THERE IS MORE THAN ONE FLIPPED CLASSROOM

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The Flipped Classroom pedagogy has been developed for being responsive, student-centered and promoting self-directed learning. Three years ago, we started an international research project aimed at understanding how the FC can be implemented by secondary school math teachers through the use of a MOOC (Massive Open Online Course) developed at the Polytechnic of Milan. In particular, we focus on the teachers' use of MOOC videos. A variety of scenarios emerged from our direct classroom observations and work-in-team with the teachers. In this paper we propose a sketch of such a variety of FC implementations.

Keywords: MOOC; teaching with technology; student-centered learning; teachers' beliefs.

INTRODUCTION AND THEORETICAL FRAMEWORK

Flipped Classroom (FC) is mostly associated with university setting and it is commonly known as a method that arranges the lecturing part of the teaching as homework through videos. This is considered the out-of-class part of the FC and as such can be seen as a case of technology used for teaching and learning. When students come to class, FC features the students' learning in a student-centered manner, using various problem-solving activities in small groups (Bergmann & Sams, 2012). This is considered as the in-class part of FC. Both parts are vital for the FC learning model to work.

The out-of-class video learning "primes" the students for the in-class active phase. This happens with some difficulties, as Fredriksen, Hadjerrouit, Monaghan and Rensaa (in press) have singled out: (a) the students expect to be "taught" by the teacher; (b) the students express preference towards solving the exercises in solitude; (c) preparation through video lessons requires discipline; (d) the need to express mathematical problems verbally requires fluency in discourse; (e) group work requires social skills to be developed. We would say that MOOC videos are a kind of technology that promotes self-directed learning: the quality of student group collaboration and understanding, and overall the quality of the lesson, depends on how the students grasp the mathematics in the videos and on how they work out-of-class (Fredriksen *et al.*, in press). The main idea of FC is that, by saving time in introducing material, a teacher obtains an opportunity to challenge the students at both a collaborative and conceptual level through well-designed mathematical activities (Wan, 2015).

To sum up, we draw on evidence in literature that FC is a student-centered pedagogy that prompts students to go beyond rote-learning and may even promote conceptual understanding. At the same time, we acknowledge that FC is all but easy to implement in the classroom since it necessitates a significant change in the classroom's rules and practices. Moreover, we recall that recent research reports on an existence of a considerable gap between the learning potential of technology and actual teaching practices, a gap that is both qualitative and quantitative (for an elaborated review see Bretscher, 2014). The quantitative gap is understood in terms of the limited impact that new technologies have on classroom practices compared to the huge amount of money and time spent on technology and teachers' training to use it. The qualitative gap refers to the majority of teachers who use technology in a transmissive or teacher-centered way compared to the ones who exploit it for learner-directed activities. Despite curriculum changes, professional development and substantial financial investment, mathematics classroom practices are often still surprisingly similar to those practiced decades ago (McCloskey, 2014). Windschitl and Sahl (2002) have identified two factors that appear to be crucial to the ways in which teachers adopt or resist changes: (i) their

beliefs about learners, about what counts as good teaching in their institutional culture, and about the role of technology in learning; (ii) the resources available at school. Thus, it becomes crucial to investigate teachers' goals, resources and orientations towards FC in general and towards MOOC videos in particular is.

In order to analyse teachers' attitudes towards technology (MOOC videos, in our case) and student-centered lessons, their goals, their knowledge and the resources they have at disposal, we refer to Schoenfeld's (2011) theoretical lens, which focuses on teachers' beliefs, goals and resources during in-the-moment classroom decision making. The basic assumption of Schoenfeld's framework is that beliefs and orientations are an essential factor shaping teachers' decision-making, and thus shaping their behavior and professional development. In Schoenfeld's view, teachers' behaviors also depend on their goals and goals recruit resources (including: knowledge, materials, personal and interpersonal skills and connections):

> Every sequence of actions can be seen as consistent with a series of goal prioritizations that are grounded in the teacher's beliefs and orientations, and the selection, once a goal has been given highest priority, of resources intended to help achieve that goal (Schoenfeld, 2011, p. 460).

