A touch of diversity in the traditional course structure: a Flipped Classroom experiment in Remote Sensing

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Introduction

My own education was mainly characterized by traditional lectures[1] in both small and large classrooms with little activation and interaction of the students and only a small amount of group work and discussions. While I did not question these methods back then, now, transitioning into the role of a teacher, I find myself reflecting on alternative pedagogical methods. I am particularly interested in understanding which methods best facilitate learning and how I can design a lecture that is both interesting, engaging, and informative and at the same time inclusive to address the varied needs of students. In the landscape of modern education, innovative pedagogical approaches continually emerge. Among these is the Flipped Classroom (FC) model, which marks a paradigm shift in modern education as it challenges conventional lecture-based teaching and moves the agency of learning from instructors to students.

Here, I will introduce the FC model, explain how it was implemented in a medium scale lecture setting, analyze the outcomes, and suggest future perspectives.

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[1] *Traditional lecture* refers to a pedagogical method that involves an instructor that conveys information to students through verbal communication and visual aids. There is typically limited or no interaction with the students.

What is the Flipped Classroom?

The FC method represents a paradigm shift in traditional pedagogical approaches, emphasizing active learning and student-centered instruction. It emerged as a concept in the early 2000s, coined as *Classroom Flip* by Baker (2000) and *Inverted Classroom* by Lage et al. (2000). Both reversed the conventional order of instruction by moving the actual lecture out of the classroom, providing the students with the class content as pre-recorded lectures, readings, or multimedia materials that they study at home before meeting in class. This promotes active learning and fosters deeper engagement with the course content among students who take ownership of their learning process and as such get a more personalized educational experience (Talbert, 2017). In turn, this enables in-class time to be dedicated to interactive activities such as group work and discussions, problem-solving sessions, peer-instruction activities, where students can apply their pre-existing knowledge, engage in collaborative learning, and receive immediate (formative) feedback (Lage et al., 2000) (Fig. 1). The role of the teacher changes from a lecturer in the traditional setting to a supervisor in the FC. The time allocated for either a traditional lecture or the FC format remains unchanged.

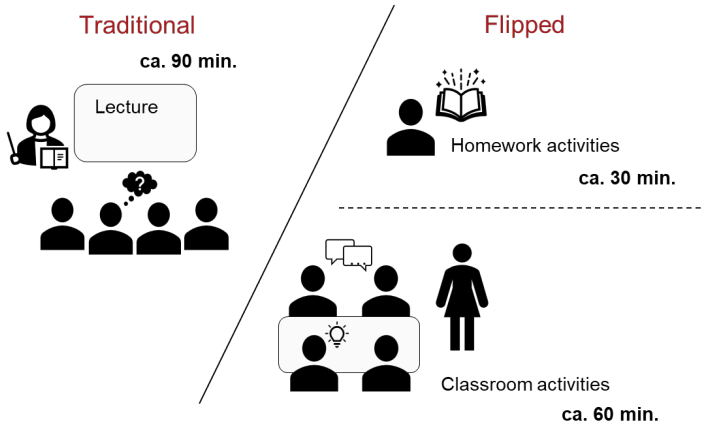

Fig. 1. *General concept of the Flipped Classroom as compared to a traditional lecture.*

The FC concept has advantages particularly for students that have a harder time following a traditional lecture, as they can control the speed at which they consume information, and they can also use additional

sources if they find that useful (Bergmann and Sams, 2012). Similarly, working with the class content in smaller groups makes it more likely for more students, and especially those that are more reserved than others, to actively engage with a topic.

Course background and justification

I chose the "*Introduction to Remote Sensing*" (NIGB14039U) to place the intervention of the FC. This is a bachelor course that typically enrolls around 30 students, this year it counted 37 students. The course introduces the students to the main concepts related to optical remote sensing and intended learning outcomes (ILOs) include amongst others the ability to evaluate the suitability of various remote sensing data for addressing geographical issues in space and time (Appendix A). The course runs over seven weeks, and each week consists of a 90-minute traditional lecture on Tuesdays and a corresponding 3-hour hands-on class on Thursdays where the students work in groups on a pre-defined cookbook exercise. Finally, in the groups, they hand in a report where they apply the methods that they learned on a problem and geographic region of their choice, which serves as the basis for the exam.

