COLLECTIVE EXPERIENCE OF APPLICATION OF AN INVERTED CLASSROOM IN THE COMPUTER SCIENCE DEGREE PROGRAM

I. Aldalur, M. Illarramendi, M. Iturbe, I. Roman, U. Markiegi
Mondragon University
Arrasate-Mondragon, Spain

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ABSTRACT

In the last years, higher education is immersed in the transformation of the teaching experience with the aim of involving students more, as well as motivating them. Nowadays, students are very familiarized with new technologies and media while lecturers have been forced to transform their traditional notes to digital ones. This transformation pace has been accelerated in the last year due to the COVID19 pandemic. One of the main exponents of the said transformation is the adoption of the inverted classroom, a substantially studied teaching methodology where students work on some key concepts before a lecture takes place and face-to-face lecture time is reserved for added value activities. This work presents the results of a case study involving the implementation of the inverted classroom in a computer engineering bachelor's degree. This experiment involves six different subjects in three courses during the 2020/21 academic year. The paper presents the principal motivation for the study, as well as the preparation process and methodology of the out-of-classroom multimedia materials and training of the faculty. It also covers the methodology used for multimedia content creation. Finally, the evaluation results are presented, gathered from questionnaires directed to students and lecturers.

1 INTRODUCTION

In recent decades, the university environment is undergoing through deep changes derived mainly from technological and pedagogical innovations in the field. New technologies provide mechanisms to multiply opportunities for communication and collaboration during the learning process, extending the traditional classroom context to a digital space. However, these technological advances are experienced unevenly between the teaching and student communities. On the one hand, newly enrolled students demand greater use of technology in the learning process, as the information consumption in newer student generations is marked by the continuous use of technology (e.g., they are able to use their smartphones, tablets or computers for hours on end). This ability to be continuously connected through digital devices, however, rivals the ability to concentrate and learn. On the other hand, the teaching community, aware of the opportunities and challenges, is engaged in a progressive transformation to incorporate technology into education in a rational way.

Advances in neuroscience point to student motivation and involvement as a determining success factor in the learning process. In recent decades, the teaching community has made innovative pedagogical proposals that seek student participation through active methodologies as a framework to increase motivation and involvement. One of the most relevant methodologies is the inverted classroom. This methodology consists of students studying and preparing lecture contents outside the classroom, before the actual lecture starts by accessing said contents at home through the use of technology (e.g. videos or required readings). Subsequently, with the lecturer as a guide, classroom time is allotted to additional added-value activities where students deepen and complement the content previously acquired. Such activities can be guided to develop the practical side of the lecture or engaging in more interactive and participatory activities such as idea analysis, debates or teamwork.

With the outbreak of the COVID-19 pandemic, lecturers worldwide have been forced into emergency remote education during the second semester of the 2019/2020 academic year. However, after the height of the pandemic, some universities returned to on-site lecturing for 2020/2021 albeit in a partial manner due to classroom space constraints and social distancing, forcefully adopting the technique known as blended learning, by combining face-to-face and remote lectures. This reduction of onsite lectures has outlined the necessity of optimizing onsite lecturing time. In this context, the pandemic has intensified the use of technologies, as well as the adoption of innovative teaching methodologies by higher education centres in an attempt to counteract the (at least partial) lack of traditional face-to-face lecturing: inverted classroom being one of the main exponents.

In this context, this paper presents the experience of adopting the inverted classroom at our university, across the complete computer engineering bachelor's degree. The rest of the document presents the work methodology carried out, as well as the preliminary results of the implementation and the main conclusions.

2 RELATED WORK

In the last decade, flipped classroom has been considered an outstanding methodology to motivate students in their daily routine. New technologies are fundamental in this methodology and students are very familiarized with them. This methodology is not uniquely designed or carried out in the primary or secondary school, it is also accomplished in the university and engineering faculties.

Gannod et al. [1] implemented the flipped methodology for software engineering students. It was carried out with 40 students and they had video materials to watch between 3 and 6 hours every week at home before the laboratories. These laboratories were associated with the videos and results show that the students were better adapted and advanced faster without professor's support.

Mason et al. [2] experimented the flipped methodology in a mechanical degree with 20 students with the aim of producing graduates who have excellent problem-solving skills. Before the lectures, students had some videos to watch. Then, in class, they were asked to solve a problem in groups or individually, supported by the teacher to solve their doubts. At the beginning, students were frustrated due to the methodology. Nonetheless, final results were equal or better comparing with previous results the students' satisfaction was superior.

Kim et al. [3] presented an experience in three different classes with 115 students involved. Before the lectures, they had some videos to watch and, in class, they had to solve problems related to the videos, group presentations and role plays. At the end of the experiment, they develop a set of 9 design principles for a face to face flipped course.

