The flipped classroom: a model for active student learning

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Introduction

In traditional teaching, new material is introduced in lectures. A student may activate him- or herself, but not all students have the capacity, motivation and self-discipline to do so. Lecturing tends to result in passive listening aimed at recording mentally what has been taught, perhaps with some note-taking and occasional interchange with the teacher as the sole student activities. Consequently, most students are activated only a small fraction of the time in class. The students are then given reading assignments, homework and projects to develop their understanding further. The active part of the teaching is thus carried out with little support by the instructor.

A study by Freeman et al. [1] shows that the improvements gained from active learning, in which students engage actively in the learning process throughout a course, are substantial. They find that the failure rate of students in regular passive teaching is more than 50% higher than with active teaching methods. Hence there is a moral imperative to improve teaching practices. The study forms the scientific basis for the flipped classroom teaching model presented in this chapter.

The motivation for pedagogical change is the underperformance of many academic institutions. As the heterogeneity of the student population widens with respect to their preparation for academic studies, the need for better teaching practices increases. Moreover, the coming age of automation of work will make HE (higher education) instrumental in retraining labour from past to present skills [2]. The educational process must then be highly performant.

This chapter presents a pedagogical model for active blended learning based on flipped classroom and peer instruction, and provides suggestions for teachers who would like to espouse it. We introduce the teaching model and then suggest how to develop a course with respect to online preparation and in-depth classroom instruction. The subsequent suggestions are organized into two parts: (i) developing course material, and (ii) giving the developed course. A summary and discussion conclude the text.
Flipped classroom

The basic idea in flipped classroom teaching is to reverse the traditional order of instruction where lectures precede student activities: students are instead given homework as preparation for class, and classroom time is then spent on active learning under the guidance of the teacher.

We take as a starting point a course that consists of a series of lectures as well as exercise, recitation and laboratory sessions. The students are activated by homework and other assignments outside scheduled hours. We show how such a course can be restructured for flipped classroom teaching and give a brief overview of a model that uses both online and in-class instruction.

Structuring for blended learning

A course may be divided into learning modules. The structure of a course module is illustrated in Figure 1. The students prepare by self-study for the meetings in class. The preparations may consist of video presentations, reading assignments and quizzes for assessment of the independent learning. Following the preparation by the students themselves, time in class may be used for verifying and reflecting on the preparatory learning and to clarify difficulties and misconceptions. An outlook on the following module may provide connections that support the students in integrating the knowledge to a greater whole.

Student preparations online

Preparing for class can be done without an online learning tool, but such a tool will simplify the task for both the teachers and the students. Most tools offer self-correcting quizzes that provide instant feedback to students on their preparation progress and some provide data on each student’s individual interactions with the system: how and when video presentations were viewed, results for online quizzes, interactions on chat forums and more. The teacher may use such information to

![Illustration of a flipped classroom learning module](image_url)
prepare for the meetings in class, for instance to select useful items for discussion, such as quiz outcomes or questions posed on chat forums.

Meetings in class
The active learning should continue in the classroom. The preparations have pre-empted any need for lecturing. Thus the overall aim should be to clarify any misconceptions and gaps in understanding from the preparation, and to get deeper into the studied subject, ultimately to ensure that the students not only memorize facts, but also meet higher-level educational objectives [3]. A well-tested method is peer instruction by which students are engaged in discussion around questions posed by the teacher [4]. The method is described in the subsequent section.

Course development
The development of a flipped classroom course might require a major redesign of an existing, traditional course. It must be partitioned into modules, and each module must be designed for student preparation and in-class activities. A main change is the use of online material and the monitoring of student activities through the online learning management system (LMS). We first give suggestions for the redesign of a course; we then provide suggestions for production of online presentations, for creating interaction and for sharing and reusing online course material.

Online contents
The syllabus for the course should state expected prior knowledge and learning outcomes, as well as examination and grading of the students’ performance. Figure 2 shows the structure of a flipped classroom course. It is useful to prepare information for the students about the course structure and its pedagogical model, especially if the students are not used to the flipped classroom model. This may be done through an online presentation to get the students familiar with the online
system from the start. This form of meta-information about the course may be continued for each learning module. It assists the students in understanding what to do and why it is necessary, in order to promote their motivation.

The course could contain an online module on the expected prerequisite knowledge of the students, containing both quizzes that check the assumed knowledge as well as questionnaires for self-assessment where the student can tick off itemized concepts, indicating for instance applicable knowledge, familiarity and no prior knowledge. The results indicate a need to rehearse concepts and show whether any student is insufficiently prepared for the course. The learning modules (shown in Figure 1) provide the contents of the course. The final examination could be any combination of written exams and recorded presentations. Examination may be distributed over the course duration.