One could argue that the "*Introduction to Remote Sensing*" course already encompasses different teaching formats, such as lectures and lab work/ seminars and that it is well structured in a way that the practical part is strategically aligned with the theoretical content covered in the corresponding lectures of the same week. This enables the students to build upon the foundation laid in the lectures, and apply methods and concepts to real-world problems, thereby enhancing their comprehension and retention of key concepts.

While I acknowledge the basic structure of the course, I would argue that there are two main issues that could potentially hinder a holistic student learning experience. First, all lectures are designed as traditional lectures where students are presented with information, which they passively consume. The lack of student activation may, however, restrict their cognitive engagement with the content and limit their understanding of a given topic, which consequently may impact their ability to effectively use the knowledge during seminars and working on their final

project. Second, the hands-on exercises in the seminars themselves are designed in a cookbook style where students are provided with explicit step-by-step instructions. This makes it easy to follow a process and achieve a desired result (behavioral engagement), however it does not engage the students on a cognitive and emotional level (Fredricks et al. 2004), and as such is likely to not promote critical thinking and the development problem-solving skills. Ultimately, this may result in a situation where the students are not optimally prepared to work on their own problem and data for the final project.

Objectives of the Flipped Classroom

By shifting the focus from passive consumption of information to active cognitive engagement with and application of the course content, the FC model seeks to optimize learning outcomes by fostering a more student-centered learning environment thereby enhancing students' understanding and retention of course material.

Some of the ILOs as declared on the course description page (Appendix A), e.g., *evaluate the advantages and disadvantages of analyzing remote sensing data* aim at higher and highest levels of cognitive learning following Bloom's taxonomy (Anderson & Krathwohl, 2001). I would argue that achieving these ILOs would benefit from a student-centered learning environment and an active cognitive engagement with the course content.

As such, my overall goal with implementing the FC was to break up the routine of the traditional one-way communication between a teacher and students, and to facilitate a dialogue-based and interactive learning environment, ultimately enhancing student learning.

Structure and implementation of the Flipped Classroom

Week 7 of the "*Introduction to Remote Sensing*" course aims at broadening the students view on remote sensing by introducing them to methods and concepts beyond optical remote sensing, namely RADAR, LiDAR, and passive microwave (PM) remote sensing. They can use these methods to discuss their own work in the final project but are not expected to apply it or know in detail the underlying principles. I decided to place

the FC in this last week of the course, as I felt it provides a safe environment for this experiment (not exam-relevant) and the threefold character of this course week seemed perfect for group work and peer-instruction activities.

In the week before the FC (week 6), I used the last 10 minutes of the lecture to provide students with an overview of the upcoming week's agenda. I introduced myself and the context of my teaching, which is the University Pedagogy course. I further briefly explained the general concept of the FC as well as the three thematical topics they will be working on to stir their curiosity. Then, I split them into three groups based on alphabetic order, with two groups of 12 and 1 group of 13 students. Each group was assigned a specific remote sensing method, along with a corresponding color (RADAR: orange, LiDAR: blue, PM: green), and was provided with links to YouTube videos relevant to their assigned topic. These videos were recorded lectures on the specific topic (one video on method and one on applications) from The Australian National University. In addition to watching the videos, students were asked to complete a brief questionnaire (Appendix B) that was designed to provide insight into 1. the number of students who viewed the videos (and are expected to attend class), 2. the specific videos they watched, and 3. areas of difficulty they encountered. This also gave them the opportunity to ask questions they may have left.

