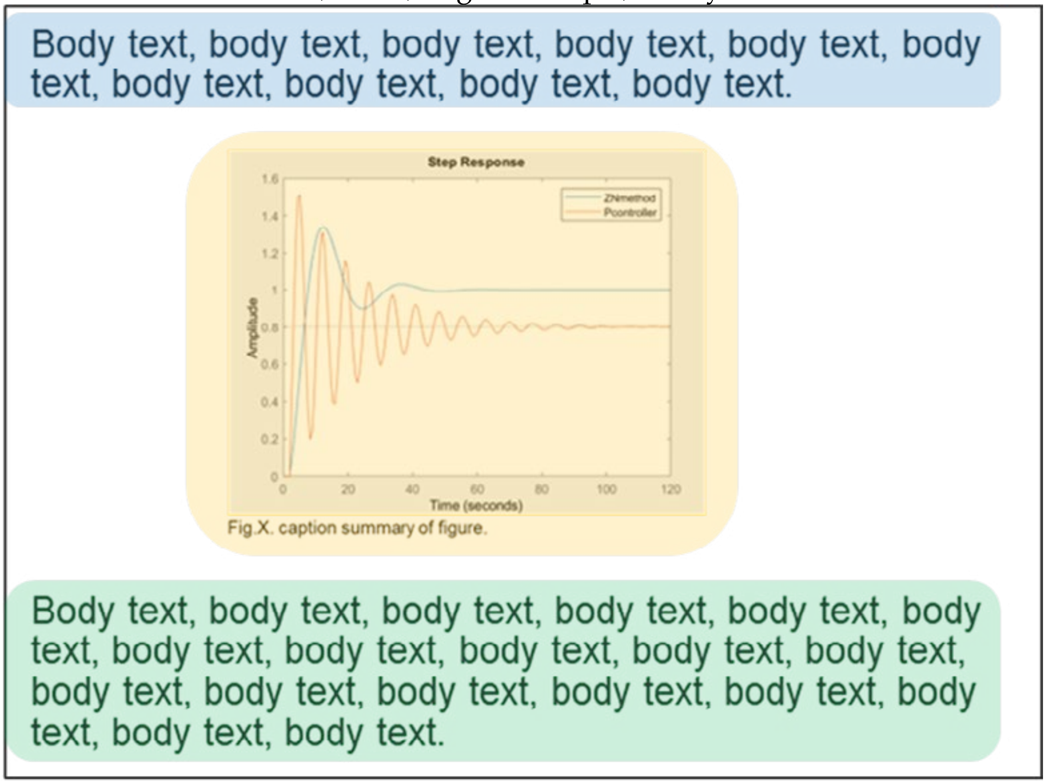
Integral to this process-oriented approach was focusing on a technical writing skill that was relevant to the students and their studies and was also manageable in terms of learning and skill development in just one study period. Developing how to write a whole report can be intimidating, as it is difficult for a teacher and a student to address every aspect of the report genre in the time available. But within a report, there are many smaller text pieces with their own rhetorical features which a learner could really spend time on exploring, practicing and developing. One such text piece is the commentary of visual data.

In technical writing, figures and tables are common components. They visualize details that can be interpreted in more than one way and are therefore not necessarily self-explanatory. They require "textual cues to help direct a reader to the desired interpretation of the evidence" (Poe et al., 2010, p. 115). In my teaching, I refer to the textual cues as *data commentary*, similarly to Swales and Feak's in their chapter on the subject (2012). The commentary not only needs to describe and clarify the data displayed in the visual but also to put the data in context. The integration of this commentary with the visuals within a text is often referred to as *data commentary writing* (DC writing).

Students can have difficulty understanding what the textual cues are. Typically, they think it just concerns the caption of the figure or table, but it also applies to information in the body text. Some students use minimal textual clues there, but minimally like with the phrase "See Fig. 1", which could potentially leave the reader to interpret the data themselves. Other students just give unclear details, sometimes by way of poor terminology and symbol usage, and/or confusing wording and sentence structure.

To develop their DC writing skills in the mechatronics course, students were first expected to consider the different parts of the commentary and their order. They were advised to follow three steps to help with a logical discourse structure: *introduce*, *show*, and *clarify*, as illustrated in Figure 2.

Figure 2: Visualization of data commentary discourse organization steps. In blue: step 1, introduce; in yellow: step 2, show; in green: step 3, clarify.



Step 1, *introduce* (highlighted in blue), concerns content in the main text that gives context and locates the figure or table. Step 2, *show* (highlighted in yellow), concerns the literal display of the figure or table and its caption. And step 3, *clarify* (highlighted in green), concerns content in the main text that explains what details in the visual that are worth observing and their relevance. This three-step approach can seem a bit rigid, certainly when many published papers do not reflect this structure, but it is taught to offer a framework to work from. Naturally, the students were informed that this framework can vary depending on content, discipline, layout, and publication processes of a text. But the emphasis in the intervention was on students producing writing that facilitated the comprehension of the visualized data and its relevance in a logical and coherent fashion.

To produce successful DC writing, a writer needs to write appropriately both rhetorically and scientifically. The technical knowledge and detail cannot be ignored because the DC-writing task involves interpretating data not just deciding which order the information appears (Eriksson & Nordrum, 2018). Consequently, having both content and writing instructors involved in the teaching of this technical skill was a necessity. The content teacher focused on technical knowledge and terminology and the writing teacher on the DC writing approach, as well as aspects of coherence and cohesion.

The assessment focused on these structural and technical details, but also included some more general academic discourse criteria, like paragraphing and language usage and style. Being third year students and having had input on academic writing previously in the program, academic style competence was expected. Poorly executed texts had to be revised in order to pass (all assignments were of the pass-/fail-type).

The first of the two assignments was a short text, concerned mainly with applying the DC writing skill knowledge to one figure, created in the technical part of the course. The reason for starting with a simpler, lower stakes task was to make the new concept more accessible and manageable. The second assignment was a complete text, a comparison of two technical methods. The comparison was considered advantageous as it needed multiple figures, so more than one instance of DC writing. This gave the students the opportunity to apply their practiced knowledge in a more complex context.

Despite what I thought was a well-planned study sequence and choice of writing skill to work on, the students seemed to learn very little; the final assignment was minimally, if at all, influenced by the course's instruction and feedback. Additionally, the way the students also minimally approached the revision of the assignment was for me a red flag. I thus embarked upon reviewing the entire learning sequence, starting first by reflecting on my pedagogical approach.

3 Motivating and engaging student learning

If someone successfully learns something new, they make a transition from the liminal space, the aspect in a learner's development where they start to transform their thinking (Land et al, 2014). If a learner is still uncertain and teeters between what they knew and the new knowledge delivered, then they remain in that liminal space (Kligyte, et al 2022). To help learners transform their thinking, it is necessary to not just focus on what they are learning, but also how. Like Felder and Brent (2016), and many others in the field, I advocate and practice an active-learning approach to my teaching. I want my students to actively participate in the learning process, to work through the knowledge and skill involved, not just sit quietly and listen. In other words, being actively engaged in learning can encourage more complex thought processes in the learner.

In the context of writing skill development, this involves organizing writing activities in the classroom where students apply theory given, like having students analyze or edit a text example and justifying their answers. I incorporate such teaching and learning activities (TLAs) into a systematic, process-oriented learning sequence, which facilitates a logical path between each input and task in the sequence, occurring either in the classroom or through out-of-class activities or assignments. It is not uncommon that a learning sequence ends with a final written product, but it is the journey to reach that final version that is critical: working with examples, composing own text in draft stages, receiving and applying peer and teacher feedback on draft versions, and editing. These planned tasks are active; so, based on the theory, the students will learn.

However, if students do not engage with the tasks, learning will be minimal or not happen. And how deeply a learner engages in the teaching and learning activities depends on their motivation, which can be externally (controlled) or internally (autonomously) driven (Collie & Martin, 2019). The latter is ideal because it is self-determined, in other words involves a personal interest and desire to learn and be challenged. So, optimally, the individual needs to have placed value on the topic being taught, which can in turn foster self-determination to develop the skill or knowledge concerned.

Teachers are involved in controlled motivation. As part of their instruction, they need to help the students identify the personal value in what and how they are learning. If achieved, there could be a greater likelihood that students can transition from the liminal stage and more competently use the skill by the end of the learning period. However, student motivation is sometimes lacking, and this is because of a lack of interest in the subject and thus lack of personal value in the learning. Consequently, when developing a course, it is essential for a teacher to consider how the TLAs can instill personal value in the skills and knowledge being taught to stimulate motivation.

Specific activities that could do this need to be ones that encourage thinking, action, and emotion that can reflect the inclination and drive of a student (Collie & Martin, 2019). In the context of writing skill development, including examples of the writing in focus can be useful. Through text analysis and text editing of these examples, this could help students identify what might be appropriate and effective or not. Moreover, if they are authentic examples, i.e. they are examples of texts that they will need to write, "alignment between task and actual writing to be done" (Swales & Feak, 2023, p.3) can be created, thus further stimulating students' interest and motivation. As Rus' (2015) states, it helps students relate to "see the practical objective of the writing task" (p. 1112).

