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Flip your classroom - But be aware!

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Mark Cieliebak

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Fred Astaire does his own version of flipping the room in the film Royal wedding. Photo: Public domain

Introduction

Flipped Classroom (FC) is a teaching method where lecture and homework are "flipped": first, students prepare the topic of next lecture at home, e.g. by reading part of a text book; then, in the lecture, they work with the teacher to clarify open questions, discuss the topic, and solve exercises.

Flipped classrooms have become very popular in recent years. They go back to the 1990's, when Eric Mazur introduced Peer Instructions in his physics lectures at Harvard University (Mazur, 1996). Since then, the concept has evolved into an established teaching method that is now used successfully at elementary schools, high schools and universities. Since 2012, more than 30 books, guidelines and research papers have been published on the method. (For a recent literature survey, see (Hamdan & al., 2013) and (Yarbro & al., 2014).)

We have used FC at [Zurich university of Applied Sciences](#) in various courses of studies, including computer science, physics, and environmental sciences. In this article, we present our hands-on experiences with the method: first, we explain the main components of a flipped



Mark Cieliebak

Mark Cieliebak is Deputy Head of Research Area "Distributed Software Systems" at Zurich University of Applied Sciences (ZHAW). He did his PhD in computer science at ETH Zurich and worked several years as Head of IT in a software startup, until he joined ZHAW in 2012. In his research, he focusses on software engineering, efficient algorithms and automatic text understanding, where he publishes frequently. In addition, he is an enthusiastic teacher and lecturer. He received a special award for "Outstanding Teaching" at ETH Zurich, and also recently received the "Teaching Award 2014" at his university. Contact: cziel@zhaw.ch

classroom, and we describe the general pros and cons of the concept; then we show how our students react to the concept, and we present the results of a study that compares flipped classroom with classic teaching; finally, we discuss our lessons learned from using FC for many years.

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How can you set up a flipped classroom?

There exist many variants of FCs, and teachers usually adapt the basic principles to their needs. As a showcase, we describe how we implemented FC in a computer science course on "Algorithms and Data Structures" that we taught in 2014 at Zurich University of Applied Sciences. The approach is generic, and may serve as a template how to setup a Flipped Classroom for arbitrary topics.

In our setting, the semester runs for 14 weeks, and every week targets a specific topic such as "Basic Sorting Algorithms". This allows us to have closed and independent teaching units.

Every week is divided into four phases (see Figure 1):

1. Preparation, where the students get to know the topic;
2. Quizzes, where the students answer simple online questions about the topic;
3. Plenum, where students and teacher delve deep into the topic; and
4. Exercises, which the students solve alone.

We now explain each phase in more detail.



Figure 1: Main Phases of a Flipped Classroom

Preparation

We are using a free online learning management system ([OLAT](#)) where we provide the students with all relevant information for the lecture. In particular, for each week we supply the following data:

- Topic of the lecture
- Motivation, why this is relevant
- Learning targets
- Introductory video (2-3 minutes)
- Learning material that needs to be prepared (book chapter, video tutorial or other online resources)
- Links with additional material and information.

Serious preparation of the learning material should take 60-90 minutes for the students.

Quizzes

After preparation phase, the students complete a short online survey, where they answer 6-9 questions about the topic ("quizzes"). These questions are directly related to the learning material, and should be easy to solve if they studied the learning material. Answering the quizzes should take 10 minutes at most.

The quizzes end each week with a mandatory question: "What did you not understand? Or, if everything was clear, what did you find most interesting?"

Plenum

The students solve the quizzes each week until one day before the plenum. The results show the teacher which parts of the topics were well understood, and which have to be explained in more detail in the lecture.

A typical plenum has 90 Minutes and consists of three parts:

1. Short introduction and motivation of the topic;
2. Clarification of open questions; and

3. Solving small assignments.

Open questions are derived directly from quizzy responses, in particular from the last question "What did you not understand?". In fact, it is often possible to put some of the responses directly on a slide and discuss them in the plenum (e.g. "Is it OK to solve small or medium size problems with brute force?")

In the last part, each assignment takes 5-10 minutes to solve, and students work either alone or in small groups. For assignments, we use simple exercises or [ConcepTests](#) (Mazur, 1995). Students present their solutions of the assignments and discuss them in the plenum.