For the contents of the course, the instructor must decide how each part should be taught: first, what should be covered by the online preparatory material and what should be taught in class, and, secondly, how should the parts be taught. There are many possibilities to explore, and several media and modes might be applied to the same course module in order to cater for students’ different learning styles. When mapping teaching methods to the different parts of the course contents, one should also consider how to monitor the learning. For instance, if both video presentations and reading assignments are used as preparation, they might both be checked by quizzes in the online system.

The online monitoring serves three purposes: first, as a diagnostic test for the student that he or she has learnt what was taught; secondly, for the teacher to see that the students prepare for class; and, thirdly, to identify sections where many students have problems owing to inherent difficulty of the concept or because the material was not clear, or because their background is lacking. These sections may then be reviewed and discussed in class to ensure that they are understood. Passing quizzes is also motivating for the student. The results may be summarized in a scorecard to serve as a gauge of the students’ own results and to show improvements.

Inform the students that they will be monitored online. Privacy with respect to the teacher is the same online as in the classroom; a difference is that students do not see each other online, except for direct interactions and in course forums. It is useful to have the students acknowledging the policies regarding monitoring and personal conduct by posing them as quiz questions in the introductory online course module.

**Creating online presentations**

Video-based instruction works well in most subjects for students to prepare for class. Hence the teacher must produce such material; it might be a new challenge for many. The important part is to get started. A useful minimum is to record a brief overview of each learning module (preparation for class must then be based on reading and other self-study assignments). It may eventually be expanded.

Be reminded that the human attention span is short. Hence recorded video segments should be restricted to a few minutes, ten at most. It is also a reasonable unit for production since it allows updating of the course by rerecording individual segments. Taking an existing 45-minute lecture and breaking it into 5-10-minute
pieces might however not work well. Hence structure the contents into reasonably sized topics and consider how to present each topic. One approach could be to spend a few minutes giving an easily accessible overview of the topic and how it will be presented, and then describing the detailed parts and their interrelationships.

Table 1 summarizes findings and recommendations of Guo et al. [5] with respect to video production. We recommend not complicating the recording process. The recording might become easier by using or mimicking regular teaching situations. For instance, most teachers are accustomed to talking while standing in front of class and hence might record standing up (it affects the way of speaking); a few persons present in a meeting room can serve as an audience, if desired.

Some equipment will be needed to record material for online use, in addition to a computer. There are several software tools to record the computer screen into video, for instance Camtasia from Techsmith (http://www.techsmith.com/camtasia.html) and web-based tools such as Screencast-o-matic (http://www.screencast-o-matic.com) and Dream Broker (http://dreambroker.com). These tools make video of the presentation, and they capture audio, cursor movements and highlights, as well as everything else that appears on the screen (including notifications from other programs). They also contain an editor for video and sound, and for adding highlights, cursors, animations and more.

Table 1
Summary of recommendations by Guo et al. [5] on video production for online instruction

<table>
<thead>
<tr>
<th>Finding</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>Shorter videos are much more engaging</td>
<td>Invest heavily in pre-production lesson planning to segment videos into chunks shorter than 6 minutes</td>
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<tr>
<td>Videos that intersperse an instructor’s talking head with slides are more engaging than slides alone</td>
<td>Invest in post-production editing to display the instructor’s head at opportune times in the video</td>
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<tr>
<td>Videos produced with a more personal feel could be more engaging than high-fidelity studio recordings</td>
<td>Try filming in an informal setting; it might not be necessary to invest in big-budget studio productions</td>
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<tr>
<td>Khan-style tablet drawing tutorials are more engaging than PowerPoint slides or code screencasts</td>
<td>Introduce motion and continuous visual flow into tutorials, along with extemporaneous speaking</td>
</tr>
<tr>
<td>Even high-quality pre-recorded classroom lectures are not as engaging when chopped up for a MOOC</td>
<td>If instructors insist on recording classroom lectures, they should still plan with the MOOC format in mind</td>
</tr>
<tr>
<td>Videos where instructors speak fairly fast and with high enthusiasm are more engaging</td>
<td>Coach instructors to bring out their enthusiasm and reassure that they do not need to purposely slow down</td>
</tr>
<tr>
<td>Students engage differently with lecture and tutorial videos</td>
<td>For lectures, focus more on the first-watch experience; for tutorials, add support for re-watching and skimming</td>
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Other types of video material require other equipment. A document camera is useful for capturing handwriting and manual demonstrations; a web camera can be used to capture the instructor at the computer; and a camera fixed on a tripod can be used to be captured him or her at the board (the camera in a smartphone might serve well). The sound quality is very important! Hence use a headset or a more advanced microphone for the audio, and make test recordings.