Formative feedback during the writing process is another way to create interest because it can help the students see what works or what needs developing. By reading and addressing the feedback, the students are engaged in the needs of the text. Another useful motivation activity can be the addition of moments of reflection in the learning sequence like an exit slip or a minute paper (Felder & Brent, 2016, p.62). These are active-learning tasks that encourage the students to take time to think through a concept and what they have been taught, whether it is clear enough, before proceeding to the next step in the learning sequence. It also informs the teacher if they need to act on any issues.

A significant method of stimulating student motivation in the learning of writing skills is having both content and writing teachers involves on theory input, assignment feedback and criteria formulation (Eriksson & Nordrum, 2018). This is something that the intervention discussed in this paper had in the original design. As discussed, effective technical writing is not only dependent on appropriate rhetorical moves and clear language but also on relevant and correct discipline knowledge and understanding. The level of collaboration needs to be close so that the students do not think of technical content and writing as being separate from each other. Instead, through combined instruction, the writing and technical components of technical writing can be shown to be discursively connected.

After reflecting on some of the concepts above and reviewing the TLAs in my learning sequence, I concluded that many components were already quite suitable. The process-oriented approach, the multiple practice opportunities, and the types of TLAs involved (text analysis, reworking a poor example, discussing main feedback points, and peer review) created an active-learning atmosphere. The assignments (practice in class, the practice assignment and final paper) were relevant and manageable. What I felt needed changing related to controlled motivation, i.e. helping the students see the value (the relevance) in what they are learning and helping them internalize the concepts along the way. Therefore, I chose to the implement the following changes: incorporate authentic writing examples, help the students deal with their feedback, use moments of reflection to help the students internalise concepts, and try to have a closer collaboration with the content teacher.

In the first run of the intervention in the mechatronics course, this message was not transmitted; students were not interested or so engaged in the sessions, and they did not change their approach to the writing skill from one task to the next. Action needed to be taken.

4 Monitoring the changes

The redesign was tested in the next course run of the course. During that run, to gain a better understanding of the events as they unfolded and of any correlation between the tasks and what students produced, my observations were recorded in a reflective journal (following a D-I-E-P (describe, interpret, evaluate, plan) formula (Study & Learning Centre, 2007). Details related to student responses and actions, discussions with collaborators, and assignment outcomes were noted. Finally, at the end of the course, the students were asked about their perspective of the usefulness of the TLAs in an anonymous survey.

5 Results and discussion

As hoped, the implemented changes did stimulate motivation and engagement in the students to develop their technical writing skills in the new run of the course. Students engaged considerably more in classroom tasks and their approach to DC writing experienced some level of transformation by the end of the course. Several comments in the survey response reinforce this:

- *The way we learned data commentary. It wasn't to hard but not to easy*
- *It gave me a good approach on how to write data commentary.*
- *…insight into how to present data clearly.*
- *The final writing assignment was good repetition.*
- *I have a more structured way of presenting my data. present -> comment -> discuss, is very useful.*

The attitude is positive and key features of the teaching are noted, for example, "gave me a good approach", "good repetition", and "more structured". Examining my recorded observations from the course, I identified. Four elements that are the likely agents of this outcome. They are summarized and discussed below.

5.1 Use of students' own writing

In the original run, I provided a DC writing example, which I had chosen together with the content teacher, for the task in the first workshop. Although the text was relevant regarding figure-type, the piece of writing was otherwise quite abstract (from what larger text it was from was not clear). In the new run, the students were requested to bring their own examples, ones they deemed "good" and "poor". Their judgement and selection were based on a specifically prepared DC writing theory video that they watched before class. There were a variety of examples. Some from Wikipedia articles, others from online reports or journal articles. But most students brought examples of their own writing from previous courses. The level of engagement in the group discussions around these kinds of examples were high. The students purposefully and animatedly discussed aspects of DC writing and strategies to explain their choices and then to improve the poorer example. Using their own writing generated interest in the skill which then evolved into motivation to develop the skill.

5.2 Dedicated class time to addressing teacher feedback

In the original run, part of the second workshop was allocated to feedback explanation in the form of a lecture and giving the students a few minutes to ask questions. Later in the course, it was discovered that many students had not accessed their feedback, and/or did not know how to access the feedback. This of course affected the learning in sequence. In the new run, half of that workshop was dedicated to following up on the practice assignment. A brief overview of key issues was provided and then the students were given the opportunity to access the written teacher feedback (and shown how), talk about it in their groups and address the feedback. There was time to put questions to the writing teacher about the feedback and time to edit the text. In a subsequent run, the content teacher also attended the session, which added a higher level of value to the technical teacher's role and helped with questions relating to technical details. Giving students time in class to ask feedback-related questions to the teacher, and some time to work with the commented text, generated interest in what was being taught. Having time to improve their work gave an incentive to do the same in the next tasks.

5.3 Inclusion of reflection tasks

A completely new feature of the intervention was the inclusion of reflection tasks. At the end of workshops one and two, the concept of "exit slip" was used. For example, at the end of workshop 1, after the students had discussed and revised the "poor" DC writing example, they were asked via a digital audience response tool: For you personally, what are the key learning points from today's session? These were some anonymous responses:

- *How to structure information around a figure.*
- *To structure your data and elaborate on the important aspects and not just "show and tell"*
- *…make sure the reader receives the information the author intends to reach out with*
- *Make it easy for the reader*

The second workshop focused on asking the students if there were any problems with the tasks/skill. The responses can give a teacher insight into what the students are or are not learning, allowing the teacher to address any difficulties, if necessary, soon after. For the students, this moment of reflection provides each student, not just the groups, an opportunity to think back over a session and internalise the knowledge and experience from it.

5.4 Close collaboration between content and writing instructors

In the original intervention design, collaboration between the writing and technical instructors was already established as a key feature. The collaboration has intensified with each run, with more discussion about what to teach, what to comment on, and helping the content teacher see beyond the technical detail, and the writing teacher see the needs of the genre. This matters greatly when the number of ambiguities in their texts concerning technical details like concepts, terminology, and symbol usage can distract from the overall message. It is thus invaluable that the technical instructor is involved in reading and giving feedback and that there is a dialogue about this between the two experts. This collaboration demonstrates to the students how developing writing skills cannot be separated from their subject knowledge. This was amplified by the team-teaching moment in the second workshop in a second run of the new design. The classroom collaboration seemed to enhance engagement in developing their texts as student activity around addressing feedback was considerably higher than previously.

5.5 Some challenges

Despite the higher engagement and seemingly higher motivation in developing their technical writing skills, some groups still needed to revise the final assignment to pass. However, the reason for not passing was more due to errors in basic writing skills, like paragraph composition and aspects of coherence and cohesion, and basic technical details, like the use of equations and symbols and appropriate terminology rather than the DC writing approach. Even if the framework advice was followed and worked well, the other issues weakened communication to the extent that the technical text, or the data interpretation, was not clear or sometimes incorrect. And as mentioned earlier, effective DC writing is a combination of all aspects functioning well.

6 Conclusion

The findings of this study were somewhat limited because it was only observational with some additional insight from the anonymous student survey. To develop a fuller picture, it could be beneficial to analyze the students' two assignments, comparing the two assignments to discover if there is any evidence of improvement in their writing, and/or comparing the text output across the different course runs.

However, the aim of this study was to see how students could be motivated and engaged to develop their technical writing skills. The answer is: by considering what would make the students place value on what was being taught. After reviewing theory and the TLAs of a writing intervention, four elements were identified as having an impact: utilizing students' own writing for analysis and reworking; dedicating time in class for students to ask questions and address feedback; having reflection tasks at suitable junctures in the learning sequence to ascertain their level of comprehension; and utilizing the combined knowledge of technical and writing instructors. These elements helped the students see the value of what they were learning, stimulating motivation and engagement, encouraging a move toward transforming their knowledge and moving out of the liminal space for this skill.

There is also a fifth element that is key to the students being motivated and engaged, but it is not new. It was in the original design: the DC writing task. DC writing is relevant: a piece of communication that our technical students will produce regularly in the future in various contexts. DC writing is integrated: includes both communication and technical needs and brings content and writing teachers together. DC writing is manageable: is not about writing a full report, as is often the case at Chalmers. A relevant and manageable task helps the students not feel so overwhelmed, increasing the likelihood of engaging in the task.

The study also revealed that some students still had difficulty with basic writing and technical skills, aspects that were not really expected to be such an issue during the third year of undergraduate education. Future runs need to take this into consideration. Additionally, in the most recent run, some stylistic elements like over-sophisticated vocabulary choices or phrase formulations in the latest run indicate that students are now using AI-tools to generate or edit some of their texts. Perhaps it should be investigated to what extent this usage affects the students' learning and development of this technical skill. And considering the focus of this paper, it would also be of interest to know to what extent the use of AI-text support reduces motivation and engagement in learning of technical writing skills. This could have a long-term effect.

References

Collie, R. J., & Martin, A. J. (2019). Motivation and engagement in learning. In *Oxford research encyclopedia of education*.

Eriksson, A. & Nordrum, L. (2018). Unpacking challenges of data commentary writing in master's thesis projects: an insider perspective from chemical engineering. Research in Science & Technological Education, 36(4), 499-520. https://doi.org/10.1080/02635143.2018.1460339

Felder, R. M. & Brent, R. (2016). *Teaching and learning STEM: A practical guide*. John Wiley & Sons.

Kligyte, G., Buck, A., Le Hunte, B., Ulis, S., McGregor, A., & Wilson, B. (2022). Re-imagining transdisciplinary education work through liminality: Creative third space in liminal times. *The Australian educational researcher*, *49*(3), 617-634.

