Flipping the Physics Classroom

Final report

March 20, 2020

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1 Introduction

The flipped classroom is an instructional design in which "activities that have traditionally taken place inside the classroom now take place outside of the classroom and vice versa" [1]. The central idea is to replace traditional lecturing with structured at-home activities, typically involving videos or other learning technologies, and to use class time for hand-on exercises and other active-learning activities [1, 2]. While the flipped classroom has attracted considerable attention from pedagogical researchers, its effectiveness has not yet been firmly established, with mixed results being reported in the literature (see for example ref. [3] for positive results and refs. [4, 5, 6] for negative results). Additionally, studies have revealed mixed attitudes towards flipped classrooms from students [7].

The aim of this TUFF-funded project has been creating a working group assisting, promoting and coordinating implementation of flipped classrooms in seven courses taught in the Department of Physics and Astronomy. The group is comprised of 18 instructors and researchers. The main

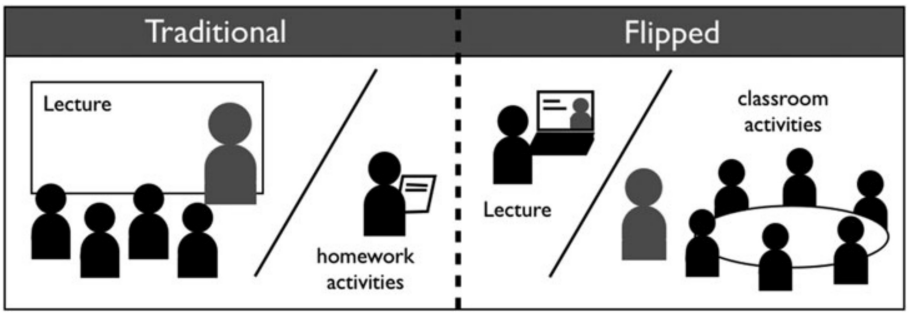

Figure 1: Flipped vs traditional classroom. Figure from Jungić et al. [8].

Course	N	Semester	Instructor
Gravitation and Cosmology (1FA157)	22	Spring 2019	Marco Chiodaroli
Nuclear Physics (1FA346)	60	Fall 2019	Ali Al-Adili
Quantum Mechanics, Advanced Course (1FA352)	50	Fall 2019	Rikard Enberg
Mathematical Methods (1FA121)	116	Spring 2019	Magdalena Larfors
Dynamical Systems and Chaos (1FA152)	34	Spring 2019	Agnese Bissi
Mechanics - ground course (1FA105)	200	Fall 2019	Susanne Mirbt
Quantum physics (1FA521)	38	Spring 2019	Lisa Freyhult

Table 1: Specific courses involved in the project; N is the approximate number of students.

innovative aspect of the project is to address in a coordinated fashion educational improvements which had been previously conducted at the level of individual courses and to create an opportunity for collecting valuable data for a mixed-method study which would be instrumental in further developing the flipped-classroom technique. At the moment of this writing, the group is still in operation and obtained a second year of funding.

2 Implementation of the project

The project has been implemented as follows:

1. Seven workshop meetings among the project's participants were conducted. In these meetings, group members shared ideas, reviewed relevant literature, received suggestions and feedback on their material, and harmonized their respective flipped-classroom implementations. Workshop meetings have also been essential for developing our pilot study. All co-applicants contributed to the workshop meetings.

2. A flipped component was introduced in seven courses taught in the Department of Physics and Astronomy, which are listed in Table 1 with their respective instructors. Each course flipped at least one module corresponding to 1-3 individual lectures. Our flipped-classroom design divides instruction into four distinct structured phases: (1) pre-class information gathering, (2) preliminary assessment quiz, (3) in-class active learning, and (4) post-meeting assessment. Specific implementations, including choice of in-class activities, differ across courses. For example, details on the implementation for the Spring 2019 flipped courses can be found in Table 2.

3. A mixed-method pilot study on students' attitudes towards flipped classrooms was carried out. The study involved a quantitative component, with a pilot survey, and two-focus group interviews.