Finally, the finished videos should be published. YouTube or Vimeo may be used, if no designated site is provided. The videos need not be public: the unlisted setting hides them from search engines. The videos are then to be linked into the LMS where quizzes are added and through which the students will access the videos. An example of such a system is Scalable Learning (http://www.scalable-learning.com).

**Online interaction**

Recorded material and reading assignments form the basis for class preparations. However, adding interactivity will make the study more efficient. The videos could be interrupted by quizzes, as supported by most LMSs. The quizzes are simple multiple-choice questions for which you indicate the correct answers and the system then marks them automatically. Hence the quizzes should address the major elements to be learnt in a course module with about one or two quizzes per video segment.

For good effect, the alternatives in multiple-choice quizzes should be close to one another while being separated by some important aspect to be reckoned by the students. Answering should require thought! Based on experience, try to capture common misunderstandings in the alternatives. An incorrect answer should be a signal to think more deeply and to review the relevant material; correct answers should indicate that the student is sufficiently well-prepared for the subsequent in-class activities.

If the class size is reasonable, free-text answers can be added to openly phrased questions on the material. The students may, for instance, itemize the three or four most important points in the module. They may also provide their own questions that could be compiled, edited and offered back to the class as review questions. However, the larger the class, the more automatic the feedback must be.

A resource that grows with the number of students is the peer-instruction capacity. Many teachers have experienced learning by teaching; students may have the experience by supporting one another [6]. Students may write free-text comments, summaries and questions on an online module; each text could be reviewed by a few other students and then revised by the authoring student. The reviewer could grade the quality of the reviewed contents and the author could in turn grade the reviewer on how useful the comments and critique are. Hence both parties in the process will learn. The collection of finalized summaries may serve as reviewing material for the course. Peer reviewing may be used for term papers, project reports, slide sets for class presentations, programme code, system design and other forms of student-generated contents. The process is illustrated in Figure 3.

**Sharing and reusing courses and course material**

All material should be prepared for reuse: first, for one’s own reuse when giving the course again; secondly, when colleagues give the course, and, thirdly, when
components of it are used in other courses. The fact that the material is in digital form makes it easier to update and edit it. For instance, the video sources should be kept so that one may re-edit the published videos if needed; quiz questions may easily be corrected or changed.

A course may also use video material produced by others. It could be public presentations such as TEDTalks, or shared presentations. The material should be provided through the LMS for adding quizzes. The system also gives statistics on how and when the presentations were viewed, which is not possible if the students view the presentations directly from the publishing site. We expect that publishing and sharing of components of course material will increase because it is efficient to pool development efforts. Each teacher may then build a course based on the best components for the subject, which might not be her or his own. Widespread use of Creative Commons licences will help such reuse.

A more comprehensive reuse is to build upon complete online courses, for instance the MOOCs offered by universities directly as well as by Coursera, edX, FutureLearn, Iversity and other companies. They are, in principle, fully self-contained. The teacher may offer in-class meetings to monitor the learning and to make it more profound as well as supplementary instruction such as laboratory sessions and projects. It is also possible to provide examination in order to award credits.

**Giving courses**

This section proposes practical guidelines for giving courses that have been prepared according to the flipped classroom teaching model with the structure shown in Figure 2.

**Student preparation and class meetings**

As stated above, the students should prepare for each class meeting outside scheduled course activities. The preparatory material should allow them to complete the task with no or little teacher support. The online systems might, however, provide chat functions with teaching staff and a forum for the students to
assist one another if they encounter problems with the material. The preparation should be mandatory with a deadline sufficiently ahead of the following class meeting to allow the teacher to check the completion and to prepare for class.

The LMS gives the teacher data on the progress and preparation of all students, allowing the instruction to be adapted to the performance on the preparation for the module. Students’ difficulties could be due to shortcomings in the presentation of the material or to some inherent complexity of the concept being taught. Hence a class might start with clarification of questions from the preparations. Most time should, however, be spent on getting deeper into the subject.

