Combining strategies to make General Physics lectures more attractive and to improve students’ performances

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Abstract. Going one step further in the use and impact measurement of new strategies to improve the teaching-learning process during lecturing General Physics courses, the current contribution reports the last results/observations obtained by the authors on the combination of simple classroom experiments with active methodologies and new technologies (media). Cross-checking the answers in multiple choice questions done online during the lectures and in exams at the end of the term shows that this strategy has, at least partly, a positive effect on clarifying misconceptions. The overall opinion of the students was assessed and it showed that this lecturing approach is useful and motivating, making the lectures more attractive and stimulating eagerness to understand Physics.

1. Introduction
For almost a decade the authors of this contribution have been involved in lecturing General Physics courses of the Faculty of Science and Technology at the University of the Basque Country (UPV/EHU). Since the beginning, their main objective has been to change first year students’ opinion, quite general among first year students in the Spanish universities, that General Physics is a hard subject, difficult to understand and tough to pass. More specifically, the goals are to make physics more appealing to students, increase their motivation to learn and, consequently, improve their academic performance. For that purpose, in the last academic years the authors introduced some strategies which were new for them, but were based on recent science education trends [1,2]. First, the authors investigated the role of a formative evaluation via mandatory or optional Moodle quizzes at the end of every unit of the course. The main conclusions were that those students passing the quizzes increased their probability of passing the course and obtained better final marks, regardless of whether the quizzes were mandatory or optional [3,4]. The latter case showed that even if they were not enforced to solve quizzes, they were aware that a self-evaluation was for their own benefit. In the last year, using an alternative and complementary approach to make Physics lectures more attractive, the classical strategy of performing simple demonstrations [5] in the classroom was recovered and combined with new technologies with the aim of detecting and solving wrong
preconceptions of the students [6,7]. By introducing a question related with the experiments in the mid-term exam, it was confirmed, on the basis of a statistical analysis, that a higher amount of students answered them correctly at the end of the process.

Going one step further, the current contribution reports the last results and students’ opinions on the combination of simple experiments with active methodologies. In addition, using this strategy, cooperative learning and peer instruction were also promoted [8]. The outcome of a flipped classroom (FC) activity combined with cooperative learning and some demonstrations on electromagnetism is assessed.

2. Methodology; combination of a flipped classroom with simple experimental demonstrations
As a typical FC, the activity consisted of a team work (3 students each) divided into two lectures, in addition to the working hours spent to prepare the tasks outside the classroom. The students received a schedule of the activity as well as the expected learning outcomes and the topics to be treated. Fragments of different books were available in the electronic platform of the UPV/EHU (www.egela.ehu.eus) at least one week in advance. All necessary concepts related to the topics of interest were explained in these supporting texts and some enlightening videos were also provided. In the current case Faraday-Henry’s law, electromotive force due to motion and eddy currents were worked out. The puzzle methodology was also applied, i.e. each team member had to work previously on one topic from the three proposed in order to explain it later to the other team members in the classroom. They also had to prepare, individually, a concept map/summary and to pose a question involving the details related to the treated topic. This question had to be sent to the lecturer by e-mail before the lecture, to check the active implication of every student in the preparation of the activity.

In the first lecture, after a brief introduction to recall the procedure of the activity, the meeting of expert-students took place. Each team member shared his/her concept map/summary on the particular topic with the experts of other teams who treated the same topic (4-5 experts/meeting). Questions and comments were discussed as a group and a revised concept map or summary was produced and had to be delivered to the lecturers. Then, in the second part of this lecture, each team member explained his/her topic to the other members in their original groups. In order to help them to explain and understand the main concepts, and to connect those concepts with phenomena and applications in the real world, some simple devices to make demonstrations related to electromagnetic induction were available during the whole session. Figure 1 shows a magnetic brake and a coil with a magnet as examples of the devices used for the demonstration.

Figure 1. Examples of the devices used for demonstrations during the lectures.
During the second lecture the students spent 15-20 minutes to propose an exercise integrating all topics treated or, alternatively, made a detailed summary of the concepts treated, which had to be handed in to the lecturer. An open discussion took place subsequently to clarify whether all the concepts were well understood. This way, both oral and writing communication skills are also worked out. Finally, to check the proper understanding of the concepts by the students, each of them answered an individual 6-question test run online via Socrative [9] using their cell phone (see one example in figure 2). The questions were similar to the ones they have to answer in the Moodle quizzes at the end of the subject. The students’ opinions on this methodology was also gathered through an online questionnaire.