A goal, whether explicit or tacit and unarticulated, is something that a teacher wants to accomplish. Resources include all kinds of 'goods' that are available for a teacher. For example, the tools in the classroom; students' knowledge; teachers' knowledge, interpersonal skills and relations with students.

RESEARCH QUESTIONS AND METHODOLOGY

The research questions we aim at addressing are: (1) how do secondary school math teachers plan to and actually integrate MOOC videos in their classrooms? (2) How do teachers promote self-directed and student-centered learning when using MOOC videos? In a pilot study with two teachers (Andrà, Brunetto & Kontorovich, under review), we compare and contrast their goals, resources and orientations. At the present stage of the research, we have at disposal more data coming from a larger set of teachers who participated in the research project. The data for this paper is concerned with the final weeks of the first semester, when the teachers need to arrange suitable activities to recap mathematics studied during the school year and to help students to end the semester with good marks. Thus, we proposed teachers to integrate MOOC videos, accompanying exercises and their solutions into their classrooms. Introducing new technology for recalling not new mathematical content was aimed at preventing students from facing a double difficulty: the difficulty of adjusting to a new way of teaching and learning and the difficulty of engaging with unfamiliar mathematics.

As a part of our project, twelve secondary teachers chose 1-3 MOOC videos to work with from a MOOC course made of 84 videos, covering different topics (arithmetic, sets, logics, algebra, analytic geometry, exponential and logarithms, trigonometry, probability and statistics). For each topic, 3-6 videos recap mathematical theory (definitions, properties and theorems), and procedures (algorithms and computations). Among the teachers who participated in the study, Nadia (N), Francesca (F) and Elisabetta (E) teach in three grade-12 classes, where it was necessary to recall exponential and logarithms in the first two ones, and the use of Excel spreadsheet for descriptive statistical analysis in the third one. Following Schoenfeld, we explored goals, resources and orientations through teachers' lesson images and conducted lessons, paying specific attention to unplanned decisions that were made. N teaches in a school where math lessons are delivered 6 hours/week, while F and E 3 hours/week.

DATA ANALYSIS AND RESULTS

Table 1 contains excerpts of the three teachers' goals, orientations and resources, in particular their description of the classes in relation with how they expect they will work with the MOOC and their orientations towards MOOC.

	Nadia (N)	Francesca (F)	Elisabetta (E)
Topic	Exponential and logarithms		Descriptive statistics
Math lessons	6 hours/week	3 hours/week	
Goals	I want my students to do not panic if some steps in a procedure are not made explicit, if one cannot grasp something at first or if different parameters are used.	[My goal is] To recap exponentials and logarithms. I also have non-math goals: to favour autonomy, to stimulate curiosity and to provoke critical thinking towards multimedia resources.	I want my students to become able to use Excel spreadsheet to compute the relevant statistics for data. They should become able to understand a video even if it uses different symbols and different words.
Resources: Excerpts from teachers' descriptions of their students	They are used to the FC and I expect that their major difficulties will be with logging in and with the organization of the courseware.	It's a class of only girls and they are really cooperative and collaborative with me. Some of them are good in math.	It's not easy to engage this classroom in math activities: one girl is the leader of the class and she wants to be the best at everything. If someone shows her ability, she punishes her mate.
Orientations: Teachers' feelings towards MOOC	I feel good with technology. I am interested in MOOC since the graphics are really good and the quality of videos is excellent. The advantages of FC are to save time that can be invested in group activities and the students can hear the voices of more than one teacher, so that they access different ways of dealing with the same math concept.	I feel good with technology. The advantages of using MOOC are: saving time, better understanding since the students can stop the videos, favouring the students' self-confidence with technology. Video-lessons are attended at home, where students are comfortable, but at the same time there's a risk they won't work, compromising the efficacy of FC. A drawback is the impossibility to make questions and to receive answers from the teacher in the video. This flaw can be dealt the day after, at school, with their teacher.	I feel good with technology. I believe that the topics that can be better introduced with MOOC videos are those that are procedural. In this way, the MOOC interferes less with the way the teacher wants to introduce the mathematical theory. For example, I would like to introduce the logarithmic function in class and leave the students work at home with translations of the function.

Table 1: teachers' goals, resources and orientations.