Land, R., Rattray, J., & Vivian, P. (2014). Learning in the liminal space: A semiotic approach to threshold concepts. *Higher education*, *67*, 199-217.
Poe, M., Lerner, N. and Craig, J. (2010). *Learning to Communicate in Science and Engineering: Case Studies from MIT*. Cambridge, MA: MIT Press
Rus, D. (2015). Developing technical writing skills to engineering students. Procedia Technology, 19, 1109-1114. https://doi.org/10.1016/j.protcy.2015.02.158
Study & Learning Centre. (2007). *Reflective writing: DIEP*. RMIT University. https://learninglab.rmit.edu.au/content/how-use-diep.html
Swales, J. M & Feak, C. B. (2012). *Academic Writing for Graduate Students: Essential Tasks and Skills*. Ann Arbor, MI: University of Michigan Press

Learning by teaching in a flipped PhD course

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Abstract

In this paper, we investigate the potential of using learning by teaching to create PhD courses that use flipped classroom teaching. Learning by teaching is a pedagogical approach where students learn the material by teaching it to their peers. Normally, the teacher selects and prepares the material, but we leverage the maturity of our students and ask them to develop the material as well. The course is divided into different modules, and groups of students are responsible for developing and teaching one module each. To help maintain good quality in all modules, the examiner provides detailed guidelines and careful feedback on all material the teaching students develop. Our course survey indicates that both the students and the examiner highly appreciate this course design and that it enables us to develop new high-quality courses without overloading the examiner.

Abstract

I den här artikeln undersöker vi möjligheten att använda lärande genom undervisning för att utveckla doktorandkurser med hjälp av omvänt klassrum. Lärande genom undervisning är en pedagogisk method där studenterna lär sig materialet genom att undervisa sina kamrater. Vanligtvis väljer läraren och förbereder materialet, men vi utnyttjar det faktum att vi har senior studenter och ber studenterna att utvevckla själva materialet. Kursen är uppdelad i olika moduler och grupper av studenter är ansvariga för att undervisa en modul var. För att upprätthålla god kvalitet i alla moduler tillhandahåller examinatorn detaljerade riktlinjer och noggrann feedback på allt material som de undervisande studenterna utvecklar. Vår kursundersökning indikerar att både studenterna och examinatorn uppskattar denna kursdesign och att den möjliggör att vi kan utveckla nya högkvalitativa kurser utan att överbelasta examinatorn.

Keywords: PhD education; flipped classroom teaching; learning by teaching

1 Introduction

It is often challenging to find sufficient resources to develop high-quality PhD courses with all the teaching elements that we are used to from large undergraduate courses. This is particularly problematic for research groups working in fields that develop quickly, where the need for new PhD courses arises regularly and sometimes quickly. Moreover, this situation is further complicated by the significant workload of the researchers responsible for the development.

In recent years, flipped classroom teaching has become increasingly popular at technical universities, and when properly implemented, it can lead to significant gains in learning Bishop and Verleger (2013). While there is no consensus on how flipped classroom teaching should be defined, it can generally be described as an alternative pedagogical method that replaces traditional lectures with two teaching elements. The first element is a preparatory task where students engage with the material independently, typically at home. The second element is an active learning session conducted in the classroom. At-home preparation usually involves watching videos and, to a certain degree, reading scholarly articles, while in-class active learning includes collaborative problem-solving and peer instruction Crouch and Mazur (2001); Li, Lund, and Nordsteien (2023). The videos in question are usually prerecorded by the instructor, who also prepares in-class activities for the students. Hence, even though flipped classroom teaching has important benefits, developing such courses can be time-consuming and challenging for teachers.

One reason it is demanding to develop flipped-classroom teaching courses is that it is very time-consuming to record good video presentations for the students to watch at home. In some of our existing courses, we have experimented with using videos recorded by other teachers Svensson, Hammarstrand, and Stöhr (2015). Our results indicate that this approach may offer a perfect trade-off between effort and quality for many teachers. Still, developing these courses from scratch remains time-consuming, which makes it unfeasible if the examiner's workload is already high.

Learning by teaching is an interesting strategy for teaching a topic while reducing the workload for the examiner Topping (1996). It is well-known that one can gain significant insights about a topic by teaching it to someone else. Learning by teaching has been observed to be superior to traditional teaching methods in certain contexts. The method helps students become more involved in their learning process, and train their critical thinking abilities. Learning by teaching is a type of active learning and students participating in an active learning environment generally perceive this pedagogical approach positively Deslauriers, McCarty, Miller, Callaghan, and Kestin (2019). Still, they often self-estimate learning outcomes to be poorer than those participating in a passive learning classroom environment, even though the course material is identical. Despite this, when tested for accumulated knowledge, the participants who learned by teaching tend to achieve better results than their counterparts from a passive classroom setup Deslauriers et al. (2019). However, relying on students to act as teachers can be problematic since their teaching ability may vary. Learning by teaching therefore has a better potential to reduce the workload for the examiner when the students are more experienced.

We are particularly interested in using learning by teaching in courses that use flipped classroom teaching. Only a few studies address the connection between the two pedagogical methods Yin (2020). Also, in existing papers, learning by teaching is incorporated as an active learning activity in class, whereas the examiner has prepared and recorded all the material the students should study before coming to class. In our case, as this was a brand-new course, there were no pre-recorded videos from the examiner for the students to reference. Consequently, students had to conduct extensive research to prepare for their assigned module and to identify suitable material (including videos).

This paper investigates the use of the ”learning by teaching” strategy within a PhD course, implemented through a flipped classroom model. Unlike most courses that utilize learning by teaching, such as Yin (2020), our course involved more advanced students and took an additional step by requiring the students to develop both in-class and post-class activities. Throughout the course, participants engaged in both teaching and learning through the flipped classroom model. As instructors, the PhD students had the opportunity to deepen their understanding by teaching, while as learners, they benefited from the innovative methods of the flipped classroom. The underlying hypothesis is that with appropriate guidance, PhD students are experienced enough to partially replace the examiner as educators.

In our study, we seek to answer the following research questions:

- Can we obtain high quality in all modules even though the PhD students' teaching experience varies significantly?

- Do the PhD students find learning by teaching a useful experience to learn the material and improve as a teacher?
- Does the course design enable the examiner to develop new courses with a limited effort?

2 Method

We have implemented and evaluated a teaching strategy where the PhD students attending the course help develop the material under the supervision of the examiner. The examiner selected the overall content and main learning objectives, but the students strongly influenced all the details. The course is separated into five modules, and the students are also separated into five groups, each responsible for teaching one module. Roughly 25 students were taking the course, and most groups therefore had five group members. In what follows, we will refer to the students teaching a certain module as the teachers.

2.1 Learning by teaching

For each module, the examiner described the content, helped plan the work, and provided feedback on every step of the process. There were some differences between the different modules, but most of them were organised as follows:

At the first meeting, we discussed our teaching strategy, how to organise the work among the teachers, the use of flipped classroom teaching, and what is expected from the home assignments. The teachers were then expected to suggest a list of detailed learning objectives and provide the learning material in the form of specific videos (to watch) and, sometimes, papers (to read). We then debated the suggested videos and learning objectives at the second meeting. Given the learning objectives, we also talked about how such objectives can help guide us when selecting activities and assignments to ensure that we cover all learning objectives to a reasonable degree.

For the remaining preparations, teachers in each module were separated into two (sub-) groups consisting of a group of two teachers responsible for the post-class home assignment and a group of three teachers in charge of the in-class active learning activities. The group that prepared the in-class activities also made the videos available for the students. Usually, the videos were separated into shorter videos, and the teachers provided multi-choice questions for the students to answer after watching each video.

2.2 Flipped classroom teaching

We used the flipped classroom teaching style described in Svensson and Adawi (2015) and Svensson et al. (2015). Each module employed a learning sequence starting with a pre-class assignment, active learning in class and finally a post-class home assignment that students solved individually. To maintain a reasonable workload for the teachers and the examiner, while providing timely feedback, the home assignments were also peer reviewed.

For active learning in class, the students were separated into groups of three to four. At each in-class session with the students, we used a combination of peer instructions, collaborative problem-solving, and discussion tasks. To ensure that most of the time in class was dedicated to active learning, the teachers prepared slides that they could use to introduce and summarize each task. Some of the PhD students had experience being teaching assistants in a different course, which was taught using flipped classroom teaching by the examiner. We ensured that some of those students taught the first module, intending to set a good example.

2.3 Course evaluation

To investigate the first two proposed research questions, we utilized a questionnaire distributed to the students upon completion of the course. Given that this is a PhD-level course, the examiner took full responsibility for developing and administering the survey. The majority of the questions were designed to assess various aspects of the course structure and to gather suggestions for potential improvements in future iterations. Students were asked to respond to statements using a scale ranging from complete agreement to complete disagreement, with the option to provide additional feedback through free-text comments. The third research question was addressed using data collected by the examiner during meetings with students as they prepared the various modules.

3 Results

Related to the first research question, the quality of all modules was deemed high in the questionnaires and the students expressed that the course enabled them to learn well from all modules. To uphold high standards across all modules, the examiner provided teachers with ongoing assistance through the preparation phase. Nonetheless, feedback revealed that one module was perceived as comparatively disorganized and confusing. The cause for this discrepancy remains uncertain; however, it is presumable that the teachers overseeing said module had more limited teaching experience.

