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# INTRODUCING FLIPPED LEARNING IN THEORETICAL CLASSES OF COMPUTER AIDED DESIGN

V. Gracia-Ibáñez, M. Vergara, V. Pérez-Belis, C. González-Lluch, M.J. Bellés-Ibáñez

*Universitat Jaume I (SPAIN)*

## Abstract

The Bachelor's Degree in Industrial Design and Product Development Engineering at Jaume I University (UJI) in Castelló (Spain) include 3 one-semester courses of Technical Drawing and Computer Aided Design (CAD). Throughout the three subjects, students learn to create Engineering Technical Drawings according to Normative firstly through sketching in Technical Drawing and Graphics (TDG) and then with CAD applications starting with two-dimensional CAD applications to three-dimensional ones in CADI & CADII. The three subjects have been coordinated in several aspects (such as development of material to facilitate student's self-learning, the use of self-assessment or peer-assessment) and they share a common structure with theoretical and practical sessions, along with the development of a graphic project throughout the course.

Theoretical classes have been taught in standard lecture format (teachers explaining contents), being uninteresting for students. Going further in subjects' coordination, the teachers of the three subjects during 2020 created a teaching innovation group to start implementing flipped classes in the theoretical sessions to driven the focus from the teacher to the students. They must learn by their own, previously to the face-to-face class by means of different material and tasks prepared by the teacher. Then, in face-to-face class, learning that is more active is carried out. They practise by doing different tasks and the real understanding of the concepts that were self-trained previously is put to the test.

During the first semester of 2020, the experience was carried out in TDG in just one session, but with encouraging results, concluding that the experience should be implemented in more sessions since students significantly increased their knowledge, as well as their participation and interest. In the second semester of 2020, a similar experience has been carried out in CADI. Half of the sessions before the first midterm exam were in flipped mode, whereas the rest were taught in the traditional way. Furthermore, the theoretical exam included questions worked on the flipped classes. Students answered a questionnaire about their experience with both methodologies 'traditional lecture classes' and 'flipped classes'.

The results obtained show that students rated very similarly the attendance to traditional classes and to the flipped ones as for their utility for concepts understanding and for the exam preparation. However, while the attendance of non-repeater students was similar regardless the type of methodology, the attendance of repeater students increased in flipped classes. As for flipped classes, the material prepared for previous tasks (videos and questions) and the face-to-face tasks were highly rated. A slight preference for flipped classes was shown despite the previous tasks. When comparing both methodologies, they found the flipped classes more entertaining and useful for the better understanding than the traditional ones. Furthermore, the questions of the activities of the flipped classes introduced in the exam were percentage-wise better answered than the rest of questions. As for the exam preparation, the students rated highly to have a free online book at disposal, the weekly questionnaires that allow keeping their studies updated or the use of Socrative, regardless of the methodology used.

Keywords: Flipped classroom, CAD, theoretical classes.

## 1 INTRODUCTION

Despite the Bologna process focused on developing specific skills linked to the demands of the labour market [1], many universities continue using the traditional teaching methodologies based on lecture classes instead of working on these competences. In addition, traditional lectures classes in a digital generation not used to listening attentively for long must face the attention gap problem due to media multitasking [2] that diminishes sharply the attention and increases the disengagement of the learning process. Traditional lecture classes focus on teacher explanations being student totally passive with a

retention rate according to the learning pyramid really low, however lecture classes seem to be good perceived by students [3].

Recently different methodologies have arisen which focus more on student active learning like gamification or flipped classroom with good perceptions by students [4]. Besides the good perceptions, according to Murillo-Zamorano et al. 2019 [5] flipped classroom in higher education has positive effects on students' knowledge, skills and engagement. Flipped classroom is fully based on active learning during class time [1]. The students must complete previous out-of-classroom tasks where videos have been proved to be a good way to introduce knowledge [7], even though implies a great effort for their creation [6]. Video-lectures have been increasingly used within traditional academic institutions, being fostered by COVID-19 pandemic. However, video-lectures produced in pandemic situations were in most cases produced in stressing times not being carefully edited or not considering some important clues like video duration. During this exceptional situation, face-to-face lectures were substituted by synchronous or asynchronous lectures. These two lecture formats increase the student attendance at lectures [8], being the asynchronous lectures better perceived thanks to the possibility to see videos at your own pace. However, synchronous lectures were preferred by those that prefer to interact, but probably this preference selection was also supported for the fact that students had the synchronous lecture recorded for posterior visualizations.

