Flipping the High-School Classroom: Contributions for Learning in a Case Study

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***Abstract*— This article describes the implementation of a flipped classroom methodology in a Physics course in a technical high school in Argentina (16-year-old students). For the module on fluid mechanics, students watched video lectures before going to the classroom and time at school was used to discuss more examples of the concepts shown in the videos, solve problems and work on experiments. Qualitative and quantitative data were analyzed for this particular case study in order to shed light on the perceptions students have on the influence of this methodology on their learning process. Results showed that students believe that flipping the classroom has a positive impact on their learning experience. Even though each of them worked differently with the video lectures at home (i.e. they performed different cognitive, metacognitive and resource-management tasks), they pointed out several advantages of having the possibility to re-watch the lectures. The instructor highlighted that there was an increased level of engagement in face to face activities. Since the choice of an academic degree could be powerfully influenced by the experiences of high school, how science is taught at this level can significantly affect the decision of a student to choose a scientific degree such as engineering.**

Keywords—flipped classroom; science teaching; video lectures; high school

I. INTRODUCTION

Nowadays, education takes place in a scenario where institutions are being redefined [1], inasmuch as today students are no longer the people that the educational system was once designed to teach to [2]. What is, then, the role of the school in this dynamic and changing context? Information and communication technologies (ICTs) are shaping people's lives and thus it is mandatory to reshape the way in which education is delivered. Indeed, the inclusion of ICTs should focus on achieving a major transformation of the educational system [3].

The choice of an academic degree could be powerfully influenced by the experiences and learning outcomes of secondary school. How science is taught at secondary school can affect significantly the decision of a student to choose a scientific degree such as engineering. The didactic tools used, as well as the strategies, are major factors in the preference of a student for some subjects. Given that the adolescents at secondary school are digital natives, the use of ICT stands as a powerful way to awaken interest on STEM subjects. In this context, innovative teaching experiences that are both disruptive and valuable could be an effective tool to spur students' interest and motivation for learning scientific subjects while trying to achieve an extra value in terms of learning outcomes.

In the aforementioned context of rapid information exchange that young students are used to, it is evident that it is not possible to keep their attention on the exposition of a teacher for a long time. Additionally, video lectures seem as appropriate as face-to-face lessons to convey basic concepts [4].

This paper aims at analyzing the didactic experience using video lectures and a flipped classroom methodology in a high-school Physics course. The analysis focus on the influence of the inclusion of video lectures over the learning process. The research methodology can be described as a mixed one, involving quantitative and qualitative data. The theoretical framework for this research is based on the action research principles, understanding it as a process of critical analysis of the teaching practices and its projections [5], [6]. This perspective locates teachers as researchers since they are capable of investigating, questioning and reflecting on their own interventions in the context of teaching and learning. The research question that drives this investigation is: what is the influence on the learning process of using video lectures as resources for teaching? In order to shed light on this issue, the question was approached from the students' points of view.

This article presents a valuable analysis on students' perceptions about the use of video lectures to flip the classroom and on the type of work they do while using the videos as a learning resource. This meaningful analysis complements the mostly quantitative kind of analysis that is available in the literature.

It is worth highlighting that flipping the classroom implies two additional transformations or flips. First, on the way classes are thought and knowledge is delivered: the classroom as a space to address questions rather than a place where unquestionable truths and answers are provided. Second, on the relation between theory and practice: the importance of practice in the school context is emphasized; in this context, teachers are important to provide scaffolding. Consequently, the flipped classroom methodology and the reflection on its implications are a valuable step in the spur of pursuing a major transformation of the educational system.

TABLE I. STUDENTS ANSWERS TO QUESTIONS RELATED TO THE IMPLEMENTATION OF VIDEOS

	Question	Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree
Q1	I did not have difficulties finding the time to watch the videos	13 %	0 %	28 %	**47 %**	13 %
Q2	The length of the videos is appropriate	0 %	0 %	9 %	**69 %**	22 %

II. IMPLEMENTATION

Physics IV is a common-core compulsory subject for students in 4th year of high school. During 3rd year, students choose from six areas to further a specialization for the following three years: Constructions, Computer Science, Electronics, Industrial Processes, Chemistry and Mechanics. This experience was conducted with the group of students pursuing a technical degree in Industrial Processes. There were 33 students (aged between 16 and 17) in the class.

Amongst topics of thermodynamics and electricity and magnetism, the Physics course described in this work comprises a module on Fluids Dynamics which is usually developed along four weeks in the second semester (4 hours per week in 3 sessions). This topic is the first one covered in the course.

The material of the unit was prepared in six ten-minute-long videos. The videos were presented in an online-course-style fashion, i.e. a set of slides with the teacher's voice and video. This virtual lessons featured explanations of the core concepts including some proofs, some basic exercises and real-world applications of the topics.

Students were expected to watch a given video prior to the face-to-face time at the classroom and time at school was used to discuss more examples of the concepts shown in the videos, solve problems and work on experiments. In order to ensure that students watched the videos, the material was uploaded to the EdPuzzle[1], a platform that allows to include questions during the video. For all of the videos, the percentage of the students that did the activities was always above 90 %.