3. Outcomes on the students’ performances and opinions
Using the strategies described above, the authors introduced cooperative learning and peer instruction in their lectures, and then measured their efficacy based on the answers given by the students in the online tests and in a mid-term exam. Concerning the student’s understanding of the Physics concepts (see table 1), in five out of the six multiple-choice questions about electromagnetic induction carried out in the final part of the session, more than 64 % of the students answered them correctly, reaching more than 85 % in two of them. However, in one case the percentage of correct answers dropped down to 21 %, which can be related to the intrinsic difficulty of the involved concept. This allowed the lecturers to detect the misconception and clarify it. In any case, it is observed that, when the students have worked out the concepts recently, their performance is quite good.

Cross-checking these multiple-choice questions with 4 similar ones answered by these students in the mid-term exam, it shows that this strategy has, at least partly, a positive effect on clarifying misconceptions (see table 2). More than 83 % gave correct answers to 3-4 questions, 14 % answered correctly 2 questions and only 3 % responded well 1 or no questions, which is in agreement with the

Figure 2. Example of one of the multiple-choice questions included in the test at the end of the FC activity, as it is seen on the screen of a cell phone.
results obtained in the test after the FC sessions (see table 1a). On the other hand, for the questions related to the topic treated in the FC, the students that did not take part showed poorer performances: 39.5 % gave correct answers to 3-4 questions, 28 % answered correctly 2 questions and 32.5 % responded well 1 or no questions. Here it has to be noted that not all of the students that took the mid-term exams had taken part in the FC session. Nevertheless, although no strict correlation can be attributed to not having done the activity, this outcome might be significant.

Table 1. Results for the test after the FC activity: (a) number of correct answers for each question, and (b) number of correct answers given by the students

| Question # | correct answers | wrong answers |
|------------|-----------------|---------------|
|            | # | %  | # | %  |
| Q2         | 9 | 21.4 | 33 | 78.6 |
| Q3         | 27 | 64.3 | 15 | 35.7 |
| Q4         | 36 | 85.7 | 6 | 14.3 |
| Q5         | 39 | 92.9 | 3 | 7.1 |
| Q6         | 30 | 71.4 | 12 | 28.6 |

| # correct answers | TOTAL # students | % students | FC # students | % students | no FC # students | % students |
|-------------------|------------------|------------|---------------|------------|------------------|------------|
| 6                 | 2                | 4.8        | 16            | 38.1       | 6                | 14.3       |
| 4                 | 16               | 38.1       | 3             | 6          | 2                | 0.0        |
| 3                 | 8                | 22.2       | 5             | 12         | 12               | 27.9       |
| 2                 | 10               | 21.5       | 1             | 2.8        | 9                | 20.9       |
| 1                 | 5                | 6.3        | 0             | 0.0        | 5                | 11.6       |

Table 2. Comparison of the number of correct answers given by the students in the mid-term exam depending on whether they attended FC sessions (FC) or not (no FC).

Turning to the students’ opinions, after doing these activities, 75 % of them fully agreed, and 25 % agreed to some extent, that “The real demonstrations/experiments used during the lecture are very useful for a better understanding of the topics studied”. Asked for an overall opinion on this type of activities 42 % gave a mark between 9 and 10, 55 % a mark between 7 and 8, and only 3 % evaluated it within the 5-6 interval. It should be emphasized that these positive opinions can be considered representative and unbiased, since the questionnaire was anonymous and the activities were optional and not taken into account for final marks.

4. Conclusions
As expected from the results published in the literature on science education, flipped classroom in combination with simple demonstrations and cooperative learning is shown to be an effective methodology to make Physics more attractive for first-year university students. Even though statistical quantitative evidence hasn’t been shown, a direct positive impact on the student performances can be attributed to this lecturing strategy. In this respect, the authors are aware that, for future research, they must improve the procedure to measure the impact of new strategies in the students’ learning process, in order to prove real correlation factors: for example, taking into account students’ previous background and performance in the subject, or their attendance and participation. Nevertheless, it is impossible to define groups of students that receive training based/non-based on the application of
these techniques without compromising the fairness of the teaching process due to all students. On the other hand, however, it can be concluded that the overall opinion of the students is that this lecturing approach is useful and motivating, making the lectures more attractive and stimulating eagerness to understand Physics. Therefore, since the methodology analyzed in this article was just an isolated activity, there is still a lot of room for improvement regarding the teaching work too, to integrate such activities in the general lecturing scheme.

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