For each topic, we have a large collection of slides with examples, explanations, and assignments, which we generated before semester start. During the semester, each teacher just selects the appropriate slides for his/her plenum, and adds new slides or explanations only if necessary (this reduces the amount of work for each teacher).

Exercises and grading

After the plenum, students solve hand-on exercises alone. Each week, exercises take 3-6 hours to complete, and cover the current topic in depth. Solutions are submitted for grading electronically (via OLAT), and reviewed by the teacher. Results of the review are discussed with the students individually in the following week.

Successful participation in quizzes and exercises over the entire semester makes up for 20% of the final grade (10% each). This is intended to motivate students to work continuously during the semester. In addition, there is a written exam at end of semester (80%).

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Using flipped classrooms

Pro's

Flipped classrooms promise one huge advantage over traditional teaching methods: time. Since the students prepare the topic at home, they know already all the basic definitions and simpler facts. Hence, the teacher can save time explaining these trivialities, and concentrate on more challenging and interesting aspects of the topic, on the difficult parts. In fact, there is usually plenty of time during the plenum for discussions and individual feedback.

Other arguments in favor of FC are:

- students can learn according to their individual progress;
- students understand and remember better through interaction and activity than by frontal teaching;
- time in lecture is used more efficient;
- students who missed a class are able to catch up;
- teacher knows open questions beforehand, and prepares good answers.

Con's

There are, of course, also arguments against FC:

- students have to invest more time;
- preparing learning material is a bigger effort for the teacher;
- does not work if students do not prepare for each lecture;
- students might not learn more.

In the following, we will tackle these arguments and summarize our experiences with using FC at our university.

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How do students react?

When first presenting the concept of flipped classrooms, students react rather reluctantly. Most students have never attended FC before, and they see primarily the additional amount of work. However, over time their attitude changes and almost all students give excellent ratings to the concept: In an independent evaluation, over 78% agreed that "Flipped classroom suits them better than traditional lectures" (Keck Frei & Thomann 2014).

Upon asking individual students for feedback, these are some of the most typical positive answers (translated):

- "The material can be covered more intensively."
- "I left every lecture with the feeling that I really understood it; unfortunately, this is often not the case for classic lectures."
- "I am forced to get in touch with the topic before the lecture. This allows me to build an own opinion of the topic first."
- "The lectures are much more efficient; this way, there is much time for real-world

- examples."
- "I like the quizzes!"

On the other hand, students also see disadvantages in the approach (translated):

- "Preparation takes very much time."
- "I don't think it should be used for every course; this would not be possible."
- "This only works with very motivated students."
- "For me as a beginner, flipped classroom does not work."
- "Whoever visits the plenum without preparation will understand little to nothing."

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Do students learn more?

We have been using FC for several years at our university, and feedback of the students on this teaching method was always very positive. They proactively participated in discussions, presented their solutions, over 80% prepared their homework, and they scored well in exams. However, there was always discussion whether the method "works", if it is – at the end – any better than classical teaching methods.

For this reason, we initiated a research study on the effects of flipped classrooms. Geri Thomann and Andrea Keck Frei from Zurich University of Teacher Education conducted the study in 2014 on behalf of School of Engineering of Zurich University of Applied Sciences (Keck Frei & Thomann, 2014).

In the study, three classes of computer science students were compared, one of which was taught with FC, the other two with classical lectures. The study has not been published yet, but we summarize the main results here. (See also Cieliebak, 2014).

Although the sample of the study was rather small, the results are very encouraging:

- Students in flipped classrooms use much more time for preparing the lectures.
- Both groups of students perform equally well in the exams, with Flipped Classroom students slightly better.
- Students with flipped classroom improved their non-technical competences (communication, organization, etc.) much more than those with classical lectures.

Overall, the study concludes with "a positive conclusion for Flipped Classroom" (Keck Frei & Thomann 2014, translated).

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What are our Lessons Learned?

In the following, we summarize our most important "lessons learned", when teaching in Flipped Classrooms.