Parejo et al. [4] implemented the flipped classroom experience in the second year of software engineering degree in the software architecture and integration subject. They compared the results of two different years involving 434 students and 6 lecturers. Before the laboratory sessions, students must watch some videos and a questionnaire was used at the beginning of the class to be sure that videos were completely understood. If one questions was not correctly answered by the crowd, the lecturer explains the concept in class. Results show that students had 24 minutes more to complete the laboratories which provoke that more than 70% of students considered the time to complete the laboratories adequate.

Chiquito et al. [5] completed the experience in the second year of a course called Technology of Materials. They divided students in two groups, 98 followed the traditional approach and 97 used the flipped classroom methodology. The flipped students had to watch some videos before the class and complete and activity to check students' knowledge before the activity. Results show that students which used flipped methodology obtained better results and they detected that female students obtained better results than males in this group.

Gren [6] studied the flipped classroom experience in software engineering subject with 50 students involved. Before the lectures, students had to watch videos around 10-20 minutes. In class, a questionnaire was used to have some feedback about students' knowledge before the class activity. Comparing their results with the previous 5 years, they conclude that flipped classroom methodology improved the academic results.

Hussain et al [7] involved 18 students in a flipped classroom methodology in an engineering degree in a mechatronics course. Before the lectures, students were delivered some online videos with the main concepts to use in the next class session. In class, different techniques were utilized for teaching such as teacher-student interaction, student-student interaction, engaging students by using audio and visuals aids, hand-on activities, and problem-solving exercises. After the lectures Bloom's taxonomy was used for students' summative assessments which helps the lecturers to develop a rubric for grading and discriminating students' performances at various levels. Results show that flipped methodology and improved engagements with their lecturer and their peers although results were not enhanced significantly.

3 CASE STUDY

The starting point of the project is given during the deployment of the strategic plan of the university in the degree of computer engineering carried out in May 2020.

Among the established objectives, a project proposal is defined for the implementation of the inverted classroom methodology as a mechanism to (1) increase the involvement and motivation of students in class and (2) train faculty in the digitization of content.

The project is presented to the academic coordination and receives approval and resources for its implementation in the 2020-2021 academic year. The project involves the implementation at scale of the inverted classroom methodology in two subjects per course with the involvement of 10 lecturers and 253 students.

Before carrying out the experience, in the early half of July 2020, we gathered information from other works to see how we could adapt it to our own case. The related work shows some of the experiences we evaluated.

The lecturers at our university are experienced in the use of active methodologies. Evidence of this is that for more than a decade they have been applying the Project Based Learning (PBL) methodology in all their engineering degrees. In this context, although the university had been providing training pills to the teaching team in active methodologies (including training in the inverted classroom methodology) for several years, a specific training was designed for the project, which took place in July 2020.

During the training, the project's teaching team was trained in the basic concepts of the inverted classroom methodology and the training was completed with three workshops: a first workshop to establish the rules of the methodology that all subjects had to follow, a second workshop to design the implementation of the methodology in each of the subjects involved and a final practical workshop to get started in the autonomous management of the recording studio. It should be noted that prior to the training period, the design and arrangements for setting up the recording studio were made.

All subjects have adopted 4 rules established in the common methodology:

- (1) Outside of class hours, students watch a video(s) with the contents of the subject.
- (2) In the following classroom session, they take a brief questionnaire related to the video they have seen. In this way, students are encouraged to come to class with the basic concepts already reviewed and with the possibility of clarifying any doubts they may have about the audio-visual material. Once the cycle of the more theoretical and conceptual part is closed.
- (3) All subjects have also been supported by exercises and practices. This activity has been carried out in class (being able to finish out of class) and in this way the classroom time has been used to really solve doubts in the application of theoretical concepts. The objective has been to make the most of the classroom time to reinforce the learning process. After each topic or learning module,
- (4) The teaching staff provided feedback to the students on the questionnaires completed.

However, the evaluation applied in each subject has not been affected with respect to previous courses with the incorporation of the methodology. In all the degrees, continuous assessment is applied throughout the degree course, which each subject implements with different types of tests: questionnaires, practices (individual or group) and individual exams on the subject.

Following the guidelines described above, during the first semester of the current academic year (from September 2020 to February 2021), the subjects selected in

July 2020 have already carried out the experience. The following section will show the results obtained following the inverted classroom methodology described above.

4 RESULTS

The results presented in this section correspond to the first semester of the 2020-2021 academic year. During this period, 6 subjects, 10 lecturers and 253 students have been involved. In this piece of work, the reception of the experience has been analysed. For this purpose, two separate surveys were carried out with students and lecturers.