Technical Drawing and Computer Aided Design competences are integrated within the Bachelor's Degree in Industrial Design and Product Development Engineering at Jaume I University (UJI) in Castelló (Spain) through 3 one-semester courses: Technical Drawing and Graphics (TDG) during 1st year and Computer Aided Design I and II (CADI and CADII), in 2nd and 3rd year, respectively. The three subjects are focused on creating Engineering Technical Drawings according to Normative firstly through sketching (TDG) and then with CAD applications starting with two-dimensional CAD applications (CAD I) to three-dimensional ones (CAD II).

TDG, CADI and CADII courses include theoretical lessons and practical sessions, along with the development of a graphic project throughout the course. The three subjects have been traditionally coordinated in several aspects (such as development of material to facilitate student's self-learning, the use of self-assessment or peer-assessment). Listening to students [9], teachers found the theoretical classes, which were taught in standard lecture format (teachers explaining contents), were unattractive for students. Going a step further in subjects' coordination, the teachers of the three subjects during 2020 created a teaching innovation group with the aim of starting to implement flipped classes in the theoretical sessions. A previous experience teaching Computer Aided Design to design engineers [6] showed a similar student satisfaction when comparing traditional learning to flipped classes, although teachers perceived better results in problem-solving competences. This paper shows an experience in implementing flipped classrooms in theoretical sessions of the CADI course during the second semester of 2020. A previous experience in TDG with the implementation of flipped class in just one session [10] during the first semester of 2020 encouraged us to implement this methodology in CAD I course, increasing the number of sessions in which the methodology was applied.

## **2 METHODOLOGY**

Aiming to compare traditional lectures to flipped classes, half of the sessions before the first midterm exam were in flipped format whereas the rest were taught in the traditional way. Traditional classes were taught as a common lecture being most of the time devoted to the teacher explaining the concepts while the students were listening to the teacher. At the end of these one-hour lectures, a quick check of the understanding of the explanations by students was performed using 4 to 6 questions (choosing the true answer from several proposals) implemented in Socrative. Conversely, flipped classes were advised to students, with enough time, with a careful explanation of the previous tasks they were expected to fulfill before attending the face-to-face class. Previous tasks consisted in watching short videos with questions to be answered embedded within the videos. Additionally, they should write all the concepts they did not understand or those questions that might remain unclear within a wiki in the virtual classroom in Moodle. Likewise, if they had no questions, they should write it. Then, in face-to-face classes, a previous common discussion to solve the questions that the students wrote in the wiki was performed. Then, they participated in activities where they put to the test the knowledge acquired at home by solving problems. The distance restrictions due to COVID-19 lead the teacher to implement the activities through virtual classroom activities instead of doing it in paper. In the same way, the situation made that students refrain from collaborating more freely as desired given the safety distances.

Regardless of the theoretical classes' methodology, the students have at disposal a free online book where theory is explained. Theory assessment includes a final exam (60% of the theory final mark), two midterm exams (32% of the theory final mark) and weekly questionnaires (8% of the theory final mark) about the concepts seen each week. The experience was applied before the first midterm exam. Apart of obtaining the students' perception of the methodology used would be interesting to know the students' perception of the utility of the questionnaires and the adequacy of the exam to that seen in class. Furthermore, at the end of the traditional lecture classes, Socrative is commonly used to check the understanding of the concepts exposed. Socrative is a platform that could be used regardless of the theoretical classes' methodology, but obtaining the students' perception of its use is also of interest.

To obtain evidence of the students' perception of the new methodology applied, they answered a survey. The students were asked about their percentage of attendance to the classes of each methodology. As there was 3 sessions of each type they answered that they attended to none (0%), one (33%), two (66%) or all the three sessions (100%) of each type. Those who did not attended to any session of one type of methodology could not answer the questions referred to this methodology. They were also asked whether they were repeater or non-repeater to see if their perception was different and about different questions to be answered in a Likert Scale 1-5 referring to different questions shown in tables 1 to 5.