Aside from the learning objectives of the subject, the purposes of this methodology were

- to improve the quality of time at school (by achieving higher levels of participation and by making teacher scaffolding more meaningful for students); and
- to reduce the amount of homework (that is to say, instead of giving students an endless list of exercises to solve, they were asked to perform a task that was well-defined in terms of time, something that can help making the most of the time at home).

[1] EdPuzzle: https://edpuzzle.com/

Likewise, the evaluation of the experience implied a process of involvement in their own learning and in the management of a new type of resource for learning. During an instance of debate after working with the videos, students were encouraged to acknowledge the learning processes that they performed. This was supposed to contribute to the acquisition of metacognitive learning strategies.

III. DATA COLLECTION

After the implementation of the video lectures, a series of reflection activities between students and teachers were performed. The purpose of this activities was to inquire on video lectures' influence on learning in order to have feedback for teaching. Furthermore, it was expected that students gained insight on their learning strategies.

The research process involved a group meeting in which students filled a questionnaire with open questions; a group debate; and a Likert-scale questionnaire.

With the aid of these instruments, it was intended to shed lights on students' opinions regarding: the use of videos, the learning strategies that they adopted when working with videos and the contributions for learning of this innovative resource.

IV. RESULTS

Students' views are presented organized in three areas: the use of videos as a teaching resource, the learning strategies involved in the process of using videos as a learning resource, and the contributions for learning.

A. What do students think about the implementation of video lectures?

In general, there was a general acceptance of the tool and the method employed. From students' answers to the Likert-scale questionnaire (shown in Table I), it is possible to infer that the activities as well as the videos were properly thought and organized: most of the students did not find it difficult to find time to watch the videos (Q1), probably thanks to the fact that the length of the videos was appropriate (Q2).

Students remarked that it is important for the video lectures to be precise and dynamic, something that allows to save time when studying and to make revision time at home "less painful". Regarding this issue, students highlighted that although they have to do activities at home, "it is much better than conventional homework" and added "it is homework but it is worth it." They also mentioned that the use of video lectures

TABLE II. STUDENTS' ANSWERS TO QUESTIONS RELATED TO THE CONTRIBUTIONS OF VIDEO LECTURES FOR LEARNING

	Question	Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree
Q1	The videos helped me understand the subject	0 %	6 %	6 %	**44 %**	**44 %**
Q2	Videos are a good introduction for theoretical concepts	0 %	0 %	16 %	28 %	**56 %**
Q3	I wish I had video lectures for other topics in this subject	6 %	6 %	3 %	28 %	**56 %**
Q4	I wish I had video lectures for other subjects	6 %	9 %	16 %	22 %	**47 %**

is beneficial for the time at school as well: the time in the classroom become less boring.

The biggest advantages of video lectures are linked to the fact that they are asynchronous. Given the accessibility of the resource, students value the fact that they can watch the material whenever and wherever they want to and the possibility of rewatching it. It was mentioned that "adolescents are used to spend most of the day with their phone in the hand, therefore studying without needing to reach the folder or the book makes it more accessible" (note the curious use of the third person).

Students were inquired on what would they change about the videos. It was found that most of them would not make any significant changes. In general, the aspects that they mentioned are technical ones (improve volume or sound quality, change the platform of the videos) or related to the teacher (rigid attitude, not very natural, different from lessons). Very few criticized the fact that the video is watched before the lesson: they suggested that the videos were used as a revision (as optional activities). However, most of the students stated that there were no major changes to make.

B. What do students do when they watch the videos?

It was intended to contrast the procedures that are required for learning from a written material with those operations involved in understanding an audiovisual academic resource (which is inherently different from videos on scientific dissemination, typically found on YouTube). Besides, it was expected that students could become aware of this procedures or operations in order to encourage thinking on their learning process. Students were asked: What type of work do you do with the video? What actions or operations do you do while watching the video?

It is possible to identify different levels of depth in the type of work done with the video. The first level could be denominated superficial: students just listen and watch the video. "I just watch it," a student stated. This represents the minority of the students, since most of them do perform other type of actions. Another student wrote "I try to repeat it until I understand it; if I did understand it, I do not watch it more than once." While in this case there is a possibility of rewatching it, it is not possible to infer any other type of action apart from watching.

The second level refers to doing some type of own work on the video, be it taking notes, writing a summary, writing down doubts or trying to explain what was understood. This sort of actions requires, as students said, watching the video more than once or watching it in parts. Amongst students' answers it is possible to find expressions that reflect this attitude, namely: "After watching the video, I write down my doubts to ask them to the teacher," "I watch it once, then I repeat it writing down equations and important stuff," "I write down equations and try to link concepts."