Table 1. Results of the Student Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

	Frequencies						
	SD	**D**	**N**	**A**	**SA**	**Median**	**Mode**
Q1: I usually watched the videos before class.	5	19	45	82	102	A	SA
Q2: The videos were easy to understand/follow.	10	34	72	90	47	A	A
Q3: The video material was well designed, well-structured and clearly defined.	14	20	69	101	49	A	A
Q4: The videos have helped me to learn.	10	33	71	86	53	A	A
Q5: The activities developed in class after the quiz have helped me to learn.	22	22	62	94	53	A	A
Q6: The ability to rewatch and rewind the videos has helped me to learn.	6	21	35	79	112	A	SA
Q7: A short video format presenting the main study topics helped me learn more than the very detailed and extensive videos.	10	25	71	95	52	A	A
Q8: Taking multiple-choice quizzes after watching the videos has allowed me to delve deeper into the more complex content before class and therefore helped me understand it better.	29	39	77	78	30	N	A
Q9: Having watched the videos and reviewed the materials provided prior to the class sessions has helped me complete the class activities with more confidence as I was not at a loss.	14	33	76	99	31	A	A
Q10: Having watched the videos and reviewed the materials provided prior to the class sessions has helped me to complete the class activities more easily because the activities were familiar to me.	11	28	76	102	36	A	A

Following the work carried out by [8], we surveyed the student body to find out their opinion on this new initiative in ten different aspects (see Table 1). The questions used in [8] have been slightly modified, and the responses have been collected based on the Likert scale [9] as in the original paper. A summary of the responses (253 questionnaires in total) by the student body is shown in Figure 1.

In general, the students agreed with the statements made in the survey and the reception of the experience was positive. It is worth highlighting statements Q1 and Q6, where the responses have been more favourable. In these statements, it is affirmed that the videos are viewed prior to the classes, and that one valuable aspect of having the audio-visual content is the possibility of revision. On the other hand, the

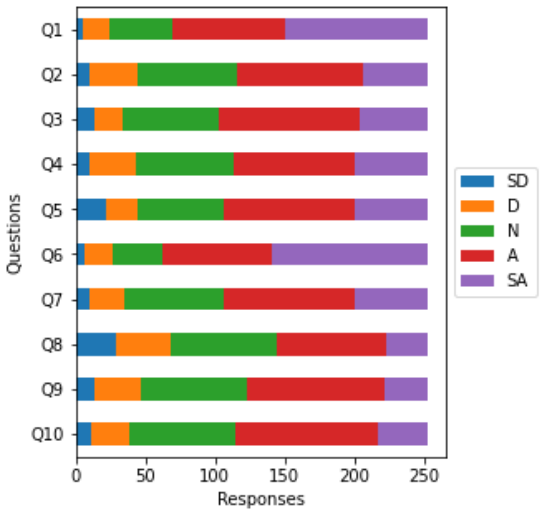

Fig. 1. Results of the Student's Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

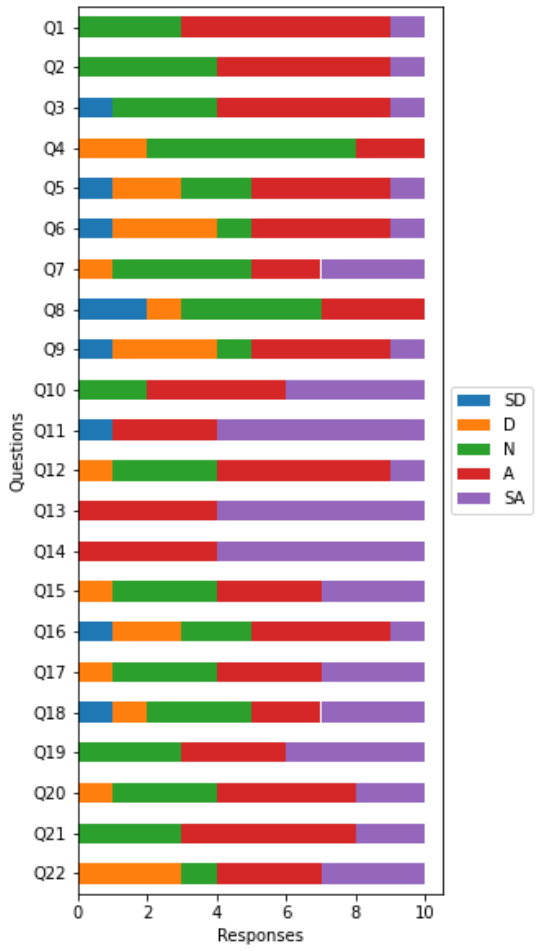

Fig. 2. Results of the Lecturer's Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

use of questionnaires did not receive the same consensus in statements Q8, regarding the usefulness of the questionnaires.

