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# Combining Flipped Classroom Model and Educational Videos for Improving Teaching-Learning Process in Thermodynamics and Thermal Engineering †

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**Abstract:** Flipped classroom model (FCM) and educational videos have been applied in several subjects related to thermal engineering. Results have been evaluated by questionnaires, observation in the classroom and also number of videos visualization. In general, students evaluate positively the application of the new methodologies, although some suggestions for improvement have been obtained. In particular, the use of videos can reduce some of the difficulties of FCM related to previous preparation by students. Finally, students' marks have been compared to number of videos watched, and a positive (although weak) trend has been seen.

**Keywords:** flipped classroom; educational videos; engineering education; active methodologies

## 1. Introduction

Compared to traditional master classes, flipped classroom model (FCM) provides several advantages: the student play a leading role in attendance sessions, increasing motivation and satisfaction, active methodologies and information and communication technologies (ICT) are naturally incorporated into the learning process, and various transverse competences can be developed and evaluated in the classroom [1–4]. Focusing on engineering, FCM has been applied in several examples related to spreadsheet use [5], chemistry [6] or automatic systems theory [7].

Besides, the use of educational videos as reusable learning objects (RLO) [8,9] facilitates the learning process in both conventional and flipped classes, makes it more attractive and provides the students a tool for self-study of the main and/or more difficult items of the subject. Furthermore, if these videos are available in an open courseware, its applicability is increased.

In the framework of several projects financed by the Program for Promoting Teaching Innovation of Universidad de Zaragoza, both methodologies have been applied by the authors in several subjects related to thermodynamics and thermal engineering, providing valuable results [10]. Sometimes, they have been applied separately and, in most situations, they are combined. In this framework, the aim of the paper is to use this experience to evaluate how the combined application of FCM and videos improves the teaching-learning process focusing on both field observations about FCM and quantitative raelations among video visualizations and final mark.

## 2. Materials and Methods

The analysis is based on the experience of the authors in the application of FCM and educational videos in several subjects related to thermodynamics and thermal engineering during two academic courses. Table 1 summarizes the subjects where the experience has been developed.

**Table 1.** Subjects where flipped classroom and/or videos have been applied.

| Subject | Program Degree | Videos | Flipped Classroom |
|---|---|---|---|
| Technical Thermodynamics and Fundamentals of Heat Transfer | Several | YES | 6 h |
| Thermal Engineering | Industrial Engineering, Mechanical Engineering | YES | 3 h |
| Thermal Machines and Engines | Mechanical Engineering | YES | 3 h |
| Thermotechnology | Chemical Engineering | NO | 2 h |
| Energy Efficiency in Buildings | Master on Renewable Energy and Energy Efficiency | NO | 2 h |

Among the previous examples of application, the subject "Technical Thermodynamics and Fundamentals of Heat Transfer" in the Degree of Industrial Engineering Technologies will be analyzed in detail. In this subject, flipped classroom is applied in the second chapter studied in the classroom devoted to calculations of thermodynamic properties, which is very relevant because concepts and methods learnt there are applied in most of the subsequent chapters of the subject. FCM is also applied in some lab and computer sessions. Besides, 23 short videos (of around 10 to 15 min) are available for the students in the Moodle platform of the subject: 6 are related to the aforementioned Chapter 2, 7 for lab and computer session, and 10 are general videos dealing with different sections of the subject. Videos of the first two groups have been developed by the authors.

In order to assess the influence of the innovative learning methodologies applied, several analysis methods are used: questionnaires for students, observation cards (for FCM) and, finally, data about number of videos visualization provided by Moodle.

## 3. Results

A main result of the application of flipped classroom model is positive student evaluation, which is summarized in Table 2.

**Table 2.** Evaluation of FCM by students.

| Aspect | Very Low | Low | Average | High | Very High |
|---|---|---|---|---|---|
| Degree of satisfaction | 0% | 15% | 41% | 26% | 18% |
| Degree of learning | 0% | 11% | 38% | 41% | 10% |

Besides, some conclusions have been observed in the application of FCM. Sometimes, students have not had prepared properly the session; accordingly, they take more time for starting and, finally, the effective time available is reduced. These effects can be minimized by the application of videos and including also a message for remembering. In some sessions, students prefer to work alone, whereas sometimes they work in small groups. If the group is not small, students usually have to wait, what advises the presence of a second lecturer or an assistant.

In order to assess quantitatively the influence of videos, information provided by Moodle about number and time of video visualization has been used and correlated to students' marks. Figure 1 shows how these marks depend on the number of videos watched (what ranges from 0 to 23). In each group, the average mark, and this average plus and minus its standard deviation is represented. Figure 2 shows the distribution of number of videos visualization. It can be seen how

the number of students watching less than 5 videos is very low and more than one third of students watch at least 15 videos.

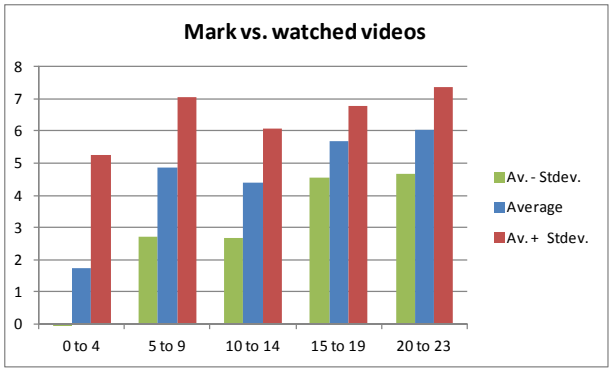


**Figure 1.** Mark vs. number of watched videos: average +– standard deviation.

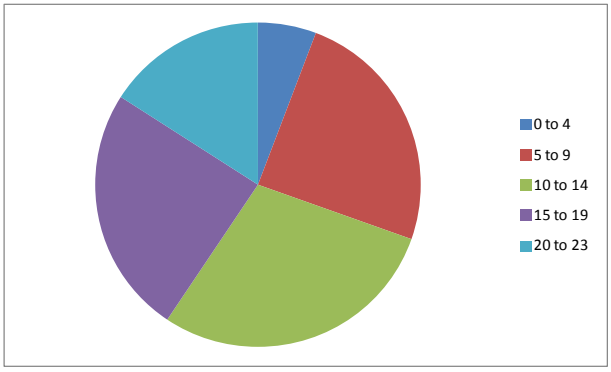


**Figure 2.** Fraction of students according to number of watched videos.

## 4. Discussion

In general, students consider that flipped classroom model and educational videos are positive from both degrees of satisfaction and learning. FCM application can be improved by considering several points; in particular, the use of short videos can help to minimize the number of students that attend classroom without having reviewed the material provided by the professor and also to make the study of the subject more attractive and successful. On the other hand, advantages of the application of videos increase when the classroom is not conventional and students use different resources for learning (in other words, when the classroom is flipped). In any case, it should be noted that most students do not prefer to transform completely the subject from conventional to FCM, but to apply this method to selected tasks. In general, students are more open to innovations at the beginning of the semester than at the end, when they are busier.

Information by Moodle about number of video visualizations can become a relevant source of data for quantifying the effect of the use of videos. Although it is not easy to identify strong relationships, some trends have been appreciated. Students who have watched more videos tend to have higher marks and also with lower dispersion. Students with low visualization can also have good marks, but it is not very usual, and they are likely to have also low marks. Although a good mark cannot be attributed only to videos, because students who watch more videos are likely to spend more time in "conventional" learning activities, a positive trend has been observed.

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