N and E's major *goal* is to enhance students' ability to operate and learn from MOOC videos. They mention a potential difficulty that can arise from MOOC lecturer using terminology and symbols that are different from the ones used in a classroom. Moreover, N says that her students are used to watch math videos at home, while for E's students it is going to be the first time. At the same time, N and E share a similar goal, namely that their students become fluent with mathematics discussed in the videos. F's goals can be classified into long-term goals within Schoenfled's view, since she also wants to develop critical thinking. F's reflections on her students make an impression that she sees her students as more collaborative. E, on the other hand, describes her classroom as "difficult", given that a girl plays the role of a leader. With respect to considering MOOC as a *resource*, the teachers are aware of the possibility for using it to save time in the class. They are also aware that videos are not interactive: there exist a chance that the students will not engage with videos at home. Notably, E's *orientations* propose that she wants to be the one who (re)introduces the mathematical concepts, consequently, she prefers to use the MOOC videos for recalling procedures.

Lesson images

Both N and F assigned the same video to be watched at home. In this 3-minutes long video, the graph and some properties of an exponential function $f(x)=a^x$ are explained. The particular cases of e^x and $1/e^x$ are also discussed (Figure 1 shows a snapshot from the video). The logarithmic function
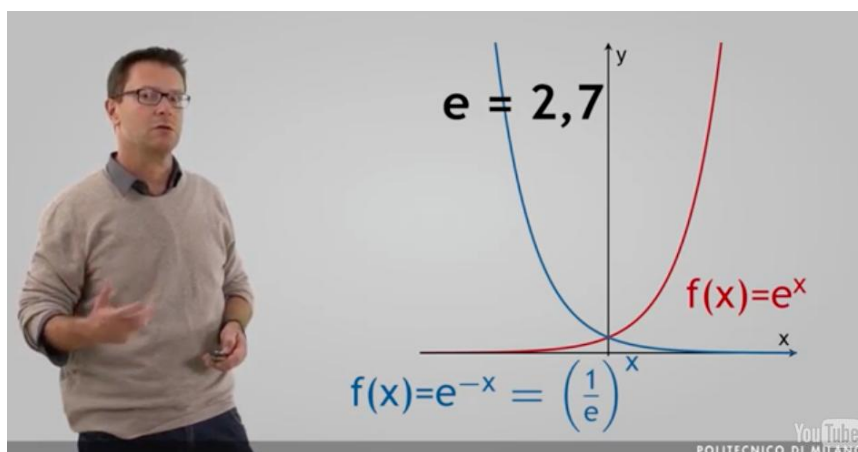
is recalled as well.

Figure 1: a snapshot from the video assigned by N and F.

Nadia. "[...]I will assign the videos on exponential and logarithmic functions to be watched at home and I will assign some questions to be answered as well. I will assign the theoretical video which recalls definitions and properties, and two practical videos which show the solution of exercises. The questions I will assign to my students will enable them to reflect on how a video can be watched, which questions can one pose to oneself, how exercises can be solved. I want to see my students' answers in advance, hence I will collect their work through emails. In class, I will start from the part in the video where the graphs of exp(x) and of exp(-x) are shown simultaneously. I will ask my students to draw the graph of f(x) and f(-x) for the following functions: a parabola of the form ax^2+bx+c, sin(x) and cos(x). This will prompt the students to notice symmetries in some cases and I will introduce the definition of an even function focusing on the features on the examples drawn by the students. The students will work in groups". In N's lesson image, her *goal* about her students' ability to watch the video and be able to understand emerges in her intention to invite them to reflect on how to access the video content: in fact, she says that "the questions I will assign to my students will enable them to reflect on how a video can be watched, which questions

can one pose to oneself, how exercises can be solved". Nadia also mentions the good quality of graphs and in fact she wants to exploit one of the graphs in the video to introduce the definition of even function: this speaks to N's *resources*.

Francesca. "In a previous lesson, I will show my students how to access the MOOC and I will assign them the exercises in the MOOC, both ones that have a solution provided in videos and those which required to be solved in solitude. In class, I will discuss with students' solutions, which I will collect via email in advance, and we will do more exercises". In F's lesson image, we notice that she plans to spend a lesson commenting the videos ("I will discuss with students' solutions"), watched at home and to do more exercises. This is in line with her *orientation* about the MOOC, namely that the students don't have the possibility to ask questions to the teacher in the video, but this can be done in class the day after.