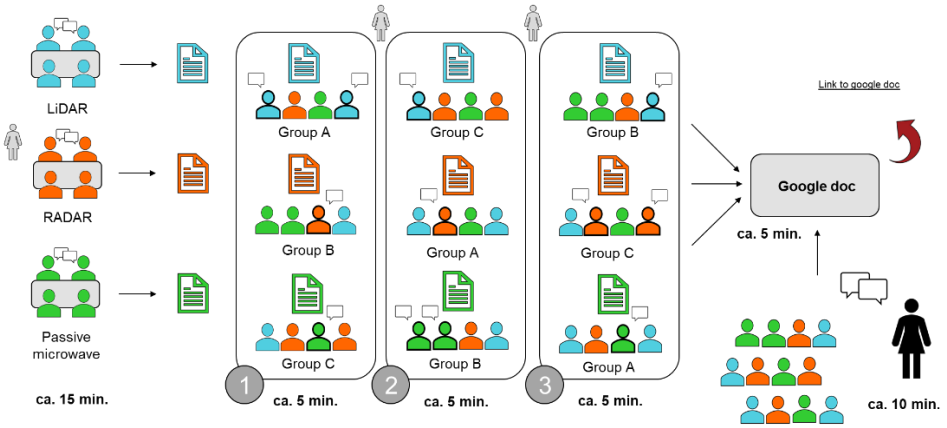

Fig. 2. *Overview of the flipped classroom session. After a small introduction to the day, a) the students gathered in groups (three in total) based on the topic they have been working with in the home activity (groups were assigned beforehand) and created a poster. b) Groups were reshuffled so that each new*

group contained an approximately equal number of students from all three topics. Each group gathered around a poster and in ca. 5 minutes, the students that were involved in making the poster presented their topic to the others. Then they move on to the next poster, and the next. c) After three iterations the students start filling out a google doc with the main information on the three topics. d) Lastly, we complete the doc in plenum, clarify questions, and follow up on the session.

The day of the in-class activity of the FC, circa half of the students showed up, 6 watched videos about LiDAR and PM, respectively, and 4 watched videos about RADAR. I began the class with introducing the students to the groupwork activity using Fig. 2, and in their respective groups, they picked up a giant poster and pens at my desk and found themselves a corner in the room to start discussing their topic and preparing the poster according to some key points that I provided, e.g., spatial resolution, core concept of the method, typical applications, etc. I walked around the classroom, mostly observing them but also available to address any questions and offer feedback to the groups. After approximately 20 minutes, we followed the scheme as given in Fig. 2.: new groups (matrix groups) were formed so that each new group contained an equal number of students from all three topics. Each group gathered around a poster and in ca. 5 minutes, the students that were involved in making the poster presented their topic to the others. Then they moved on to the next poster, and the next. These matrix group presentations aimed to promote shared responsibility within each group, as all members had to explain their group's main findings to some of their peers.

After all topics were presented, the students started filling out a google doc with the main information on the three topics in their matrix groups and after ca. 5 minutes we complete the doc in plenum, clarified remaining questions, and followed up on the session. The very last task of the day was to evaluate the lecture for what I had prepared another google form (Appendix C).

I also had prepared for alternative plans in case only a few students (Plan B) or most of the students have not watched the videos (Plan C), respectively (Appendix D).

Student evaluation of the FC

Student evaluation of the FC was done in the last five to ten minutes of the lecture using google form as an online questionnaire covering different aspects of the intended learning outcome of the FC. The students were asked their opinion on the FC as a teaching format, to rate the format relative to a traditional lecture, in terms of learning outcome, and reflect on their perception of the FC format, e.g., where did they learn the most, what went well, what could be improved (Appendix C).

Overall, the FC received positive feedback. About 75% of the students indicated that they enjoy the FC as a teaching format in general and just as many said that they liked this particular FC session (Appendix C, question 1 and 2), aligning with my observations in the classroom. Students appreciated the more active and analog format of the lecture where they were leading the activities instead of listening to a traditional lecture.

> *"I like the interactive part where you get to talk to the other students, and you dare to ask the stupid questions you don't dare to ask in lectures."*

> *"Posters are fun, they create a more visual experience and can contribute to learning."*

The initial group discussions were particularly effective in supporting the students' learning, as more than half indicated that they learned most in the group work and preparation of the posters (Fig. 3). Moreover, 80% indicated that the group work helped to clarify questions they had after completing the home activity (Appendix C, question 3).