Peer instruction is a well-established method for active learning that may be employed for most class sizes [4]. The basic technique is to pose a question that the students first answer individually, then discuss with a peer and then answer again. The correctness of the first answer is not revealed until the second answer has been given. The common case is that the second answer is correct more often than the first one. It manifests the learning that takes place when the students discuss. Answers can be reported using clickers, coloured cards, hands in the air or any other means (clickers automatically log responses from an audience; see [7] for advice on usage). Other examples of activities are problem solving and discussions in small groups followed by whole-class discussion. If class size permits, there are time-tested techniques such as Socratic questioning and the disputation where a student defends a point of view against opponents.

Before ending class, make an outlook on the next module of learning: the topic and the preparatory material, as well as the contents of the next meeting in class. Explain how it builds upon or complements what has been taught so far.

There are other forms of instructor-led activities that may use online preparations in the same flipped way: laboratory, seminars, recitations, study visits and fieldwork, as well as projects and other group work.

**Examination**

When teaching a class that has been offered before in a regular format, one may consider keeping the examination unchanged for a year or two as a gauge of changes in results owing to the new teaching model. Supplementary examination might be added. The main goal is to test the students against the learning objectives of the course.

The preparations as well as the class activities can also be used for examination. A basic requirement for each student is to complete most preparations online and to attend class in order to pass. It could be expanded with regular hand-ins and tests dispensed in class to serve as complete or complementary examination for the course. Hence consider the full scale from the two extremes, with one end being a final exam at the end of the course over to the other extreme being a series of smaller examinations on the different course modules. Remark that the final exam is cumulative over all contents and might test the synthesis of the parts.

Depending on class size and subject, one may use also audio-visuals for examination, such as video and audio recordings of the student solving a problem or explaining a concept. Hence examination is not limited in form to problem
sets, essays and written project reports. Exams may be administered digitally in class by systems such as DigiExam (http://www.digiexam.se). They simplify the handling of the exam and multiple choice questions may be machine graded. Online examination is still difficult to trust, for instance with respect to authentication of the students’ identities and to prevent additional persons and resources being available at the student’s site to assist with the test. However, these problems are no greater than with take-home exams which are commonly used.

The joint design of instruction, formative assessment (testing for diagnostic purposes, such as online quizzes) and summative assessment for examination is challenging. The combination is, however, powerful for effective teaching. It is important that the assessments address higher learning objectives and that they do not merely test memorization of facts and rule-based calculations [3].

Integration of a course into a curriculum
Think about the context of the course, whether an entire educational programme, a major of a programme or preparation for, or a part of, work life: connect to the context. The instructor may, for instance, consult with colleagues who teach courses that are prerequisites for his or her course. They may design a diagnostic test together, focused on the retention of the knowledge needed from those courses. Those teachers and teachers of follow-on courses might be invited into the LMS to see the online material and connect to it in their own courses.

Do not let go of students simply because they have passed the course. Allow them continued access to the online material for review. If a review session is provided at the end of the course, then open it also to prior students. And why not allow them to retake the final exam if one is provided to show retention of the knowledge?

Summary and discussion
This chapter builds on the premise that active learning, where students take responsibility for their own learning, is superior to lecturing and reading. One form of active learning is blending of classroom and online instruction. Online material and the tools used to dispense it support the students’ own work in terms of promoting self-control and self-assessment of acquired knowledge. The tools also allow monitoring of the students’ work by the teacher. The online preparation allows the teacher to use the meetings in class for getting in depth into the subject. Hence blended learning might boost the quality and efficiency of teaching in HE. The opportunity and also the challenge are, first, to design the online preparatory material well enough to be able to go deep into the material when meeting the students in class, and, secondly, to use the class time effectively when the students have prepared. We have suggested using peer instruction as a method for active learning in the classroom. This is where the teacher may excel in bestowing his or her expertise upon the students. For further reading we recommend the article by Merrill [8] and the guide by Wieman [9].

Note that the model we espouse is different from the online pedagogical model used by MOOCs [10]. The suggestions in this chapter for producing online
material are also applicable for that teaching model. MOOCs might dispense instruction to tens of thousands of students per course round with a marginal cost per student close to zero. Contrast this with campus courses for which the cost is substantial and proportional to the number of students. The only rational argument for justifying the cost is thus by transforming the class meetings into a valuable resource for the students: going from passive to active learning. Failing to do so will eventually undermine the public and political support for the university and the students will turn to other institutions such as MOOC providers that offer meet-ups with tutoring.

With the suggestions that we give in this chapter for the flipped classroom, we encourage teachers to promote active learning in their courses.

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References