The students also expressed appreciation for assuming the role of the teacher. Notably, students highlighted that selecting what material to include helped them learn the topic of the module they were teaching. The teachers responsible for developing the material used in the classroom also gained insights into the pedagogical aspects of designing active learning sessions. However, according to some participants, developing the course material in groups of five led to a considerable overhead regarding meetings. Additionally, task delegation resulted in a nuanced understanding of specific material components while maintaining only a superficial grasp of others. Moreover, some students would have liked even more explicit instructions from the examiner and more time to develop the material.

The overall impression of the course was highly favourable, and students rated both the course and the experience of being instructed by fellow PhD students high (with average scores above four on a 5-point scale for both aspects). Most students appreciated the course's flipped classroom teaching format, even though the available time in the classroom could have been used more wisely, at least in some of our sessions. Time management is challenging even for highly experienced teachers, and some students mentioned that they would have liked more time to discuss the different assignments given in class.

From the examiner's standpoint, it would have been unfeasible to flip the course without the invaluable contribution of the PhD students. Guiding the students and observing their work and the results they achieved was a rewarding experience. In terms of workload, it was an intense period for the examiner, considering that multiple modules were developed in parallel, but the approach of meta-teaching the course and guiding PhD students in their roles as flipped classroom instructors appears to have produced a solid course that requires much less effort from the examiner than a regular course would have. A rough estimate is that developing the course without using learning by teaching would have required four to five times as many working hours.

4 Implications

The teaching strategy studied in this paper could significantly influence PhD education at many universities and departments around the globe. By enabling research groups to rapidly train their PhD students in emerging research areas, this approach could facilitate shifts in research focus and allow for swift responses to critical breakthroughs. As a result, the proposed methodology could enhance the productivity of research groups, leading to broader benefits for entire research communities.

However, implementing flipped classroom teaching effectively can be challenging, with numerous essential elements required for successful in-class sessions. Teachers, for example, must create tasks that emphasize the most pertinent concepts and appropriately challenge students at the right level. In this context, the examiner plays a crucial role in guiding teachers through their design decisions. An examiner with deep knowledge of the subject matter and practical experience in flipped classroom teaching is essential. While this may pose a limitation, we remain hopeful that others will still recognize the advantages of the proposed course design and adopt it successfully.

5 Conclusions and future work

We have combined learning by teaching and flipped classroom teaching for developing and teaching a PhD course. Learning by teaching for PhD courses is particularly appealing for at least two reasons. First, we often need new courses on a PhD level, whereas many senior researchers have limited time to develop such courses. Second, often, the students taking these courses have some previous teaching experience, which hopefully improves their students' learning experience. Our study indicates that if the examiner provides guidelines for using flipped classroom teaching and feedback on the material the teachers develop, it is possible to obtain a course that the students highly appreciate and that an experienced examiner can develop with a reasonable effort.

Looking ahead, we plan to further explore the outcome when the course is offered again. Although the first iteration was successful, it also highlighted areas for improvement, such as the disproportionate time students spent on the module they taught compared to other parts of the course and the lack of organization in one of the modules. In the upcoming iteration, we plan to retain the overall course structure, offering the current version as a draft to the instructors, and closely assess how well these issues are resolved.

References

Bishop, J., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. In 2013 asee annual conference & exposition (pp. 1–18).

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. American journal of physics, 69(9), 970–977.

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. Proceedings of the National Academy of Sciences, 116(39), 19251–19257.

Li, R., Lund, A., & Nordsteien, A. (2023). The link between flipped and active learning: a scoping review. Teaching in Higher Education, 28(8), 1993–2027.

Svensson, L., & Adawi, T. (2015). Designing and evaluating a flipped signals and systems course. In European conference on e-learning (pp. 584–592).

Svensson, L., Hammarstrand, L., & Stöhr, C. (2015). Flipping a PhD course using movies from a MOOC. In Proceedings från 5: e utvecklingskonferensen för sveriges ingenjörsutbildningar, uppsala, november 18-19, 2015 (Vol. 5, pp. 168–171).

Topping, K. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. Higher education, 32(3), 321–345.

Yin, H. (2020). Exploring the effectiveness of a flipped classroom with student teaching. e-Journal of Business Education and Scholarship of Teaching, 14(1), 66–78.

WORK IN PROGRESS

Developing a Curriculum for Environmental Assessment of Construction Products with Nanoparticles

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Abstract

The construction sector is witnessing an increase in the incorporation of nanoparticles in products like paints, additives, and coatings. However, there's limited teaching material on the environmental impact of these products and how to quantify said impact. The Erasmus+ project NanOER aims to address this gap by developing a curriculum centred around the Life Cycle Assessment (LCA) method, which can be used to quantify the environmental impact of construction products with nanoparticles. In addition, the curriculum is designed to be modular by dividing it into 4 thematic areas covering 10 modules in total, where learning outcomes and assessments have been defined for each module. This enables educators to customize their seminars or curriculum content based on the needs and backgrounds of their target audience.

Byggsektorn bevittnar en ökning av inkorporeringen av nanopartiklar i produkter som färger, tillsatser och beläggningar. Det finns dock begränsad utbildningsmaterial om dessa produkters miljöpåverkan och hur man kvantifierar denna påverkan. Erasmus+-projektet NanOER syftar till att ta itu med denna klyfta genom att utveckla en konstruktivt anpassad läroplan centrerad kring metoden Life Cycle Assessment (LCA), som kan användas för att kvantifiera miljöpåverkan från byggprodukter med nanopartiklar. Dessutom är läroplanen utformad för att vara modulär genom att dela upp den i 4 tematiska områden som omfattar totalt 10 moduler, där lärandemål och utvärdering definerade till varje modul. På så sätt gör det möjligt för de pedagoger som vill använda läroplanen att anpassa innehållet utifrån målgruppens behov och bakgrund. Detta gör det möjligt för utbildare att anpassa sina seminarier eller läroplansinnehåll baserat på behoven och bakgrunden hos sin målgrupp.

Keywords: Life Cycle Assessment (LCA), Environmental Product Declarations (EPDs), Curriculum, Nanoparticles, Erasmus+

Introduction

The primary goal of the NanOER project is to develop a modular curriculum that introduces the knowledge and skills required to conduct Life Cycle Assessment (LCA) (SIS, 2020) and prepare Environmental Product Declarations (EPD) for construction products (SIS, 2021) with nanoparticles used in the construction sector. The motivation behind the development of the curriculum is due to the lack of available teaching material on the topic as the use of nanoparticles can have unintended negative consequences on the environment without supporting research (Bhimani et al., 2016). Hence, the curriculum is developed with a focus on the following questions:

1. How to develop a curriculum centered around LCA of construction products with nanoparticles that is modular, meaning that it can be adapted by the teacher based on the audiences needs and background knowledge base?
2. What content and supportive material is needed for an effective delivery of the curriculum?

The developed curriculum targets both students and professionals in the construction sector, addressing the growing need for expertise in the environmental assessment of construction products with nanoparticles with project-based learning. Developed through international collaboration from the University of Seville, National Technical University of Athens, Marble, Natural Stone and Material Technology Center, Delta Material Process and Innovation and Chalmers University of Technology under EU Erasmus+, the curriculum reflects the interdisciplinary nature of the topic, encompassing, construction, nanoparticles, LCA, and EPDs. The curriculum comprises 10 modules, each module consisting of defined learning objectives. Among the 10 modules, Chalmers University of Technology led the development of modules 9 and 10, which specifically address the LCA and EPD aspects. One of the key features of the curriculum is its modular design, allowing educators to customise the content based on the needs and backgrounds of the target audience, including both students and professionals such as nano-product manufacturers, construction engineers and environmental managers. This holistic curriculum not only equips learners with an appreciation of LCAs in the construction sector but also prepares them to tackle complex problems that require insights from diverse fields.

In addition to developing the curriculum with learning objectives, the project also aims to develop educational material, such as e-guidelines and flashcards, that the educator can directly use to teach and train the students.

