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# 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 utveckla 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.

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