*Table 1. Questions answered by students referred to attendance utility.*

<b>QA</b>	<b>Questions referred to attendance utility</b>
QA1	Attending traditional classes in person has been for me (1 totally useless – 5 very useful)
QA2	Attending the 'traditional' theoretical classes has helped me to prepare the exam (1 has not help me – 5 help me a lot)
QA3	Attending the theoretical flipped classes has helped me to prepare the exam (1 has not help me – 5 help me a lot)

*Table 2. Questions answered by students referred to strategies and material used in both methodologies.*

<b>QSM</b>	<b>Questions referred to strategies and material used in both methodologies</b>
QSM1	Having previous material (videos) has been useful for me (1 totally useless – 5 very useful)
QSM2	The questions inserted in the videos have been (1 totally useless – 5 very useful)
QSM3	The activities carried out in the flipped classes have been (1 totally useless – 5 very useful)
QSM4	Having the previous material from the flipped classes (videos) has helped me to prepare the exam (1 has not help me – 5 help me a lot)
QSM3	Using Socrative in traditional class has been for me (1 totally useless – 5 very useful)
QSM4	Using Socrative in class has been for me (1 not entertaining at all - 5 very entertaining)

*Table 3. Questions answered by students comparing two methodologies.*

<b>QC</b>	<b>Questions comparing two methodologies</b>
QC1	Traditional face-to-face classes help me to better understand the reading book later (1 has not help me – 5 help me a lot)
QC2	In general, the flipped classes (including previous tasks and class activities) have helped me better to understand the concepts than the 'traditional' classes (1 totally disagree – 5 totally agree)
QC3	In general, the flipped classes (including previous tasks and class activities) have been more entertaining than the 'traditional' classes (1 totally disagree – 5 totally agree)
QC4	In general, the flipped classes involve a prior effort that does not compensate. I prefer traditional classes. (1 totally disagree – 5 totally agree)

Table 4. Questions answered by students referred to other material at disposal and exam adequacy.

QME	Questions referred to other material at disposal and exam adequacy
QME1	Having the theory material in an online book has helped me to prepare the exam (1 meaning has not help me – 5 help me a lot)
QME2	The weekly questionnaires have helped me to prepare the exam (1 meaning have not help me – 5 help me a lot)
QME3	The questions in the exam were consistent with that seen in class (1 meaning totally disagree – 5 totally agree)

Furthermore, the theoretical exam included questions worked on the flipped classes (Figure 1) and it was computed the percentage of students that answered them correctly.

To draw a line starting from point c, a combination of instruments must be used, choose the correct option,

Selection and coordinate filters

Selection and grid movement filters

Editing and checking tools

Coordinate filters and orientation movement instrument

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Indicate the transformation(s) carried out on the original drawing to obtain the transformed one:

Indicate the name and numeric value of the transformation(s) parameters:

Figure 1. Example of two questions from those worked on flipped classes that were asked in the exam as part of a 20-question questionnaire to be answered in 20 minutes (midterm exam).

### 3 RESULTS

#### 3.1 Results referring to attendance

##### 3.1.1 Attendance

Forty-nine students answered the questions, only 10% of them being repeater students. Figure 2 shows the percentage of attendance to each type of classes by repeater and non-repeater students that answered to the survey.

