Activities to improve mathematics competencies achievement for Aerospace Engineering Freshmen

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INTRODUCTION

The main objective under Bologna Process has meant a shifting from teacher-centered teaching to a student-centered learning approach [1]. From this perspective, students are not just passive learners in the classroom. Instead they are active learners that should play a main role in their learning process.

In order to favour this active participation a number of different methodologies have arisen, many times combining some of them such as problem-based learning, flipped learning, collaborative learning, blended learning, etc. Under these methodologies, students usually learn on their own, alone or in groups, while special attention has been paid to achievement of competences throughout the learning process [2].

Mathematics is a basic subject in all engineering studies and it is very important that all students achieve basic competencies and skills in this discipline. One of these skills is the proper use of mathematical software, and due to the special skills to be achieved and their posterior needs, this a place where active performance is at the same time natural and a need.

In order to pursue this goal the authors have taken advantage of a very powerful mathematical software such as MATHEMATICA and an educational platform developed by Technical University of Valencia (Universitat Politècnica de València, UPV), and known as PoliformaT, which is based upon the Sakai project [3]. This has been implemented at the Design Engineering Higher Technical School (Escuela Técnica Superior de Ingeniería del Diseño, ETSID), which is one of the 13 schools of UPV. BEng Aerospace Engineering is one of the degrees delivered at ETSID [4] where the use of innovative teaching methods based on technology has been widely promoted.

In Mathematics classes at Aerospace Engineering we encourage our students to an active learning approach with the aim of motivating students for further study, getting

a deeper learning and developing thinking skills. We will deal in this paper with Mathematics I which is a compulsory annual subject delivered in the first year at ETSID. It has got 120 contact hours (12 ECTS) from which 75% of them corresponds to Theory/Problems (TP) sessions and the remaining 25% to Lab practice (LP).

The LP methodology used involves a flipped classroom methodology since students are required to prepare the class in advance as detailed in Section 2. Section 3 exposes some of the activities that students are asked to perform in order to facilitate and improve their achievement of their mathematical competencies. In Section 4 we discuss the results and a questionnaire with the students' opinion and some conclusions are presented in Section 5.

1 FLIPPED CLASSROOM METHODOLOGY

1.1 The flipped setting

A flipped classroom appears when students become the rulers of their learning and instructors just guide them in their learning process. The goal with this methodology is that students achieve a deeper learning as this makes them putting a higher effort and personal commitment in the process [5-7].

In fact flipping the classroom intends to replace the standard lecture-in-class format with opportunities for students to review, discuss, and investigate their course content with the instructor in class. There are many ways that a classroom can be flipped, the underlying premise being that students review lecture materials outside of class and then come to class to develop instructor-guided learning activities [8].

An interesting summary with tips on instructional strategies for flipping the classroom may be found in [9].

Some of these strategies include:

a) To assign readings and follow up with in-class discussion or quizzing.

b) For an online or hybrid class, to provide videos and readings for students to review and have graded forum discussions facilitated by instructors.

c) To capture your lecture from classes and provide the recordings for student review after class.

d) To assign reading material outside of class or in class, and require students to teach part of the class by some media.

All these methods enable having access to material of great value when students miss some class for some reason, to keep up with course material and finally for those who add the class late so that they can catch up the first lessons.

Flipped classroom implies a deep change in teaching practice for students and instructors, the former having to forget their passive attendance to traditional lectures, the latter having to become familiar with providing the adequate material to the new flipped setting. Students should be prepared to discuss course materials in class which can shake the students' participation.

1.2 Our Lab Practices implementation based on flipped learning

Flipping the classroom may or may not include a technology component. This may depend on the level of technology and time available. Our approach makes a reasonable use of it and fits quite well within the first type of strategy described in the previous subsection. An important aspect for its success is the fact that we assess students on the material worked on their own during each week as explained below.

For LP sessions, each LP group has around 25 students and we take advantage of the potential of the mathematical software MATHEMATICA. Our flipped learning implementation has got three different stages: pre-class, in-class discussion and in-class assessment with tests. Additionally, there are individual lab semester exams.