Note that some small implementation changes were made with respect to the application for TUFF funding which was originally submitted. Tomas Kubart, one of the original co-applicants, left the group while Susanne Mirbt joined the group. One of the courses that were originally intended to introduce a flipped component did not follow through. The resources that were set aside for that course were then re-allocated to the Mechanics ground course, which introduced a flipped component as a result.

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	Gravitation and Cosmology	**Quantum Physics**	**Mathematical Methods**	**Dynamical Systems**
Program	M.Sc.	B.Sc.	B.Sc.	M.Sc.
Students	22	38	116	34
Flipped Material	3 lectures on black holes	3-4 lectures on perturbation theory, 1D potentials	2 lectures on separation of vars, Bessel functions	2 lectures on chaos, Lorenz eqs, bifurcations
Videos	• ActivePresenter • MedFarm studio	• ActivePresenter, • interact. simulations • external videos	• ActivePresenter	• iMovie
pre-class quiz	Yes Studentportalen	Yes Studentportalen	Yes Studentportalen	Yes ScalableLearning
In-class Activities	• summary • group work on problems	• summary • group work on problems • Mentimeter	• summary • group work on problems • think-pair-share	• discussion on exercises

Table 2: Implementation details for flipped courses taught in Spring 2019.

3 Results and evaluation

As a result of the project, an approximate number of 500 students experienced the flipped-classroom method. The impact of flipped classrooms was assessed with a mixed-method pilot study comprised of two focus group interviews and a quantitative survey. The evaluation process benefited particularly from the expertise of Katerina Günter, whose overall contribution to the project has been as substantial as the one of the main applicant. Other co-applicants who gave major contributions to the evaluation process are Virginia Grande, Lisa Freyhult, Diego Tarrío and Andreas Solders.

The focus groups consisted of semi-structured interviews with a group of students from different courses. The interview questions were developed using teachers' reflections on their flipped classes but kept general to allow the students' voices to come through. The demographics of the students differed in the two interviews, which gave us a broad overview of themes most relevant to their respective groups. The first interview has been transcribed with the support of MINT funding. The second interview has been only partly transcribed at the moment of this writing.

Topics covered include: length and quality of videos, students' views on instructors asking questions during videos, resources used by students to prepare for class, the role of in-class activities in facilitating students formulating and asking questions, in-class activities as a team-building exercise.

Results from the focus groups were used for designing a pilot survey investigating students' attitudes towards flipped classrooms. Responses to the survey reveal that students have mixed reactions to flipped classrooms, in line with results in the literature [7]. Most students indicate that, with flipped classrooms, they went to class better prepared, were more comfortable asking questions and interacted better with other students. However, students consider flipped classrooms less time-efficient than traditional lecturing and feel that they got less out of the instructor. These

results prompt the questions of what factors determine whether a student has a favorable view towards flipped classrooms. At the moment of this writing, a full analysis of the data from the pilot study is ongoing.

Based on results from the focus group, students respond more favorably to a flipped-classroom design in which: (1) videos are short and concise (2) questions are asked during the videos, and (3) students are encouraged to formulate and share questions individually before class and as groups during the in-class activities. It is also important to be aware that students use a multiplicity of resources in preparing for class which are not limited to the videos created by the instructor and to the textbook. '

These guidelines will be used to adjust our implementation during the second year of operation of the group. It should be noted that the process of adjusting our instructional design is student-driven given our emphasis on results of our focus-group interviews.

4 Dissemination of results

Results from this project were presented at the TUK-2019 Universitetspedagogisk konferens (poster presentation) and at Uppsala University's Universitetspedagogisk konferens on Oct 10, 2019 (oral presentation). An abstract based on preliminary results from the pilot study was submitted to the NU2020 "Hållbart lärande" conference to be held in Huddinge later this year.

5 Continuation of the project

The project is continuing in 2020 with a second year of TUFF funding, with title "Flipping the Physics Classroom II". As previously explained, results from the focus groups and survey will be used to adjust our implementation. Our intention is that the pilot study will pave the way to a larger study on flipped classrooms during the second year of operation and beyond, leading to publishable results.

References

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