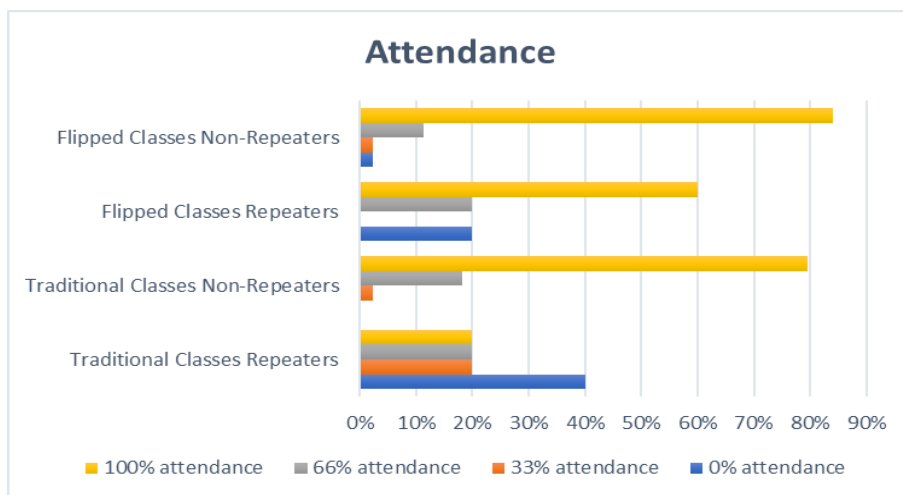


Figure 2. Percentage of attendance to each type of methodology classes (0%-33%-66%-100% of attendance to the classes) by repeater and non-repeater students.

Repeater students attending to all sessions increased from 20% in traditional lecture classes to 60% in flipped classes. Probably because of the novelty, given that they might have attended in previous year.

Non-repeater students attending to all sessions were similar in the two methodologies with a slight increase from 80% in traditional lecture classes to 85% in flipped classes.

### 3.1.2 Perception of the utility of attending to each type of class

Students' perception of the utility of attending to these classes is more important than attendance. Figure 3 shows the box & whiskers plots of the answers to questions referred to attendance utility.

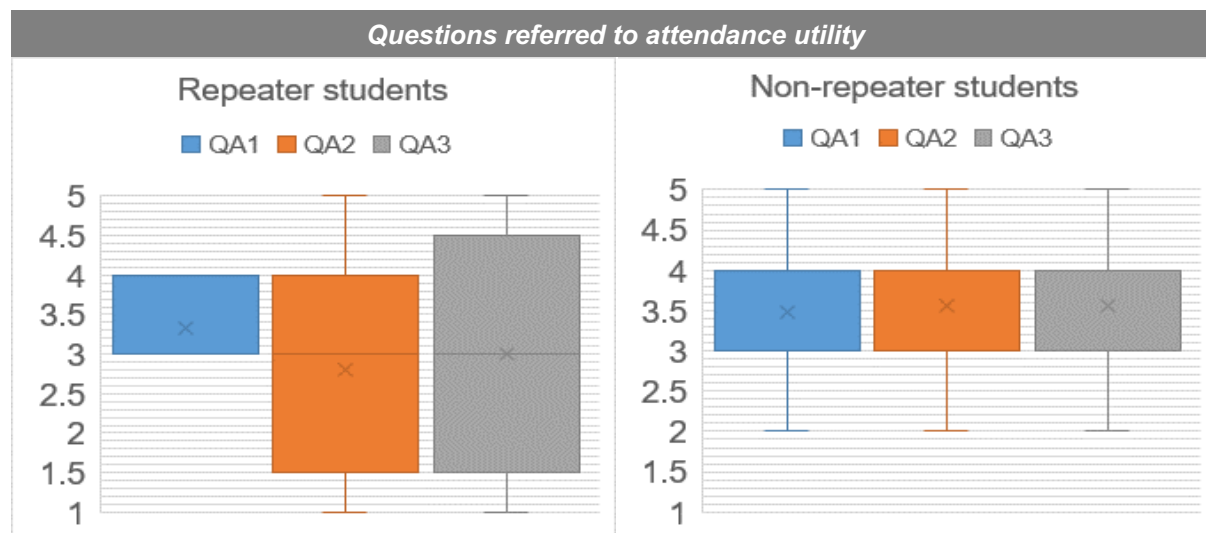


Figure 3. Answers to questions referred to attendance utility. X being mean value and horizontal line the median value, box being the interquartile range (IQR) and whiskers the 1.5xIQR values. See Table 1 for detailed questions.

Traditional classes' attendance utility was rated with a mean value of 3.5 (standard deviation of 0.7), being slightly higher rated in non-repeater students (question QA1).

The utility of attendance in terms of exam preparation was rated with a mean value of 3.6 (sd 1.0) in both cases: in traditional classes (question QA2) and in flipped classes (question QA3) showing a big difference between repeat and non-repeater students that gave a mean score under 3 to traditional classes and close to 3 in flipped classes. Repeater students seem to feel less useful the attendance to face-to-face classes for the exam preparation.