High effort for introducing flipped classrooms

When we want to switch an existing course from classic teaching to FC, it usually takes 6-8 hours per 90-minutes-lecture for preparing the material. Within this time, we select the learning material, write the web page in our learning management system, and develop quizzes, tasks for the plenum, and exercises. We usually do this before semester starts, for each week. If we produce introductory videos for a lecture, this takes additional 3-5 hours per video.

During the semester, each teacher needs additional 60-90 minutes to evaluate the quizzes and select tasks for the plenum.

Support and resistance from other teachers

When we started using FC, many other teachers were very interested in the concept, and some even started using it already. However, there were also teachers who were very skeptical, and still are. One of the reasons might be that FC challenges the basic principles of classic teaching. Therefore, one has to be prepared to handle some amount of opposition.

In addition, we found it important that those who use FC really advocate for the method: there is no use in forcing anybody not convinced of its usefulness to use the method.

Good teaching material is important, but difficult to find

Students have to study the learning material alone, without previous knowledge. For this reason, appropriate learning material is very important. In our setting, we use a textbook, accompanied with summary and additional explanations in the learning management system, plus some short introductory videos (2-3 minutes each).

A normal course script is in our opinion not sufficient as learning material, since this was usually written for post-class reading. The same applies to most textbooks, which often rely on the fact that the topic was first introduced, motivated and explained in a lecture. Finding good, self-contained textbooks that are suitable for FC is not an easy task.

Students fulfil their preparation tasks

In our experience, students usually studied the learning material thoroughly before they come into the plenum. Moreover, each week more than 80% of all students complete the quizzes before the lecture. One of the reasons is, probably, that solving quizzes contributes to the final grades.

Quizzes are useful for preparing the lectures

Since quizzes are completed before each lecture starts, the teacher can see which sub-topics did the students not yet understand. This helps very much, since the teacher knows exactly what he/she has to explain in more detail.

Quizzy question “What did you not understand?” is very helpful

With this question, the students can point out which topics they are most interested in, and they can ask specific questions. In many cases, the teacher can pose these questions directly in the plenum, and all students search together for an appropriate answer.

This has several positive effects: open and interesting discussions take place; students see that others might have the same or similar questions; and even students that do not talk/ask much in the plenum can pose their questions.

Experience shows that students pose only few useful questions in the first weeks; however, once they see that these questions are taken seriously and answered in the plenum, the amount of questions increases massively.

Introductory videos are helpful, but lots of work

We produced small introductory videos (2-3 minutes each) for most topics. In these videos, we motivated the topic and explained the main concepts and ideas. Students appreciated these videos very much, since it simplified the process of starting with a new topic from scratch. However, producing these videos is very time-consuming (3-5 hours per video). Whenever possible, we now use existing videos from the internet.

Activation in plenum is very high

In the plenum, students discuss open questions and solve small exercises. Often very vivid discussions arise, where most to all students participate actively. Nevertheless, even silent students, who do not talk too much, appreciate the concept, since they can solve exercises on their own and immediately get feedback from the teacher.

There is time for in-depth discussions

In a flipped classroom, all learning content is defined and known beforehand. The teacher does not have to present any mandatory stuff. For this reason, it is possible to use time in the plenum very flexibly: if there is a very interesting discussion, one can let it go “until the end”, until all arguments are exchanged and possible solutions have evolved. On the other hand, if no such discussions arise, one can just go through all open questions and exercises.

Teachers have to be highly competent and flexible

When teaching in a flipped classroom, you do not know beforehand which topics will be discussed in which depth. Often there are questions in the plenum that emerge to educators' total surprise, and which go far beyond the pure learning material. For this reason, teachers using the method have to be able to react spontaneously and appropriately to such topics, which requires a very high degree of expert knowledge – probably more than in classic teaching settings.

Not too many courses should be switched

As we mentioned above, students are very excited about the method, and they usually wish for more courses with FC. However, we found that not all courses should be switched: flipping the classroom requires more preparation time from the students than classic teaching – and switching too many courses might end in an overload.

In conclusion then, most students like the flipped classrooms. Preparation takes some time. Students learn at least as much as in classic teaching, but outperform in non-technical skills. As for future research, we are currently conducting a follows-up study, where we evaluate how FC affects knowledge and skills of students in the long term. Results will be available in 2015.

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