Table 2. Results of the Lecturer Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

	Frequencies					Median	Mode
	SD	D	N	A	SA		
Q1: I enjoy trying to use flipped teaching.	0	0	3	6	1	A	A
Q2: I enjoy the flipped teaching method that is completely new to me.	0	0	4	5	1	A	A
Q3: Curiosity is the driving force behind much of what I do in flipped teaching.	1	0	3	5	1	A	A
Q4: The more difficult the flipped teaching task, the more I enjoy trying to solve it.	0	2	6	2	0	N	N
Q5: I am strongly motivated by the recognition I can obtain from doing flipped teaching.	1	2	2	4	1	N	A
Q6: As long as I can do flipped teaching, I'm not that concerned about exactly what recognition I can obtain.	1	3	1	4	1	N	A
Q7: I seldom think about the recognition I can obtain for flipped teaching from students.	0	1	4	2	3	N	N
Q8: I care about what recognition mechanism exists from flipped teaching community.	2	1	4	3	0	N	N
Q9: I could complete the flipped teaching task if there was no one around to tell me what to do as I go.	1	3	1	4	1	N	A
Q10: I could complete the flipped teaching task if I could call someone for help if I got stuck.	0	0	2	4	4	A	A
Q11: I could complete the flipped teaching task if I had a lot of time to execute flipped teaching.	1	0	0	3	6	SA	SA
Q12: I have sufficient ability to prepare teaching materials for the flipped teaching tasks in advance (such as recording videos and collecting educational resources on the Internet).	0	1	3	5	1	A	A
Q13: The university provides facilities and resources for flipped teaching.	0	0	0	4	6	SA	SA
Q14: The university provides technology and software resources for flipped teaching.	0	0	0	4	6	SA	SA
Q15: The university provides facilities and resources to help me improve students' flipped learning.	0	1	3	3	3	A	A
Q16: The university provides tutoring or coaching resources for students' flipped learning.	1	2	2	4	1	N	A
Q17: I intend to continue to use flipped teaching.	0	1	3	3	3	A	A
Q18: My intentions are to continue using flipped teaching rather than using only traditional teaching.	1	1	3	2	3	N	N
Q19: If I could, I would like to continue my use of flipped teaching.	0	0	3	3	4	A	SA
Q20: I think my students would be in favour of utilizing flipped teaching in their class.	0	1	3	4	2	A	A
Q21: I think my students would believe that flipped teaching could be a useful educational method in their class.	0	0	3	5	2	A	A
Q22: I think my students possess adequate technical skills to use flipped learning.	0	3	1	3	3	A	A

In order to evaluate the reception of the experience by the faculty, a methodology similar to that followed by the students, focused on the completion of a questionnaire, was used. The questions have been defined following the work done by [10]. The responses (10 in total) have been summarized in Table 2. In general, the reception to the experience has been good and pleasant (Q1 and Q2), although the lecturers are unsure about the recognition that they will receive (Q7 and Q8) and they strongly

agree that completing the flipped teaching task is time-consuming (Q11). On the other hand, the resources provided by the university have been identified as adequate to carry out the experience (Q13 and Q14) (see Figure 2). Overall, lecturers are favourable to continue using this methodology (Q19).

5 CONCLUSIONS AND FUTURE WORK

In this paper we present the results of an inverted classroom experience carried out in the computer engineering degree. The motivation for this experience is based on the one hand on the change of information consumption habits of the new generations as well as the opportunity identified by the faculty to evolve methodologically as a result of what was experienced during the emergency teaching of the course 2019-2020 derived by the pandemic.

It is a scaled experience that has involved in the first semester of the academic year 2020-2021 six subjects of the first three years of the computer science degree, that is to say, 10 teachers and 253 students. During this experience, 164 videos were created and 38 questionnaires were designed.

For the evaluation, two surveys have been carried out to students and teachers. From the student survey we can conclude that in line with other similar works, student motivation is increased with the use of this inverted classroom methodology. On the part of the teaching staff, it is noted that the effort made by the teachers is high although it is considered necessary (probably after what was experienced in the previous course). Based on these preliminary results, we encourage the teaching community in the field of computer engineering to adopt the methodology.

In the future, we are interested in repeating the experience in the second semester. The aim would be including in the initiative another six subjects and a survey data corresponding to the second semester will be collected and an assessment of the impact of the activity on the academic performance of the students can be made.

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