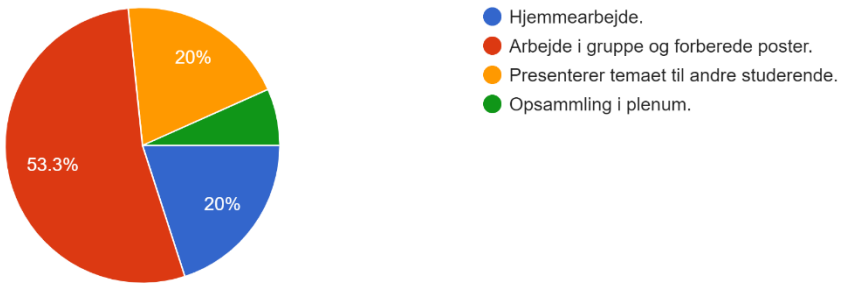

Fig. 3. *Student answers to the question "In which part of the FC activity did you feel you learned the most?" Blue: Home-activity, Red: group discussions and poster preparation, Yellow: Peer-Instructions, Green: Wrap-up in class.*

A total of 40% expressed that they learned most in the home-activity and peer-instruction/ presentation of their posters, and the remaining 10% highlighted the wrap-up in class as particularly useful for their learning and understanding (Fig. 3). This clearly shows that the FC is a very suitable tool to accommodate varied students' needs and their different ways of learning. Moreover, many expressed that the different ways to engage with the topics really helped to foster a deeper understanding:

"I know I'll remember better if I've tried to explain it to others."

"It's great that there are so many different steps of learning here."

When they were asked to compare how well or how much they think they have learned compared to a traditional lecture, the answers were ambiguous: 60% indicted they learned just as much/ well as in a traditional lecture, whereas 20% indicated they learned less or more, respectively (Fig. 4).

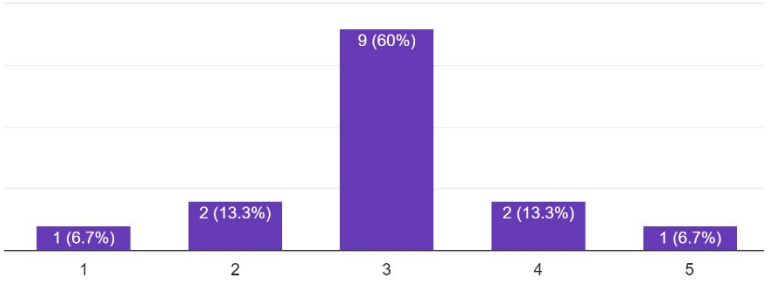

Fig. 4. *Student answers to the question "If you compare the FC to a traditional lecture, how would you rate how much or how well you have learnt? 1: much less - 5: much more."*

I think this is an interesting finding in different ways. First, it is worth mentioning that how well and how much the students learnt is not necessarily the same. Indeed, in the written feedback most students indicated that they thought they had learned very well. It could thus be that the students learnt and understood very well the topic they were engaging with at home and in their thematic groups, but the same is not necessarily true for the topics they learnt about during the poster rounds and peer instructions. Indeed, there was a big imbalance in the time they spent engaging with each topic. While students devoted around 40 to 60 minutes to delve into their designated topic (home activity: 20-40 minutes, group work: 20 minutes, peer-instruction: 5 minutes), they were allocated only 5 minutes for each of the remaining topics in the matrix groups.

"More time at each poster station, it felt a bit rushed."

This is definitely something to keep in mind when designing future lectures and balancing traditional teaching with more active formats, like e.g., the FC. While traditional lectures are well suited for delivering larger amounts of content and provide overviews, the FC model fosters a deeper understanding of smaller amounts and more specific content. In other words, using the FC, students may not learn as much as they would in a traditional lecture, but they are likely to learn it better. Another point worth mentioning is that students' perception of their learning and their actual learning are not necessarily the same. In fact, Deslauriers et al. (2019) showed that actual learning of students being actively engaged in the classroom was higher than the learning of those receiving information passively. The perception of learning, however, was opposite (Deslauriers et al. 2019).

Lastly, some students mentioned that they would have wished for a more structured wrap-up and summary of the google doc at the end of the FC session. This is much in line with my own reflection, and I would improve this the next time.

"The plenary session was a bit messy."

"Your review of the overall google docs document was very quick."

Own reflections and future perspectives

Exchanging a traditional lecture with a Flipped Classroom (FC) model was overall a successful experiment that both students and teacher enjoyed. Reflecting on my own experience and the student evaluation, several important observations and recommendations emerge.

There seemed to be a clear improvement in student learning as indicated in the questionnaires. The enhanced understanding of key concepts and retention of information through application of different learning methods (mainly group work), underscores the efficacy of the FC approach as a valuable addition to the course structure.