Method of development

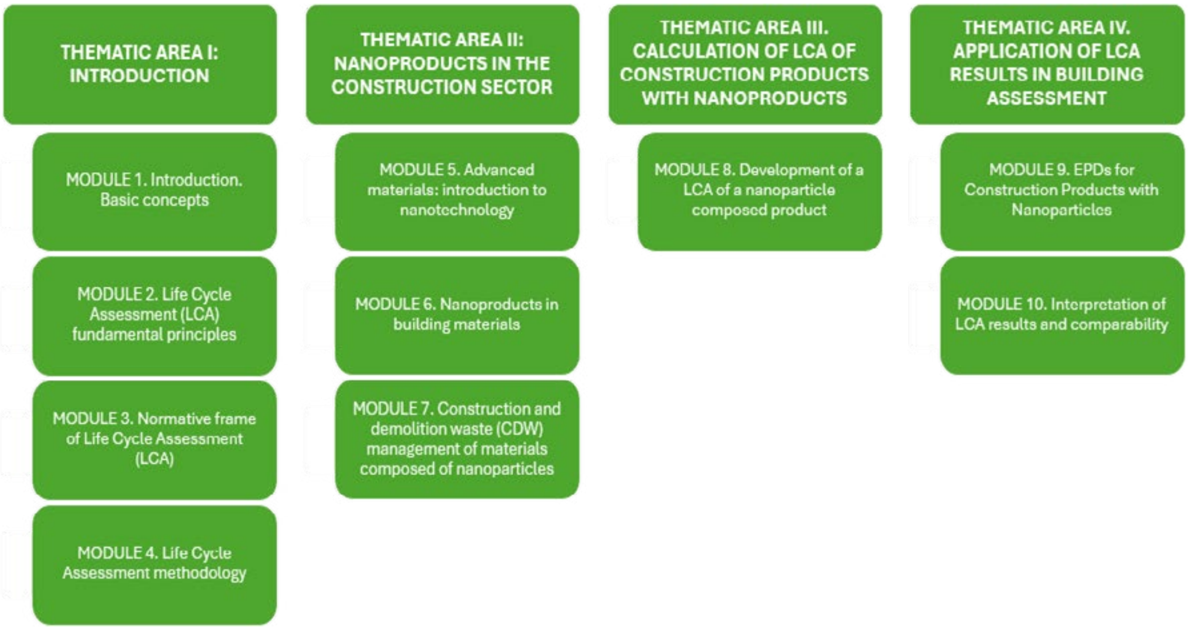
The curriculum development process involved collaboration among universities with expertise in their respective fields, ie. the construction sector, nanoparticles, LCA, and EPDs in several work packages. The curriculum development is work in progress and is planned to be finished at the end of 2024. The work was coordinated by the University of Seville, managing activities that resulted in the creation of the curriculum as well as the creation of supporting material in the form of e-guidelines, flashcards and Open Educational Resources (OER). Each university was responsible for specific modules, which were developed based on initial comparative studies of the research fields and on the available curricula within the respective countries. Several seminars were organised to ensure the synchronisation of the different modules, overseen by the coordinator. The curriculum is structured to be modular: its adaptability will undergo testing in three pilot courses organised by participating universities in the second and third quarters of 2024. These pilot courses will enable revision of the curriculum based on the evaluation and feedback from the participants.

Curriculum description

The curriculum consists of 10 modules, each consisting of defined learning outcomes associated with each module. The 10 modules are categorised into 4 thematic areas, as shown in Figure 1. The following section briefly describes the areas and modules with selected intended learning outcomes.

Thematic area 1 focuses on introducing basic concepts and LCA, thematic area 2 focuses on the nanoparticles and their use in construction products, thematic area 3 focuses on the development of LCA for construction products with nanoparticles, and finally, thematic area 4 focuses on the development of the EPDs using the results from the LCA study and its interpretation of LCA results.

Figure 1: Illustraction of the different thematic areas and the modules



Module 1 introduces the basic concepts surrounding the construction sector and nanoparticles, providing the foundation needed for interpreting the criteria and procedures for the assessment and quantification of the environmental impact in the construction sector. Module 2 focuses on LCA and its use in the construction sector, enabling the recognition of the environmental impact throughout a product's lifecycle and reflection on the adaptation of LCA when it comes to the construction sector. Module 3 provides terminologies and the normative framework of LCA to compare common applications of LCA in the construction industry and be familiar with the general limitations of the approach. Finally, module 4 provides an in-depth explanation of LCA methodology encompassing the 4 phases, of LCA and Life Cycle Inventory databases such as Ecoinvent, GaBi, ProBas, etc. In addition, module 4 also covers examples of LCA through case studies to be able to apply sustainability principles through life cycle analysis to the environmental design of processes and products

Thematic area 2 focuses on the practical applications and potential risks associated with nanoparticles in construction for the participants to identify potential risks. Module 5 provides insights into the historical background, fundamental concepts, and application of nanoparticles in general for a fundamental appreciation of the development of the field. Module 6 illustrates the application of nanoparticles in different construction products. In addition, the unit includes content regarding health and environmental risks associated with the nanoparticles for the participant to assess the complications of the application of nanoparticles in construction. Module 7 focuses on the waste management of materials composed of nanoparticles, along with the policies surrounding waste treatment so the participants can select appropriate treatments for the associated waste.

Thematic area 3 concentrates on the development of LCAs tailored explicitly for construction products incorporating nanoparticles. This module aims to equip students and professionals with the necessary skills and knowledge to conduct LCAs effectively for such products, considering their unique properties and impacts across the life cycle.

Thematic area 4 centres on EPDs for construction products containing nanoparticles. Module 9 provides the detailed overview of the standards involved in the EPD framework designed to equip the course participants with the necessary skills to develop EPDs for construction products with nanoparticles. Module 10 is designed to equip course participants with the necessary knowledge to interpret and critically review the information in an EPD for construction products with nanoparticles, to be able to compare the results with other similar products.

The curriculum is recommended to be conducted as a project-based course with student-active teaching methods, practical exercises, individual tutoring, group discussions, lectures, workshops, and field studies with summative assessment by peers or examiners. Each module or set of modules can also be used in more focused courses or seminars, more suitable for professional training.

Conclusions

In conclusion, the curriculum focusing on the LCA for construction products with nanoparticles through collaboration from the partnering organisations is important in training and developing young professionals in the construction sector. The curriculum consists of 10 modules, each with defined learning outcomes for each module. Currently, the curriculum is being tested in pilot courses at the different universities and course evaluation will follow. to evaluate the robustness, learning outcomes, modularity, and overall content. Through collaboration, feedback, and ongoing refinement, along with the flexible modular approach, the curriculum will remain responsive to evolving educational needs and aligned effectively with the objectives of the project partners and the broader academic community.

References

Bhimani, S., Shah, V., & Desai, J. (2016). *Nanotechnology in construction: A review on the environmental and health implications*. International Journal of Civil Engineering and Technology, 7(2), 159–168.

Swedish Institute for Standard (2020). *Environmental management - Life cycle assessment - Principles and framework*. (SS-EN ISO 14040:2006/A1:2020).

Swedish Institute for Standard (2021). *Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products*. (SS-EN 15804:2012+A2:2019/AC:2021).

ROUND TABLE

Undervisning anpassad till examinationsutfall

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Abstract

For most courses given at Chalmers University of Technology, feedback from the results of the summative assessment at the end of the course to the students is very limited. In particular for students who fail, nothing more awaits than self-study and, in the worst case, a series of failed re-examinations and risks of psychosocial problems. By providing targeted feedback/teaching in connection with the examination, more students can pass, and we discuss some examples of this here.

Sammanfattning

I vår typiska undervisningspraktik på Chalmers är återkopplingen från resultatet vid summativ examination i slutet av kursen till studenterna mycket begränsad. Särskilt för de studenter som misslyckas väntar inte mer än självstudier och i värsta fall en rad misslyckade omtentor och risker för psykosociala problem. Genom att komplettera examination med riktad återkoppling/undervisning som ges i anslutning till examinationen så kan fler studenter nå godkänt, och vi diskuterar här några exempel på detta.

Keywords: *examination; återkoppling*

1 Introduktion

På Chalmers saknas oftast strukturerad återkoppling till studenterna från resultatet vid summativ examination i slutet av kurser. Exempel och tankar i denna text avser vara relevanta för samtliga Chalmerskurser där så är fallet, och där problematiskt många studenter inte blir godkända vid examinationen. För studenter som misslyckas vid examinationen väntar inte mycket mer än självstudier och omtenta. En student kan hamna i en ond spiral och omtentera gång på gång utan att lyckas, och utan det lärarstöd som finns under kursen. Vi delar tankar kring hur man kan examinera annorlunda, så att utfallet vid examinationen kan användas för att ge anpassad och riktad undervisning till studenterna. Vad som är viktig att betona är att vi inte letar en ursäkt för att godkänna studenter som inte uppfyller kursmålen, utan att vi söker processer som gör det lättare för den kritiska gruppen av studenter att faktiskt nå målen.

Vår diskussion tar upp följande frågor:

1. Vilka effekter tror vi att vi kan uppnå om vi kan anpassa undervisningen i slutet av kursen efter studenternas resultat på en (omfattande) prövning av deras kunskaper och färdigheter?

2. Hur kan ett rimligt upplägg se ut med utvärdering/examination innan kursslut + efterföljande anpassad undervisning + avslutande summativ examination?

3. Vilka är de mest påtagliga riskerna och negativa konsekvenserna av att omfördela resurser till ett sådant undervisnings- och examinationsformat?

2 Bakgrund

Det finns förstås en hel del tänkt och skrivet om examination, och även specifikt om hur examination inverkar på lärande (Fischer, 2023)(Rust, 2002). I en aktuell studie från ingenjörsutbildningssammanhang (den Boer, 2021) diskuterar man skillnader mellan att ha kontinuerlig formativ eller summativ utvärdering av studenternas förmågor, och de föreslår en högre grad av omsorg för utformningen av återkopplingen från utvärderingen, så att den blir mer användbar för studenterna, vilket är helt i linje med våra tankar om undervisning anpassad efter examinationsutfall. Skillnaderna i utfall mellan summativt och formativt framstår inte som avgörande (den Boer, 2021).

Det typiska sättet att förhålla sig till formativ återkopplingen är att den ger studenterna insikter om hur de ska förhålla sig till sina studier, snarare än att den styr vilken undervisning som erbjuds. En kontrasterande analys av skillnaderna mellan summativ och formativ utvärdering ges i Harlen (1997).