The video assigned by E regards an exercise about the grades taken during an exam by 32 students and it shows how to compute the mean, the median, the standard deviation of the given data.

Elisabetta. "I want my students to become confident with Excel spreadsheet. In a previous lesson, I will introduce the main statistical measures: the mean, the median, the variance, the standard deviation, the absolute deviation. Then, I will introduce the software and main commands for working with data and computing these descriptive statistics. Then, I will assign to watch related MOOC videos as a homework and I will ask my students to do an exercise that is similar to the one presented in the videos. There is some difference between my lesson and the videos: we use different terms and the video does not address the absolute deviation. I want to see if in their solutions students will follow what we did in class, or what was done in the video". Similarly to other teachers, E wants to use the MOOC videos as a *resource* for recapping some concepts and reinforcing students' knowledge. Differently from the other teachers, however, E explicitly says this in her lesson image. E's choice of a procedural video is in line with her *orientation* about the use of MOOC, namely that it is more suited for exercises while the teacher should be left free to introduce the concepts in class. Finally, we comment on the differences between the MOOC videos and E's lesson and on her way to detect whether the students will follow the former or the latter: we see this comment from E in line with her *goal* that the students should become able to understand the video even if it differs from what they have seen in class.

Implemented lessons

Nadia. Even though N did not plan to show the videos in the classroom, she noted that many students did not sent her their homework in advance. She also suspected that the majority of the students did not watch the video. Hence, she started the lesson with the video (saying: "it will last just for a few minutes, to show the video won't compromise the lesson"), and then the students worked in groups. They sketched the graphs of exp(x) and exp(-x), of sin(x) and sin(-x), of cos(x) and cos(-x), while Nadia navigated the class and engaged in conversations with the groups. She invited them to find out general features of the drawn functions and she introduced the definition of an even function.

Francesca. Like N, F also notes that some of her students did not send her their homework and in class she asked them why. She also asked how the students coped with the assignments. The students replied that the videos were clear but they experienced difficulties with assigned exercises and requested teacher's assistance. Hence, the teacher engages the classroom in a rich discussion about "how to do". The students actively engaged in the discussion, which aligns with F's opinion about her students' cooperative mood. We also notice that her way of conducting the lesson stimulates the students' critical thinking, since many times during the lesson they were not satisfied with the procedure recapped by F and wanted also to recap "why to do so".

Elisabetta. All her students submitted their homework before the lesson and E says this with satisfaction at the beginning of the lesson. After reviewing the submissions, however, she noticed that some students have followed her lesson while others have followed the video. She, thus, engages in a frontal lesson in which she poses questions to the students in order to better know how much they grasped the out-of-class activity. The first half of the lesson can be summarised as the teacher posing questions and the students avoiding to answer, while the teacher solved exercises from the homework showing all the steps and elaborating on the concepts involved. At some point, one student asked for clarifications on the formula to compute standard deviation. The students spent the rest of the lesson in posing questions to the teacher, making-sense of her explanations and replying to the questions the teacher in turn made them.

Links between the lesson image and the implemented lesson (...and more data)

We have commented that N and E are concerned that a terminology used in the video might hinder their students' engagement with the content. In N's lesson image, she was planning to deal with the concern through inviting students to reflect on the experiences. N also mentions the good technical quality of graphs and in fact she wants to exploit one of the graphs in the video to introduce the definition of an even function (see Figure 1). In N's implemented lesson, she starts watching the video, since she noticed that few students have sent her their homework. Her orientation is that "this won't *compromise* the lesson" and we see something deep in this comment from N: we see an acknowledgement that it would be a 'deviation from the plan' and as such it is a decision made to deal with students' lack of homework, but at the same time we also see that N's orientation is that to show the video in class is in line with her *goals*. N's orientation is completely different from E's one, who chose not to show the video and to make questions about it in class, so that the students who have done their homework will both have the opportunity to shine and to help their peers even if those did not watch the video had not seen it. E explicitly says that she does not want her students to think that even if they do not make their home-work there would be an in-class opportunity to cope with this lack of work. We have noticed that N and E share similar goals (i.e., to allow their students to be able to grasp the mathematics in the videos), but the decisions that they make to cope with their students' lack of home-work are rather opposite.