### 3.2 Results referring to strategies and material used in both methodologies

Figure 4 shows the box & whiskers plots of the answers to questions referred to strategies and material used in both methodologies.

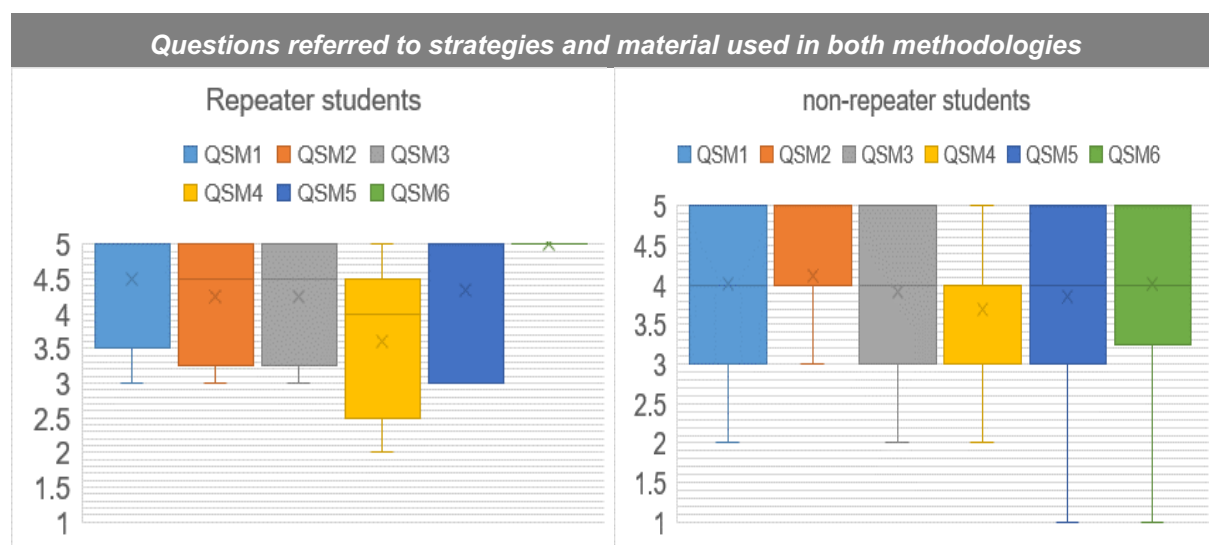


Figure 4. Answers to questions referred to strategies and material used in both methodologies. X being mean value and horizontal line the median value, box being the interquartile range (IQR) and whiskers the 1.5xIQR values.. See Table 2 for detailed questions.

The utility of previous tasks and activities performed in flipped classes (questions QSM1, QSM2 & QSM3) were highly rated with mean values of 4.1 (sd 1.0) for the videos, 4.2 (sd 0.9) for the questions inserted within the videos and 4.0 (sd 1.0) for the activities performed in face-to-face class. All of them were slightly higher rated by repeater students. However, the videos utility for preparing the exam (QSM4) was rated with a mean value of 3.7 (sd 1.1), with similar values for both repeater and non-repeater students.

In last years, Socrative questions were used in traditional classes to check the level of understanding of the concepts. Even though they do not form part of traditional classes, the perception of the utility and the entertaining of using it was asked (questions QSM5 & QSM6) obtaining high mean scores of 3.9 (sd 1.1) and 4.1 (sd 0.9) respectively, being of higher acceptance by repeater students with scores of 4.3 and 5 respectively.

Socrative could be used both in traditional and in flipped classes. Given the level of acceptance encourage us to following with its use, regardless of the methodology (traditional or flipped classes) used.

### 3.3 Results comparing two methodologies

Figure 5 shows the box & whiskers plots of the answers to questions comparing the methodologies.