In the future, I would consider balancing the time the students spend on delving into their designated topic and engaging with the other topics in the matrix groups to improve the overall learning. This could be achieved by allocating more time for poster rounds and peer instruction.

Moreover, I think it is key to wrap up and summarize the FC session in a structured manner after a class where the students themselves were in charge of their learning. It will be important to reassure them that this lesson provided them with all the information and theoretical knowledge they would have received in a traditional lecture where the teacher led the learning process. This could be improved and achieved by allocating more time for the concluding part of the FC and adding structure by having one or two students from the thematic groups presenting their topic in plenum, with the teacher stepping in when necessary.

By continually refining teaching methods based on what works best, educators can keep improving the learning experience to meet the changing needs of students.

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Appendix

Appendix A: Intended learning outcomes for the Course “Introduction to Remote Sensing” (https://kurser.ku.dk/course/nigb14039u)

Knowledge:

- Satellite-based natural resource management
- Basic remote sensing image analysis
- Digital image processing and image classification
- Project work

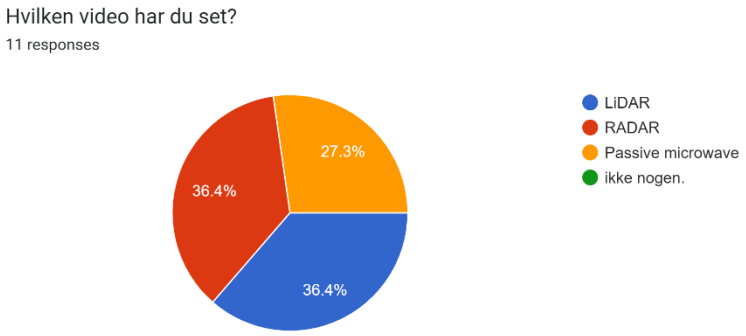
Skills:

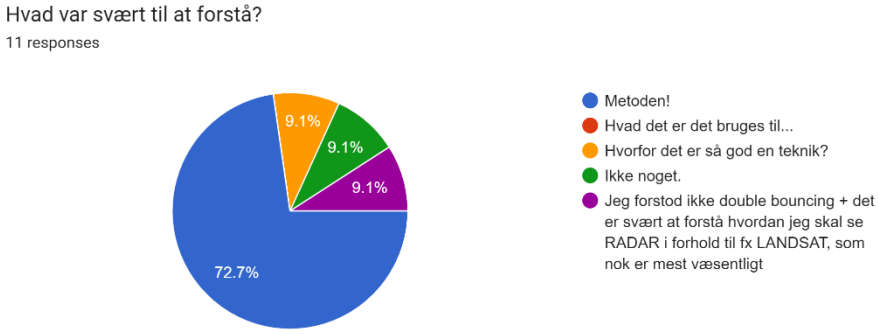
- Apply basic remote sensing concepts/terminology and principles.
- Demonstrate knowledge of basic physical principles of remote sensing.
- Describe remote sensing data types and their applications (satellites, sensors, etc.)
- Use remote sensing data for mapping natural resources.
- Perform basic image processing (geometric image alignment).
- Perform image classification (classification algorithms) of land use and change detection analysis for selected areas.
- Determination of vegetation parameters and vegetation distribution.

Competences:

- Combine data, algorithms and software to solve a limited scientific problem of your choice using digital image processing.
- Assess the suitability of different remote sensing data for use in solving geographical problems in time/space.
- Evaluate the advantages and disadvantages of analyzing remote sensing data in terms of spatial, temporal, radiometric and spectral resolution.
- Assess and discuss potential sources of error and uncertainty in remote sensing data analyses.

Appendix B: Questionnaire (with results) for homework activities





Open question: Er der noget du gerne vil have forklaret eller diskuteret igen når vi ses?

Mere præcist præcis hvordan radar fungerer rent teknisk

Hvorfor en lang antenne er lig med høj opløsning + et overblik over hvad der differentierer RADAR og optiske sensorer, jeg har nok kun forstået det halvtnej

Hvilken af de tre typer der var god til at projekter om gletsjere og hvorfor den er god?