Här understryker man att en summativ bedömning bör vara av mer holistisk, sammanfattande karaktär, och att den inte bör begränsas till att bocka av uppfyllandet av preciserade specifika kriterier. Vår inställning är att format som examinator använder för att avgöra om en student uppnår förutbestämda mål, alltid har potential att användas för att anpassa vilket lärarstöd denna student erbjuds. I den meningen blir det i vårt fall så att den summativa examinationen används formativt *för undervisningen*.

Utformningen av den summativa bedömning påverkar studenternas lärande, oavsett om den avsiktligen används som en del i undervisarens repertoar för att stödja studenternas lärprocesser eller inte. Den specifika formen för denna påverkar är föremål för samtida undersökningar (Fischer et al., 2023) där en slutsats är att den summativa bedömningens utformning är viktig men inte avgörande för enskilda studenters sätt att studera. Det föranleder med andra ord att vara lyhörd för hur det summativa utfallet kan användas som underlag till olika stöd för olika studenter.

3 Diskussion

Vid rundabordsdiskussionen på KUL var vi fem personer som deltog. Den beskrivning som ges nedan innefattar såväl det som diskuterades vid detta tillfälle, samt ytterligare diskussion som förts mellan författarna till denna text. Rundabordsdiskussionselement markeras särskilt med (*RT*) i texten.

1. Effekter som kan uppnås

Den mest direkta effekten av att arbeta med undervisning i anslutning till examinationen är att fler klarar kursen snabbare, och här finns en viktig följdeffekt – att färre behöver tas omhand i omtentaadministrationen. Det är inte osannolikt att en misslyckad första examination i samband med att kursen går kan innebära två eller flera omtentamenstillfällen, med alla merkostnader som uppstår i samband med detta. En student som kan gå vidare med en avklarad kurs bakom sig i stället för att bära oro för en framtida omtenta, bör därigenom ha bättre förutsättningar att klara övriga studier. Det finns också en viktig psykologisk faktor där vissa studentgrupper behöver en insyn av typen: "oj, det här är annorlunda än gymnasiet", speciellt nyantagna som fortfarande letar efter en fungerande studieteknik. En tidig insyn ger möjlighet att hjälpa studenter i tid (*RT*).

En uppenbar effekt av att visa extra omsorg om de studenter som riskerar att misslyckas vid traditionell examination, är direkt uppskattning från dessa. Studenterna blir mätbart mer nöjda. Det tillkommer en mer långvarig effekt av att upplevelsen ger större tilltro till att de har kapacitet att klara sina studier, och tilltro till att Chalmers vill att de ska klara studierna (*RT*). Särskilt när det sker i ett tidigt skede i studierna kan detta attitydskifte vara mycket värdefullt.

Ett konkret exempel på befintligt resultat är inte bara bra genomströmning och en positiv känsla i klassen, utan att ett förtroende har byggts upp mellan programmet och studenterna med ökad upplevd tillhörighet till utbildningsprogrammet. Närvaro vid lektioner har ökat radikalt, och studenter har blivit mycket mera öppna för att ställa frågor och erkänna sina egna brister, vilket leder till att man kan hjälpa dem bättre under kursens gång.

Att läraren aktivt arbetar med återkoppling då bristerna visats vid examination, innebär att även läraren i sin tur får återkoppling på sin hantering av stödet till de som misslyckas. Detta är kunskaper och insikter som direkt ökar lärarens kapacitet att hantera motsvarande svårigheter under kursens gång – för framtida studenter. Formatet innebär alltså även ett värdeskapande för den undervisande läraren.

2. Förslag på upplägg

Ett konkret genomfört exempel: en snabbrättad tentamen med flervalsfrågor för drygt 100 studenter och 30% godkändes. Ungefär 50 underkända studenter med tillräcklig kursnärvaro och aktivitet fick komplettering i två faser - efter skriftlig komplettering återstod cirka 10 studenter för en avslutande muntlig fas. Kompletteringen gjordes inte med stickprov; studenterna var tvungna att komplettera samtliga grundnivå-frågor de hade missat. Mycket lärartid gick till administration som underlättas av att planeras under kursens gång. Det mest problematiska för läraren var arbetsbelastningen där komplettering och kursstart för efterföljande kurs överlappade.

För att rymmas inom en läsperiod (9 veckor) kan man ha en delexamination tidigt i vecka 7. Med ett format som möjliggör snabb rättning (t ex flervalsfrågor) kan man då börja att arbeta selektivt med studenterna redan samma vecka. De som presterar väl på delexaminationen kan ges tentamen för överbetyg i vecka 9, då de som fått den anpassade undervisningen får en ny chans att visa att de når upp till godkänt. Det handlar alltså om ett flervalsprov för godkänt, där de som klarar inte får någon ytterligare undervisningsinsats, men har chans till överbetyg, medan de som misslyckas får kvalificerad återkoppling och undervisningsstöd för att nå godkänt. I grund och botten föreslår vi en bana med "milstolpar" som ger en realistisk bild av vad som krävs för att få överbetyg. Att precisera *vad* som krävs är inte så svårt, men det är mer besvärligt att precisera *när* studenten behöver kunna visa saker.

Ett förslag på alternativt format är att erbjuda en (frivillig) muntlig examination innan ordinarie skriftlig tentamen. De som klarar den muntliga examinationen behöver inte skriva (delar av) tentamen, medan de som inte klarar det muntliga ges återkoppling på vad de behöver åtgärda inför tentamen.

Om man genomför individuella diagnostiska prov, så kan undervisningsinsatser erbjudas med liknande kvalitet som i samband med examination (*RT*). En nackdel är dock att de som presterar väl inte får mer än bekräftelse på sina färdigheter (examinationen kvarstår) och incitamentet att verkligen anstränga sig inför provet blir lägre.

3. Risker och nackdelar

En urartad variant vore att tillhandahålla så mycket individuell undervisning som behövs för att alla studenter ska bli godkända. Här saknas helt hänsyn till lärarens eller organisationens begränsade resurser, och det riskerar att fränta studenterna ansvaret för sina studier. Man kan vidare befara att studenterna bedöms mer okritiskt i det uppföljande formatet, och att det blir otydligt i vilken grad lärandemål uppfylls om bedömningen sker i direkt anslutning till undervisning. Varje modell för examinationsanpassad undervisning behöver hantera riskerna för resursslöseri, för deflation av studenters värdering av sina egna insatser och för okritiska bedömningar. En viktig faktor är återigen psykologisk: studenter kan försöka planera för en sådan process i förväg som kunde leda till prokrastinering eller bortprioritering av kursen för att kunna fördela sin tid på ett annat sätt. Sådant sker återkommande och vi har noterat en förstärkt effekt i samband med Covid19 pandemin. Det är viktigt att helhetsprocessen fram till otillräcklig examinationsinsats för studenten ska präglas av att "jag har försökt allt, med det gick inte" snarare än "ah, det ordnar sig, jag kan komplettera om det går åt skogen" (*RT*). Detta är kanske den största utmaningen att hantera; med tidiga kontrolltillfällen blir det svårare att prioritera bort kursen än om kursen bara har slutexamination.

En invändning mot att inkludera examinerande moment tidigare i kursen är att det stjäl tid – från ämnesundervisning såväl inom som utom kursens ramar. Kritiken kan vara berättigad i fall där man landat i ett välfungerande kursupplägg (exempelvis anpassat för en väldefinierad och homogen målgrupp), och där resultaten vid ordinarie examination är mycket goda. I ett särpräglat sådant fall är examinationen näst intill redundant – alla studenter lär sig det de ska, läraren vet detta och studenterna vet det också. I ett sådant läge är det rimligt att maximera kursinnehåll på bekostnad av omsorg om examinationsutfallet – vilket som ytterlighet inte ger mer information än att alla kan det de ska. Att tillgripa examinationsanpassad undervisning handlar om att bemöta en problematisk situation, där de konkurrerande alternativen skulle kunna vara att sänka kraven i kursen, eller att låta färre studenter delta. Ett problem till är att olika personer behöver olika mycket tid. Frågan är i vilken mån vi kan erbjuda möjligheter i form av tillgång till tid för att nå överbetyg.

En utmaning för att kunna genomföra undervisningsmoment baserade på examinations-utfall är att rätta tillräckligt snabbt. Om man har med många studenter att göra kan det krävas någon form av automatisering i denna fas. Själva undervisningsinsatsen skalar sedan dels med antalet som misslyckas med examinationen och dels med hur disparata deras behov är. Även för en mycket stor kurs vore det alltså genomförbart med en automaträttad examination som lämnar en hanterlig volym studenter åtgärdsbart underkända.

Med en begränsad lärarresurs så behöver tid omfördelas för att en examinations-anpassad undervisningsinsats ska vara möjlig. Att bara räkna med att kunna kapita-lisera på intjänad tid för omtentor är nog överdrivet optimistiskt. Ett förslag för ned-prioritering är genomgångar av enklare kursinnehåll, där man skulle kunna återanvän-da inspelat material i stället.

4 Slutsats

För studenter, som med en mer anpassad undervisningsinsats skulle kunna nå lärandemålen i samband med att de går kursen, är det av stort potentiellt värde att använda deras examinationsutfall för att styra en sådan undervisningsinsats rätt. Detta angrepps-sätt skulle kunna tillämpas på alla Chalmerskurser med problematiskt många under-kända vid traditionell sluttentamen.