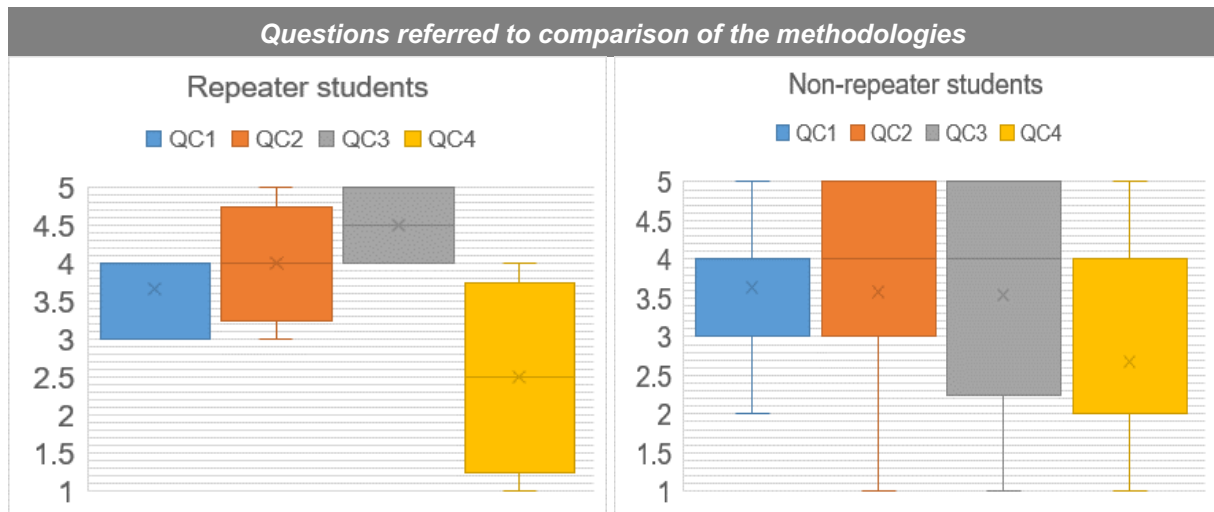


Figure 5. Answers to questions referred to comparison of the methodologies. X being mean value and horizontal line the median value, box being the interquartile range (IQR) and whiskers the 1.5xIQR values.. See Table 3 for detailed questions

Student perception of the utility to better understand the reading book later was rated with a mean value of 3.7 (sd 0.7) regarding traditional classes (question QC1), with similar answers between repeater and non-repeater students. However, when comparing both methodologies, students claimed flipped classes to be more useful to better understand concepts (question QC2) with a mean value of 3.6 (sd 1.3), but with a big difference between repeater students (with a mean value of 4) and non-repeater students with a mean value of 3.5. Repeater students seem to appreciate better flipped classes as for the understanding of the concepts.

When comparing both methodologies regarding entertaining, students rated flipped classes to be more entertaining (question QC3) with a mean value of 3.6 (sd 1.4), but again with a big difference between repeater students (with a mean value of 4.5) and non-repeater students with a mean value of 3.5. Repeater students seem to appreciate better flipped classes also as for the entertaining.

As for the question QC4 “In general, the flipped classes involve a prior effort that does not compensate, I prefer traditional classes”, students answered with a mean value of 2.7 (sd 1.3), meaning that they do not prefer traditional lecture classes, but not for a big difference.

### 3.4 Results referring to other material at disposal and exam adequacy

Figure 6 shows the box & whiskers plots of the answers to questions referred to other material at disposal and exam adequacy.