"Passive remote sensing" måler naturlige emissioner - men jeg forstår ikke helt hvad "active remote sensing" så er?Forstod ikke helt det med polarisation (vertikalt og horisontalt fx)

Lige få den en gang til i forhold til vinklen satellitten kigger ned på "bjerget," og havd det betød for, hvordan den tolkede det og hvordan det var med skyggen :)

🌍

Vil gerne høre, hvordan LIDAR kan måle jordoverfladen i et svært tilgængeligt område - f.eks. i en meget tæt befolket skov. Trænger strålingen igennem træerne?

Nok bare lidt mere detaljer omkring Passive microwave. Synes det svært at blive undervist igennem youtube vidoer i et emne der er helt nyt.

Diagrammet over laseren som returneres (x,y-akserne hvor man kan se træer, bygninger og overfladen langs x-aksen)

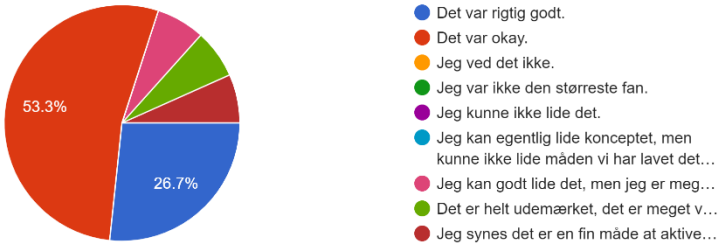
Appendix C: Results from the feedback google form

Hvad tænker du om FC konceptet generelt?

15 responses

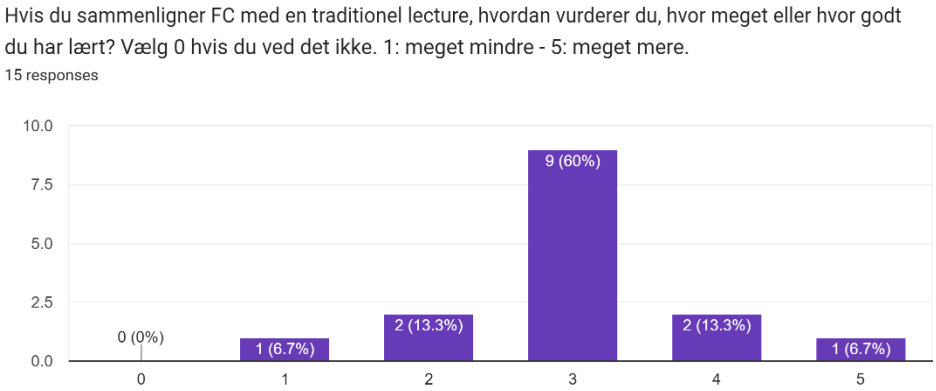
Hvad tænker du om vores FC aktivitet?

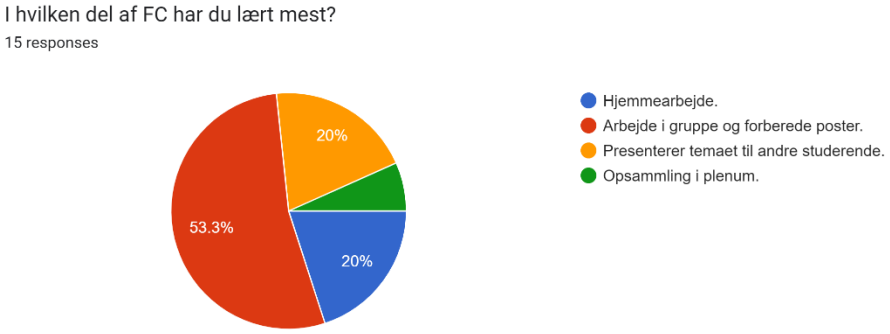
15 responses



Hjalp gruppearbejde med at forklare eventuelle spørgsmål du har haft/ ting du ikke helt forstod hjemme?

15 responses





Open Question: Hvad kunne du lide ved FC aktivitet?

Gruppearbejde - rart at få snakket omkring de ting man enten var i tvivl om, eller de ting man evt kunne hjælpe med at forklare.

Dialogen mellem klassekammerater

Arbejde i gruppe og forberede poster og præsenterer temaet til andre studerende.

At tale om emnet gør, at jeg kan huske bedre.