References

den Boer, A. WJP et al. (2021). Comparing Formative and Summative Cumulative Assessment: Two Field Experiments in an Applied University Engineering Course. Psychology Learning & Teaching, 20(1), 128–143.

Fischer, J. et al. (2023). How does assessment drive learning? A focus on students' development of evaluative judgement. Assessment & Evaluation in Higher Education, 49(2), 233-245. https://doi.org/10.1080/02602938.2023.2206986

Harlen, W., & James, M. (1997). Assessment and Learning: differences and relationships between formative and summative assessment. Assessment in Education: Principles, Policy & Practice, 4(3), 365–379. https://doi.org/10.1080/0969594970040304

Rust, C. (2002). The Impact of Assessment on Student Learning. Active Learning in Higher Education 3(2), 145-158.

WORKSHOPS

What Is Excellent Education and How Can We Achieve It in a Transition

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Abstract

Chalmers University of technology stands before a transition. It has a long-term goal of being recognized as one of Europe's leading technical universities by year 2041, as well as a short-term objective of consolidating its two campuses into a single location. Using a workshop and the authors' own reflections, this paper addresses educational challenges for successfully transitioning and presents suggested actions to counter said challenges. Main challenges identified revolve around producing a higher quality education for more students with fewer working hours and financial support, as well as challenges regarding teaching-faculty's time, knowledge and incentive. Suggested actions include effectivizing time, managing large classes, valuing teaching faculty, alternative teacher positions of employment, and achieving excellent education with limited resources.

Keywords English: *Excellent education, resource-efficient education, transformation, technical university*

Sammanfattning

Chalmers tekniska högskola står inför en framtida transformation. Dels jobbar Chalmers mot en vision att bli ett av de ledande tekniska universiteten i Europa till 2041, och dels genomförs en plan att i närtid göra en sammanslagning av Chalmers båda campus. Båda dessa strategiska förändringar kan innebära potentiella utmaningar som diskuterades i en workshop och som sammanfattas i denna rapport tillsammans med författarnas egna reflektioner. Huvudsakliga utmaningar som identifierades kretsar kring att leverera en högre kvalitét på utbildning till fler studenter med färre arbetstimmar och ekonomiska resurser, samt utmaningar kring lärares tid, kompetens och incitament. Föreslagna åtgärder inkluderar att effektivisera tidsåtgång, hantera stora klasser, värdera lärare, alternativa anställningsformer för lärare, och att uppnå excellent utbildning med begränsade resurser.

Keywords svenska: *Excellent utbildning, resurseffektiv utbildning, transformation, tekniskt universitet*

1 Introduction

Chalmers University of Technology (Chalmers) is a high-performing technical university, scoring well on international rankings regarding for example industry collaboration (CWTS Leiden Ranking, 2024) and education (Chalmers - A, 2024). Chalmers offers educational programs at both Bachelor's and Master's level.

Chalmers recently published a new vision with corresponding objectives announcing its ambition to become one of Europe's leading technical universities by the year 2041 (Chalmers - B, 2023), a vision which raises the ambition of the Bachelor's and Master's education to excellent levels. In addition, Chalmers two separate campuses will be merged in the autumn of 2025 when the Lindholmen campus will move the vast majority of its educational operations to the Johanneberg campus. This move encompasses roughly 2500 students (Chalmers - C, 2024) and is internally predicted to result in larger class sizes, as some programs will be merged and some courses might be shared between programs.

2 Questions to answer

Based on the output from a workshop and the authors own reflections, this paper aims to answer the following questions:

- What are some of the thoughts, concerns and wishes related to education amongst Chalmers staff regarding the 2041 vision and the campus move?
- What are some strategies that could be utilized to help Chalmers achieve the goal of excellent education in 2041, as well as managing the merge of the two different campuses?

3 Method

A workshop was held during the 2024 Chalmers KUL event ("Chalmers Conference on Teaching and Learning") (Chalmers - D, 2024), where 25 participants ranged from senior professors, deans of education, junior teachers, to study counselors. This one-hour workshop started off with the authors presenting the context of the workshop (the 2041 vision and the campus merge). This was followed by dividing participants into five groups of five colleagues discussing one of three different topics (see below) for roughly 30 minutes. The workshop was concluded with a joint discussion with all groups in which notes were taken by the workshop organizers (the paper authors).

The context presented regarding the 2041 vision was the vision itself:

- ”A globally outstanding university of technology, for a better world.” (Chalmers – B, 2024)

As well as two of the four associated objectives that either directly or indirectly related to teaching (Chalmers University of Technology, personal communication, June 22, 2022):

- “Improve both the quality and effectiveness of education so that, through its content and format, it addresses current and future societal challenges innovatively and relevantly.”
- “Chalmers has developed its culture of building leadership, employeeship and values, as well as operations support and environments, that, together, support and stimulate the development of academic activity.”

Additionally, the staff members were reminded of the campus merge encompassing roughly 2500 students.

The three discussion topics discussed in groups of five were:

- Discussion topic 1 (two groups of five) – What is excellent education? What are the essential elements that maintain the education at an excellent level? (Now and in 20 years)
- Discussion topic 2 (two groups of five) – How can we provide preconditions for teachers to deliver excellent education? (Now and in 20 years). What current strengths can we build upon? What weaknesses and risks are there, and how shall we avoid them?
- Discussion topic 3 (one group of five) – How does teaching and the way we deliver it need to change? What is meant by resource-efficient? Does resource-efficient and excellent education go hand-in-hand?

4 Results

Preface: The workshop was highly successful in regards to engagement and activity of participants, but less so in regards to keeping the participants focused on answering their specific discussion topic. For that reason, results of the workshop are not presented by discussion topic but rather as a unified body of information. Additionally, the authors would like to remind the reader that these are the subjective thoughts of a gathering of individuals rather than objective facts or official stances. Furthermore, due to the voluntary nature of the event, the reader should expect a bias in participant responses as it is reasonable to expect that faculty passionate about teaching are overrepresented.

The discussions covered a wide range of topics, encompassing everything from career paths at Chalmers to student housing and the functionality of public transport. A full list of statements can be found in Appendix (A). However, many statements were re-occurring or revolving around a similar topic. The authors have identified two major topics which are presented below.

Participants repeatedly highlighted a seeming contradiction between goals and available means. In their understanding, Chalmers aims to increase the quality of education whilst having larger student groups, fewer faculty members, and less financial resources per student, as mentioned by for example UKÄ (2024). Participants put heavy emphasis on a concern for managing large student groups, where they meant that quality in education is difficult to achieve in large student groups (for example as hinted to by Kara et al. (2021)) and that faculty, many of whom are used to teaching smaller groups, simply do not know how to manage larger classes in an excellent way.

Participants interpret Chalmers to be lacking systems to enable teachers to achieve excellent teaching. In their view, teachers need:

- Time - Teachers need time...
    - ... to improve course structure and content.
    - ... to update content of courses based on recent developments and technological advances.
    - ... to actually execute courses once they are planned and developed. Worth noting is that many participants voiced displeasure specifically with administrative tasks taking a lot of time.
- Knowledge - Teachers need...
    - ... knowledge regarding how to deliver excellent education in large class sizes.
    - ... opportunities to update and build knowledge within their subject matter.
- Incentive - Teachers need...
    - ... monetary incentives for being high-performing teachers.

- ... rewards for participating in pedagogical courses.
- ... an attractive career path in general for being a teacher. Many participants voiced concerns that teaching-staff are seemingly valued less than research-staff.

5 Reflections and proposed actions

Based on the results from the workshop as well as reflections from the authors, this chapter presents an analysis as well as corresponding proposed actions for several key points brought up during the workshop.

Time spent on administrative tasks - In regard to time available for teaching, many participants raised the suggestion to employ administrative staff to perform administrative tasks (as opposed to having the teachers themselves perform such tasks). The authors would like to build on this by suggesting the implementation of AI (maybe even interactable chatbots) to ease the administrative burden of faculty.

- Action - Map out what activities are regarded as "administrative tasks" (which do not require pedagogical or significant subject-matter knowledge) and can be performed by entities other than the teachers themselves. Evaluate which of these tasks are realistically performable to a high level of automation by AI, and which actions are better suited to be managed by human administrative staff. Create an estimate of time and money saved by a possible re-distribution of administrative tasks.

Managing large classes - Many teachers expressed concerns regarding a lack of competence in managing large student groups whilst maintaining excellent education.

- Action - Create a Chalmers-internal CLS-course (Chalmers – E, 2023) on specifically managing large student groups, where teachers who are expected to manage large student groups have prioritized enrollment.
- Action - Gauge interest in a collaboration with other high-performing universities that are successfully managing large student groups. For example, where Chalmers receives help in managing large student groups and in return acts as a testing area to try new pedagogical strategies or methods.

Teaching needs to be valued - Concerns have been raised about the interpreted low incentives for pursuing a teaching career at Chalmers, where pedagogical staff are interpreted to be generally lower-valued than research staff. The authors reflect that undervaluing teaching comes as a natural consequence of the hiring practices of the university, where a vast majority of faculty are employed primarily as researchers who are obliged to contribute with departmental service hours (including teaching). In other words, the positions themselves advertise teaching as being secondary. Chalmers seems to be aiming for a continuation of this status quo, and seems to strive towards fulfilling education needs by employing excellent researchers who are to provide excellent education as a secondary activity.