The first pre-class stage relies quite a lot on the educational platform PoliformaT by providing a guide with topics and exercises that students should work prior to the lab session. It also includes theoretical aspects of the topic that they should fully understand and MATHEMATICA commands related with it.

Each weekly lab practise session starts with an in-class discussion with students on the different features of the session studied by them.

Thereafter the session hosts a 30-minute in-class assessment where freshmen have to solve individually some questions and exercises by means of PoliformaT assisted by MATHEMATICA. In this part the instructor is available to help students if they ask for it. Once finished this assessment, students can check their answers and scoring.

With this methodology the students and instructors keep track of the students' learning progress. The grades obtained in lab sessions influence the students' continuous assessment.

2 OTHER ACTIVITIES TO FACILITATE COMPETENCIES ACHIEVEMENT

In addition to the weekly flipped classroom lab sessions, the students are encouraged to work out the subject by means of some assignments along some given week or fortnight which include, between others, questions related to:

a) Standard math problems with some degree of difficulty.

b) Engineering related problems.

c) Open questions with no closed answer.

Assignments are performed in a non-controlled environment (NCE), and therefore there are always some doubts in authorship. For this reason students are requested to take a multiple-choice (MC) test under controlled environment (CE), in-class, related with the type of the assignment exercises. Figure 1 gathers the results obtained by each student.

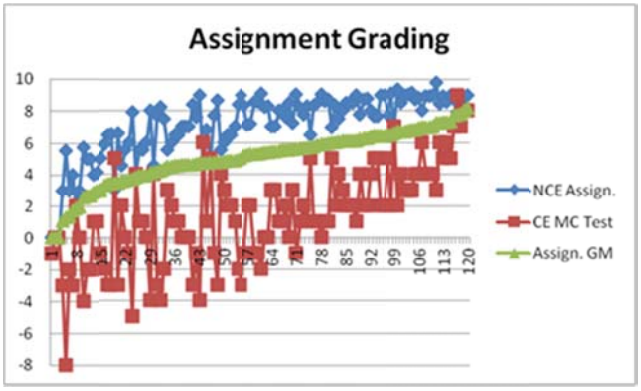

Fig. 1. Assignment grade: In blue Non Controlled Environment (NCE); in red multiple-choice test under Controlled Environment (CE); in green the global mark (GM).

As expected most students performed better under NCE, in blue in Figure 1, than at class under CE, in red in Figure 1. In some very few cases we found a huge divergence between these values which leads to think that they received some kind of aid outside of class. In the multiple-choice test under CE students were allowed

even to look at their home assignments, thus it was not a standard multiple-choice test. For that reason students were told that they would be awarded with the same positive (negative) absolute input in case of success (failure), with 0 input in case of no answer. For that reason some few students got a negative grading in the multiple-choice CE test which somehow compensated the perhaps excessive 65% value given to the NCE vs 35% of the CE.

3 RESULTS AND STUDENTS' FEEDBACK

The number of students of Mathematics I in BEng Aerospace Engineering was 126, a value that serves as a reference for the relative values and percentages. However 5 out of 126 had got a maximum of two attendances, so they should be considered as if they had abandoned the course.

The students' performance was as follows:

- 6 (4.7%) students did not take the LP exam almost matching the students with non-attendance at LP sessions. If we do not consider these 5 students, the percentage drops to 0.8%.

- 11 (8.7%) students did not take the TP tests which correspond to 4.7% of students not considering the 5 dropouts.

- The average grades obtained in the three TP tests were 6.1, 6.6 and 6.9, with standard deviations of 2.4, 2.6 and 2.1, respectively.

- The averages obtained in the two LP tests were 5.6 and 7.6 with deviations of 2.0 and 2.4.

- The average on the last 27 weekly sessions of PL was 8.7 with a deviation of 1.7.

- 112 (88.9%) students passed the subject, a 92.6% of students without accounting the 5 dropouts.

Using PoliformaT's tool 'Polls' we gathered feedback from students about the flipped methodology applied. Questionnaire consisted in several questions, related with the organization of the lab sessions and other subject related issues.

The results obtained were positive when referring the methodology employed. Most of the students thought that practices done were very consistent within the course. Related with the third stage (in-class discussion) and its benefits we show the results in Figure 2.