N's decision-making led to a student-centered lesson, while E delivered a frontal lesson. The students' lack of homework is, thus, addressed in two different ways which can be explained with teachers' orientations towards teaching and learning: N assigns a paper for each students and arranges the class so that each one can work individually but at the same time s/he can ask for her/his mates' help or N's help. This overcomes one of the possible tensions highlighted by Fredriksen *et al.*, namely that students prefer to work in solitude. E arranges a frontal lesson, which is not as teacher-centered as it appears at a first glance: her lesson, in fact, is responsive of the students' feedback provided in the homework sent to E in advance. She highlights the terminology that is not clear for the students, she commented on some students' mistakes and she designed the lesson accordingly. We can say that this particular use of MOOC videos prompts even the teachers who prefer teacher-centered lessons to arrange *responsive frontal lessons*, since they are allowed to know in advance their students' difficulties. This can be seen as an interesting feature of FC.

F, being not concerned about her students' ability to access the video content, engages the students in a classroom discussion that is rich and at the same time challenging for the students. One of her students, in fact, at a certain point says that she finds it difficult to follow what her peers say and propose, and asks the teacher to make a summary to clarify the ideas that have emerged. This request speaks both to the genuity of the classroom discussion and to this student's will to understand. Given that the class has a weak mathematical curriculum, this can not to be taken for granted. F is reaching her goal, namely to stimulate curiosity and critical thinking. Like E, also F

does not show the video in class. Like E, also F engages in a frontal lesson to correct the exercises the students have found difficult to solve in solitude. Differently from E, however, F's lesson results in a classroom discussion rather than a frontal delivery of mathematical content.

We would like to summarise the three teachers' lessons as follows: her way of using MOOC videos allows N to design a *groupwork activity* aimed discovering the features of even function. Her (different) way of using MOOC videos allows E to implement a *frontal lesson that is responsive* to students' difficulties as they emerged from their homework. Her (different) way of using MOOC videos allows F to carry out a *classroom discussion*, which is not planned: the students' need to correct the homework emerges as the lesson starts. For E, it was possible to plan a responsive lesson (while for F it was not), because E's students sent their homework in advance, while F coped with her students' lack of homework: F arranges an *unplanned* responsive lesson.

DISCUSSION

As a response to our research questions, we can propose that secondary school teachers can use MOOC videos in their classrooms in different ways (question 1): they assign videos as homework and design group activities for introducing new concepts, or they design a classroom activity that allow to pinpoint the differences in terminology and symbols between the teacher's lesson and the video, or they plan to do more exercises on the basis of the out-of-class activity. Self-directed and student-centered learning (question 2) can be seen as an intrinsic feature of FC: frontal lessons are responsive, classroom discussion in informed by out-of-class activity and group work is primed by conceptual work done at home.

To our understanding, FC is a combination of a learning setting and activities. The students were asked to watch videos at home, but if a teacher solves or even answers questions in the class, is the classroom flipped? This remains an open question, but the three teachers in our study used MOOC videos to create new forms of classroom. Definitely it was not a classical version of FC, but this was to some extent expected, because teachers and students *learn to flip*. We would say that E implements FC: she assigns out-of-class work and she arranges an in-class activity that draws on the students' homework. By not showing the video in class, she provokes the students' self-directed learning, since they are not able to follow if they had not watched the video. Also F implements FC: she does not show the videos in class and she implements a lesson that is responsive to her students' needs, namely instead of making challenging exercises as per her lesson image, she spends the majority of time showing the procedure to solve the exercises assigned as homework and replying to the students' questions. E's students learn that they need to do the out-of-class activity in order to be able to follow the in-class lesson. F's students learn that if they are not able to understand the out-of-class activity, her teacher is there to help them in class. N shows the video in class and she comments the video, connecting the students' work with the content of the video. As such, we would say that N's lesson is a case of co-teaching instead of FC. She co-teaches with the teacher in the video and she implements a student-centered lesson.

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