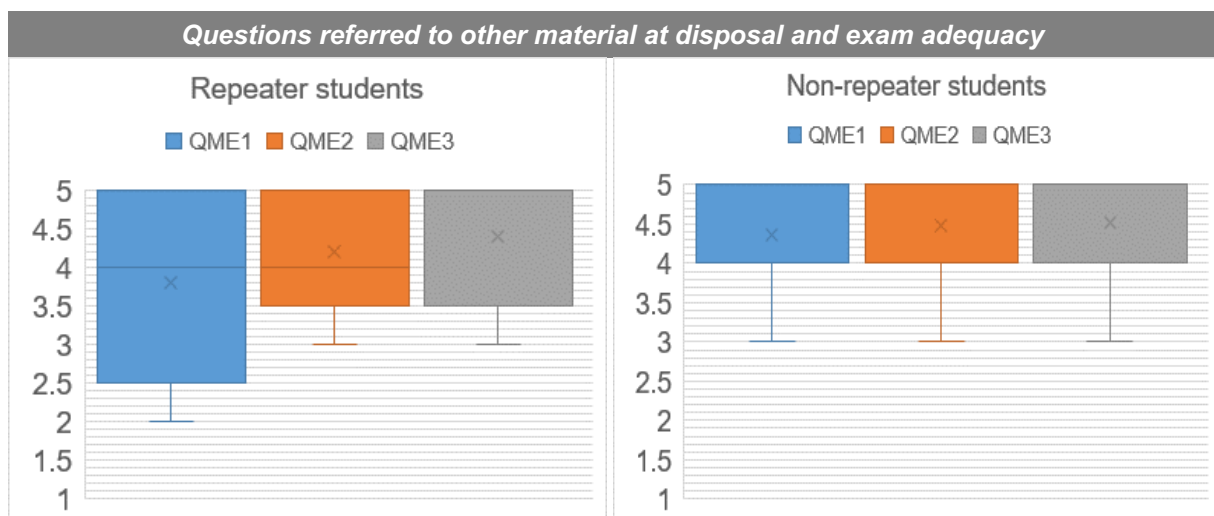


Figure 6. Answers to questions referred to other material at disposal and exam adequacy. X being mean value and horizontal line the median value, box being the interquartile range (IQR) and whiskers the 1.5xIQR values.. See Table 4 for detailed questions

Regardless of the methodology used, students have a free online book with theory explained so that they could learn by their own at home, although explanations with examples to clarify concepts are taught in face-to-face classes, and exercises deepen in concepts are worked in flipped classes. Its utility was asked (question QME1) obtaining a high mean score of 4.5 (sd 0.6) respectively, being better rated by non-repeater students.

As for the theory exam, they were asked about the utility of the weekly questionnaires about the concepts seen at class. These questionnaires are part of the final mark (8% of the final mark) and were implemented to help students to be updated with the subject. Their utility in exam preparation was asked (question QME2) with high mean score obtained of 4.4 (sd 0.9) respectively, being better rated for non-repeater students.

The adequacy of the theoretical exam to that seen in class score was a mean value of 4.5 (sd 0.7) with similar values for both repeater and non-repeater students.

### **3.5 Questions of the activities of the flipped class introduced in the exam**

Four questions similar to those worked on flipped classes were asked in the exam as part of a 20-question questionnaire to be answered in 20 minutes. Ninety-five percent of students answered at least one of them correctly, 73% of them answered correctly at least 2 and 42% answered correctly at least 3 of the four questions. They can be taken as good percentages considering that mean mark was 4.72 (sd 2.67), with 54% of student that did not pass the theoretical exam.

## **4 CONCLUSIONS**

The students rated very similarly the attendance to traditional classes and to the flipped ones as for their utility for concepts understanding and for the exam preparation. However, while the attendance of non-repeater students was similar regardless the type of methodology, the attendance of repeater students increased in flipped classes.

As for the material used in flipped classes, the material prepared for previous tasks (videos and questions) and the presence tasks were highly rated. However, the use of Socrative was also highly rated. It has been traditionally used at the end of lecture classes, but can be used in both methodologies.

When comparing both methodologies, they found the flipped classes more useful than the traditional ones for the better understanding and more entertaining which is in accordance with previous works [4]. A slight preference for flipped classes was shown despite the previous tasks. Furthermore, the questions of the activities of the flipped classes introduced in the exam were percentage-wise better answered than the rest of questions, in accordance with previous works showing a similar satisfaction but with a teacher perception of better results in knowledge application [6].

As for the exam preparation, the students rated high to have a free online book at disposal and the weekly questionnaires that allow keeping their studies updated, regardless of the methodology used. The students seem to appreciate having material for self-learning as well as resources to test their knowledge comprehension and to keep their studies updated (use of Socrative in face-to-face classes and weekly questionnaires) as a way to prepare the exam.

Their satisfaction was similar in both methodologies with a slight preference for the flipped class. They found this methodology slightly more entertaining and helpful for the better understanding of concepts, but again they rated highly to have videos at disposal and the activities worked in flipped classes. Good results of the methodology encourage us to increase its use and to improve its application with regard to previous tasks and/or to tasks performed in face-to-face class.

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