The third level involves work related to problem solving. Students pointed out, for instance, that there are two moments. "Watching it and summarizing it, then paying more attention and solving the exercises." Some students also stated that the process they go through is that one: watch it in parts, rewind it, take notes and solve exercises or answer questions. Exercises take a more central role: "I solve exercises on paper while I watch the video." It is possible to observe that students following actions in this level get closer to the language of the discipline.

In order to investigate on this issue, the notions of learning strategies were taken into account. Learning strategies are conscious and intentional activities that guide the actions that are required in order to achieve certain learning objectives [7]. They can be classified in cognitive (integrating new concepts), metacognitive (actions that allow to know, control, evaluate and regulate the own cognitive functions) and resource-management (in order to improve physical and psychological conditions for learning). Among cognitive strategies, it was found that students repeat the video (passive attitude), ask questions and select important ideas (deeper strategies). The debate revealed a metacognitive process given that students proved to be aware of specific strategies and how they chose them. Finally, regarding resource-management strategies, students highlighted their study environment: a quiet place, being relaxed (sitting or lying down).

Moreover, in the debate students pointed out that videos have an advantage over written material. They said that "listening is involuntary, different from reading" and some went further, "it is possible to listen to the videos and do something else".

C. *What are videos' contributions for the learning process?*

In the open questionnaire students were asked: What contributions do videos do in the context of the subject? Does it have any contributions for learning? From the answers to these questions and from the debate, four ideas arise: understanding of the concepts, positive assessment of videos, lesson development (after the videos) and self-organization. Students impressions complement their answers to the Likert-scale questionnaire (results shown in Table II).

Firstly, almost 90% of the students agree or totally agree with the fact that videos helped them understanding subject concepts (Q1). Indeed, 84% of the students think that videos are good for introducing theoretical concepts (Q2). During the debate, pupils remarked that they would like videos to be implemented in "tough" subjects like Mathematics and Chemistry (also stated in Q4). The majority of the surveyed students highlighted the possibility of rewatching the videos, "Videos are more flexible than lessons". The anticipatory sense of videos facilitates understanding the lessons; one student said "videos make me feel safer" and others appreciated that videos show how to solve some exercises. So positive was the impact of videos that most of the students agreed with the fact that they would like to have videos for other topics in Physics (Q3).

Secondly, students emphasized that videos "turn the subject more dynamic, enjoyable and bearable" while being "funnier than reading the course notes". What factors contribute to this perception? In students' words, "videos are more practical than written material" and "videos are precise and go straight to the point".

Thirdly, video lectures had a remarkable effect on classroom dynamics. Videos enable to better leverage time in the classroom: lessons are less painful and it is easier to participate and to solve problems, having a prior idea on what problems are about. In that sense, a student proposed a curious analogy: "videos are like trailers for the classroom".

Finally, videos are a powerful tool to help students manage their schedule and organize their time. Video lessons are ten-minutes activities programmed usually one week in advance that assist teenagers in ordering their priorities. It is easier to keep up-to-date with the course, the videos keep the material at hand and allow to organize notes properly. Needless to say that they are a valuable resource for absent students.

V. CONCLUSIONS

The use of video lectures in the Physics IV course was very well received by the students. The main advantages that students perceived are associated to the fact that a video is an asynchronous resource. Its accessibility and availability make it a valuable manner to promote self-paced interaction with learning resources and to improve self-organization. An analysis of the learning strategies involved in dealing with audiovisual material allowed to contrast it with classic written resources and to discover a preference of videos over subject notes.

From the point of view of the teacher, developing instructional videos imply thorough work "behind the scenes". Teachers should think about plenty of aspects related to the objectives of the video lectures, namely: What are the main take-away points of these videos? When, where and how will students watch these videos? Will this resource be meaningful for the subject? These types of questions escalate to a wider dimension: What is the impact of this new dynamic on time organization? And of the class organization? What about contents?

What a flipped classroom implies is a change of paradigm: a change in the role of the teacher and in the context of teaching; a change that could potentially transform the learning process. Now there is a cooperation in knowledge acquisition: students work on problems and the teachers accompany them.

It is thus fundamental that teachers investigate their teaching methodologies. Indeed, not only are students' learning outcomes subject to evaluation but also teaching practices. Evaluating own practices is an act of self-knowledge [8]. Innovative didactic experiences are susceptible to being engineered: a necessity is spotted, a solution is carefully designed and implemented, and the results are evaluated with the intention of obtaining feedback.

From the point of view of the students, innovative experiences like the one presented in this article are disruptive and do require a change of behavior as well. Providing them with the tools to gain insight on their own practices is essential to achieve the most of transformative experiences. At the end of the day, educational novelties will probably improve their experience at high school. Being the latter the prelude to university, the way in which scientific content is delivered at this level becomes a relevant factor in the decision of choosing a STEM degree.

In the scenario of transformation that was mentioned in the Introduction, technological developments in the context of education ought to be a trigger for teaching students how to deal and to live with information, while providing them with tools to grasp the sense of the rapid information exchange that surround them [3]. In other words, technological developments are an opportunity to transform connectivity in dialogue, experience and knowledge.

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