The authors argue that performing excellent research does not equate to performing excellent teaching, and that striving to always achieve both qualities in new hires or in competence development is not realistically feasible. Instead, the authors argue to allow for more pure research positions, partially to not deter excellent researchers who have no interest in teaching, and partially to not force faculty to do that which they have no desire to do. In short: Let people do what they're good at; fill pedagogical working hours with those who are both willing and excellent at pedagogy.

- Action - Investigate establishing a new norm with standard-track faculty where teaching is not part of the expected institution service.

Junior teachers - As a long-term strategy of acquiring talent, the authors recommend making it easier for departments to hire junior teachers. Currently, there is no position at Chalmers that facilitates recruitment of students as full-time permanently employed teachers after their Bachelor's or Master's graduation. Arguably, the two closest available positions are "part-time fixed-term teacher" (SWE: "timlärare") which is nominally neither full-time nor permanent, and "lecturer" (SWE: "tekniklektor") which requires several years of industry experience to quality. The only other option (that the authors are aware of) is to employ via a PhD, i.e. following the typical researcher's path where teaching is regarded as a secondary activity.

- Action - Create a new "junior lecturer" position at Chalmers to more easily recruit young talent with a high potential for pedagogical excellence, for example students who have been employed part-time as teacher's assistants and have performed beyond expectations.

Maintaining subject-knowledge via part-time employment - While being an excellent teacher may not necessarily make one an excellent researcher, it can be argued that excelling in research will enhance one's teaching abilities. Excellent teaching entails up-to-date and relevant teaching, something that requires constant competence development. The traditional way of maintaining subject knowledge is to have teaching be performed by active researchers, who are thus always updating their knowledge. This approach does however come with drawbacks as previously mentioned, i.e. regarding teaching to be a secondary activity.

An alternative way of achieving up-to-date knowledge is by introducing "part-time lecturer" and "part-time senior lecturer" as an established and advertised form of employment. This could allow lecturers to work e.g. 50% at Chalmers and 50% in industry, practicing what they teach and thus continually updating their subject-matter knowledge. As an added benefit, this setup would entail that Chalmers would not be paying wages to staff members for subject-matter competence development, as that would be done via practice in industry. Additionally, this type of employment could serve to be attractive to industry employees who wish to work with teaching but not doing so full-time (similar to for example in-house company educators).

- Action - Investigate benefits, drawbacks, and feasibility of introducing "part-time lecturer" and "part-time senior lecturer" as recruitable positions.

Contradiction between goals and available means - Participants expressed confusion regarding the seeming contradiction between raising educational quality for a greater number of students whilst decreasing the available resources (both in terms of number of faculty and money). The authors would, however, like to highlight that "better education for more students using less faculty and with less money" is not necessarily an impossible contradiction, but might instead be a call for a different solution to solve the wish. The only problem is that we do not yet know what this solution is.

6 Conclusion

Chalmers stands before a dual-transition, both to become a leading European technical university by 2041, and to keep excellence in education when two campuses merge into one. Workshop participants have identified possible roadblocks to succeeding in these transitions: a seeming contradiction between increasing the quality of education with decreasing resources; as well as a lack of teachers' time, certain types of knowledge, and incentive to perform excellent teaching.

Proposed actions are identified to overcome these roadblocks, which include: offloading administrative tasks from teachers to AI and administrative staff, teaching teachers how to manage large classes, fostering a culture to value teaching even more than currently, and easing the employment of both junior and part-time teachers. The authors suggest implications of implementing proposed actions to be the focus of a future study.

References

Chalmers - A. (2024, 21st March). *Chalmers education - best in Europe.* https://www.chalmers.se/en/current/news/chalmers-education-best-in-europe/

Chalmers - B. (2023, 30th November). *Vision and long term strategy.* https://www.chalmers.se/en/about-chalmers/organisation-and-governance/vision-and-strategy/

Chalmers - C. (2024, 25th April). *Project A unified campus at Johanneberg.* https://www.chalmers.se/en/about-chalmers/chalmers-campuses/project-a-unified-campus-at-johanneberg/

Chalmers - D. (2024, 4th April). *KUL 2024 – Chalmers konferens om undervisning och lärande.* https://www.chalmers.se/aktuellt/kalender/kul-2024-chalmers-konferens-om-undervisning-och-larande/

Chalmers - E (2023, 30th November). *Language, communication and learning.* https://www.chalmers.se/en/departments/cls/education/

CWTS Leiden Ranking. (2024, 29th April). *CWTS Leiden Ranking 2022.* https://www.leidenranking.com/ranking/2022/list

Kara, E., Tonin, M., Vlassopoulus, M. (2021). Class size effects in higher education: Differences across STEM and non-STEM fields. *Economics of Education Review, 82.* https://doi.org/10.1016/j.econedurev.2021.102104

Universitetets Kanslers Ämbetet. (2024, 23rd April). *Ökade kostnader för högskolor och universitet 2023.* https://www.uka.se/om-oss/nyheter/nyhetsartiklar/2024-04-23-okade-kostnader-for-hogskolor-och-universitet-2023

Appendix A – Full list of participant statements by discussion topic

Discussion topic 1 – What is excellent education? What are the essential elements that maintain the education at an excellent level? (Now and in 20 years)

- Students should be able to use their knowledge when they graduated.
- Teacher-student time should be maximal. Be close to the student to see if they actually learn and develop.
- Students should get general competences (personal development, self-leadership, and more)
- Active learning.
- Student know what they should know after their education
    - The three-year programs and all maritime programs shall work after their graduation
    - The five-year program shall be more theoretically capable
- Students should grow as people, more than just subject matter.
    - Chalmers meets the students' need to grow.
- Social study environment, including integrating new students.
- Students should want to be physically on campus. E.g. good study spaces, good lecture halls. Automatically uploading blackboards notes to online?
- Student accomodation is important.
- Västtrafik and public transportation should work well so students can easily come to campus.
- Premises are good, material is good, technology is good.
- Lecture / teacher time should be used optimally.
- Synergy between programs, sharing courses between programs (scale) and have smaller specific courses for program-specific subjects.
- We need to be dynamic with our courses, everything is updating and changing in the world.
- Ensure the amount of content in courses doesn't diminish over time (one person has experienced a diminishing amount of content in courses over the years).
- International students are more used to longer study days.
- If we have infinite resources:
    - Smaller student groups
    - More formative assessment
- Resource-effective:
    - How does one utilize teacher
    - High-quality examination process.
    - Feedback is important, especially in year 1.
    - Less administration performed by teachers.
- Student – Teacher time maximized
- Optimal usage of teaching time, class time, etc.
- Student can actually use their knowledge after graduation.
- Students have learned general competences.
- Integrating international students and a positive study-social environment.
- Good teachers.
    - Continually developing teachers.
- Sign of success: We have attractive alumni.

Discussion topic 2 – How can we provide preconditions for teachers to deliver excellent education? (Now and in 20 years). What current strengths can we build upon? What weaknesses and risks are there, and how shall we avoid them?

- Teachers should have the time to deliver courses.
- We need time to re-work courses to be updated with the recent development.
- What is the career path for a teacher?
- What is the reward for taking pedagogical courses?
- How do teachers get a higher salary?
- Teachers - We are excellent, top in Europe.
- Have employable roles for just teaching.
- Time for developing courses and not just teaching the course.
- Educate teachers on how to teach large class-sizes well.
- Multi-disciplinary teaching teams where it's not just researchers and not just teachers.
- Teacher-only roles need to have time to develop their own competences (e.g. by research projects etc).
- Difficult to maintain excellence in education if student number increases (if you don't have course-development).
- The most important: Teaching-staff is valued lower.
- It's a strength to have teachers who both teach and research.
- Better (more structured?) hand-overs of courses so that knowledge isn't lost.
- Collaboration between courses in the same program (or even different programs).
- Value educating higher and make room for course-development.
- Educate staff in how to better hold large courses.
- Administrative tasks removes time from educating, for example Canvas, cooking rooms, etc. Perhaps we can be more resource-effective with more admin-staff?
- We recruit good researchers at Chalmers, but the educational qualities of them are not prioritized. Including PhDs?
- Lower administrative burden.
- Students - Use students in peer assessment, to help assess others.
- AI - Teachers can use AI in the future to get insight into specific student's progression.
- AI - Use AI as a TA in the future?
- Big program-wide red thread progression between courses and between teachers (and between teachers in the same course or same subjects).
    - We need "teacher teams"

Discussion topic 3 – How does teaching and the way we deliver it need to change? What is meant by resource-efficient? Does resource-efficient and excellent education go hand-in-hand?

- Different class sizes.
- In huge courses, students primarily have contact with the PhD TAs, not with the examiner.
    - Continuity. If we rely on PhDs to teach, we have to re-teach our TAs all the time when they leave.
- Lectures in the entire course, but split the large course into smaller groups. And even perhaps groups of groups.
- Shift the responsibility of learning from the teacher to the student.
- More incentives for students being more prepared before coming to a class (flipped-classroom), e.g. bonus points with quizzes.

- For the humongous courses, we need two examiners with equal responsibility and shared workload.
- Research-input. Be available in the classroom.
- Balance between research and teaching.
    - Expectation.
    - Swedish vs English.
- Looking outwards: Integrate the international students
- Demands on the students should be maintained (i.e. don't lower our expectations of students).
- Evaluation system.

Contact and more info

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