Det er fedt at der er så mange steps i læringen her. Man lærer det først derhjemme, så har man tid til at forstå det sammen og stille spørgsmål i posters-gruppen, og så lærer man at formulere det med egne ord bagefter i præsentationen, og også godt med opsamling til sidst så man får alt med man ikke lige havde forstået

At snakke med sine medstuderende om emnet

Det er godt at tale sammen med andre om det, man har læst og selv skulle sætte ord på det og forklare det for andre. det lærer man mere af, end bare at lytte og man husker det bedre. FUngerede godt, at man startede sammen med andre, der havde læst det samme og herefter stod på egne ben og skulle forklare.

At jeg ved at jeg husker bedre, hvis når jeg selv har prøvet at forklare det videre til andre

Man kommer lidt op og stå, gør at det bliver en mere aktiv læringsproces. Posters er sjovt, skaber mere visuel oplevelse og kan bidrage til læring

Man arbejder med materialet på flere måde og analogt

Jeg kan godt lide den interaktive del hvor man kommer i snak med de andre studerende og man tør ligesom stille de dumme spørgsmål man ikke tør stille til forelæsning.

At man selv skal forklare begreber og processer.

At det var interaktivt, og det var krævende og en god øvelse at forklare hvad man ved. På den måde følte jeg mig mere aktiveret og det sidder godt i hukommelsen

At det overkommeligt at forberede sig til hjemme fra

Rigtig fint at skulle anvende og formidle viden selv

Open question: Hvordan kan det forbedres?

Ikke nogle umiddelbare idéer, synes alt i alt at det var en vellykket forelæsning.

Når man skal skrive ned i dokumentet, vil det give bedre mening at gå tilbage til sign originale gruppe.

Opsamlingen i plenum var en smule rodet. Herudover kunne det have været rart med mere tid til at fordybe sig med de andre studerende. En pause efter 45 minutter kunne have været godt:)

Flere grupper og emner. Der var ikke nok fagligt indhold ift forelæsningerne.

Det kan rigtig godt kombineres med normal undervisning så det ikke er det her hver gang

Mere inddragelse af underviser da mange spørgsmål da vi lavede poster ikke blev ordentligt besvaret i gruppen så vi kunne ikke svare på spørgsmålene da vi lavede oplæg for de andre grupper

DIn gennemgang af det samlede google docs-dokument var meget hurtig. DU kunne godt lade hver gruppe gennemgå (lidt hurtigt) og så bryde ind her. Man havde ikke overblik over, hvad de andre havde skrevet, så svært hurtigt at forstå dine indvendinger/rettelser.

Folk skal være klar over at der stilles krav til at de har sat sig ind i tingene inden de kommer til undervisning

Mere tid ved hver poster, det føltes lidt rushed.

x

Jeg synes det fungerede rigtig fint. De fleste af os tænker jeg kender til matrix grupper. Det blev forklaret meget i dybden hvilket jeg ikke ved om var nødvendigt.

Videoerne var en smule komplekse. Ville have været rart at starte med en video der forklarede de grundlæggende principper ved metoden og fysikken bag før de andre to videoer.

Jeg synes forberedelsen var lidt mangelfuld. F.eks. kunne jeg godt have tænkt mig lidt mere visuel præsentation f.eks. bedre figurer i sammenhæng med noget tekst. Den ene video jeg så var optaget med en dårlig mikrofon, så det var lidt uklart.

Jeg synes at det ville fungere bedre som øvelsestime end erstatning af forelæsning, og jeg synes at det vil fungere meget godt som øvelsestime til gengæld

Hmm... ved det ikke helt. Men jeg fornemmer, at succesen også afhænger lidt af, om de studerende er bekendte med undervisningsformen til at begynde med.

Appendix D: Alternative plans for the FC in-class activity.

Plan B becomes effective if enough students, a minimum of 3 or 4, did do the homework and watched the videos they were assigned, but few did not prepare. Those who did the homework would proceed with the FC activity as described above. The others that did not watch the video at home watch them while the others prepare the posters. They join their respective groups before the new groups are formed and participate in the peer-instruction.

In case most of the students did not prepare at home, Plan C becomes relevant, and all students will watch the videos in their assigned group, either in a dedicated corner of the room, or in a separate room. Afterwards, they will discuss the videos with respect to the focus points and fill out the google doc. We will skip the posters, form new groups, and the students will use the google doc directly to present the methods to each other.