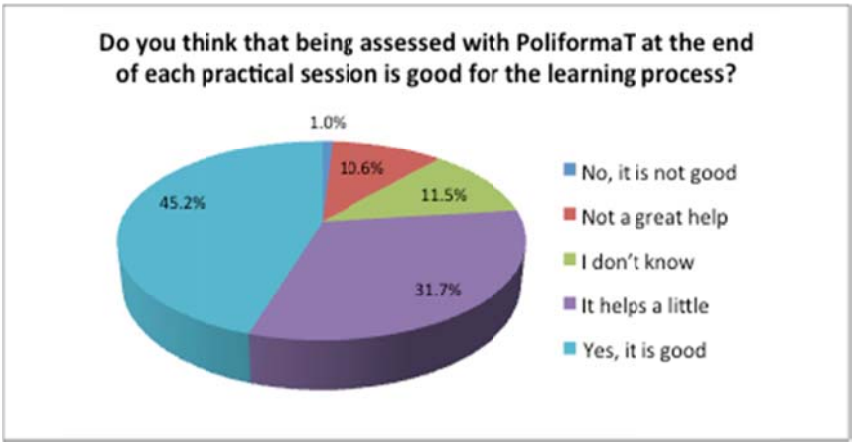

Fig. 2. Results of the poll question about assessment at lab sessions.

As shown in Figure 2, 45.2% of the students thought that the assessment helped their learning process and 31.7% that it helped a little bit. In Figure 3, we show the students' opinion about the assignments and its importance in the learning process.

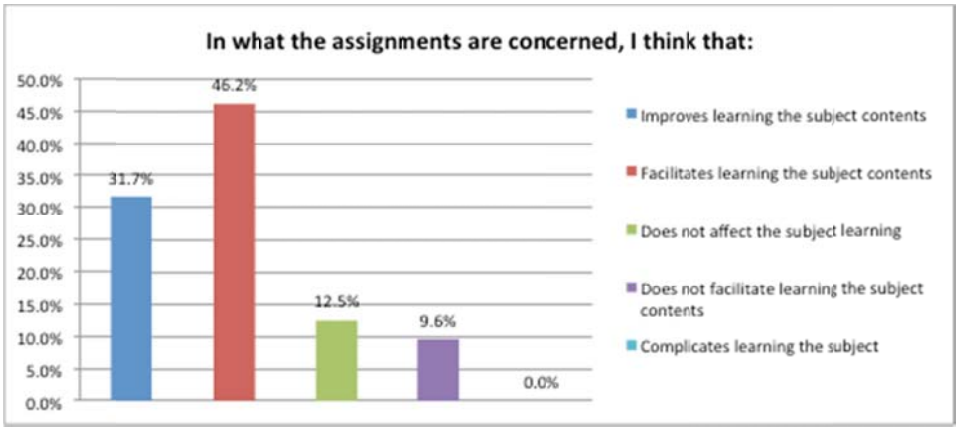

Fig. 3. Result of the Poll about assignments during the course.

From the Poll it is clear that students do not have a negative perspective towards the use of a flipped methodology. Although the performance of this methodology has just been developed in LP sessions, our opinion is that its effects have had great influence on the results of TP due to the constant review of concepts that students must carry out during the preparation of LP sessions.

4 CONCLUSIONS

The authors have incorporated a number of activities to improve Mathematics I competencies achievement in the first year of Aerospace Engineering at Technical University of Valencia, by introducing some assignments which were also evaluated with some controlled environment conditions, and changing the methodology of Lab classes in the subject based on flipped learning also known as inverse classroom, in three stages. For this adaptation the authors have designed and generated an adequate and proper material for the preparation of sessions (pre-class) as well as for the in-class activities.

A consequence of the application of this methodology has been achieving a massive participation in laboratory classes as 93% of students attend all LP sessions (97% if dropouts are not considered). Another consequence of the number of weekly assessments carried methodology is that from all the data collected in the different stages students can detect very specifically the skills that have not been acquired and act on them. Furthermore, students show great interest in maintaining the process of learning mathematics active throughout the course.

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