Supporting Intensive Continuous Assessment with BeA in a Flipped Classroom Experience

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ABSTRACT This paper presents the changes performed in a university course to adopt European Higher Education Area principles taking advantage of new technologies and educational approaches. Particularly, a Flipped Classroom model that also involves an Intensive Continuous Assessment approach is adopted, moving the presentation of theoretical contents to videos that can be watched outside of the classroom and using the classroom face-to-face time to provide explanations, problem solving and to perform assessment activities every week. A main part of innovation in the experience comes from the use of an online tool (BeA – Blended e-Assessment) that facilitates the assessment and reviewing of paper-based exams. This tool supports teachers in assessment tasks, that can be performed in a faster, simpler, more transparent and less error-prone way. The paper shows the results of an experience involving a control group and an experimentation group, in which this new approach and tool have been applied. The results obtained demonstrate the effectiveness of both proposals. In conjunction, the paper describes how a traditional university course based on lectures can be successfully adapted to a more innovative approach based on the principles of active learning and accountability thanks to the use of our blended e-Assessment tool.

INDEX TERMS Flipped Classroom, Continuous Assessment, Assessment Tools, Web Based Systems
I. INTRODUCTION
The European Higher Education Area (EHEA) and Bologna process have promoted and introduced many changes in the way higher education institutions develop their teaching and learning activities. The EHEA involves some key elements in order to facilitate mobility among European countries, such as the Framework for Qualifications, a common credit system (ECTS: European Credit Transfer System), the Diploma Supplement, etc. The ECTS concept is particularly interesting, as it proposes a Student-Centered Learning approach that promotes active learning, responsibility and accountability on the part of the student. In addition, this concept demands a reflexive approach to the teaching and learning process on the part of the teacher. Particularly, the learning outcomes and the estimation of the learner’s workload are required to be considered in curriculum design. A key idea is that by allocating credits to educational components, flexible learning pathways can be created, helping institutions shift the emphasis from traditional teacher-centered approaches to approaches that take learner’s needs and expectations into account. For the last 10 years, academic institutions and teachers all over Europe have been trying to translate these ideas into practice, exploring different approaches and tools.

At the same time, during these years, we have witnessed the development of new concepts and innovations in education. This innovation wave is promoted by three main reasons: learning needs are different, learners are different and technologies are different. Focusing on the technological front, information and communication technologies provide new possibilities not available 10 years ago. Mobile devices and cloud solutions have become mainstream. As a well-known example, MOOCs have been developed during these years as video-based platforms that take advantage of cloud technologies to allow large number of students to participate in courses. In addition to technology, teaching methods and approaches have also changed during these years. At this point, we can find new concepts such as flipped classroom or gamification. All these concepts were not present 10 years ago, but they have been extensively explored during this time and are taken into account to perform changes in higher education.

In this context of continuous innovation and education reform, we as higher education professors have also been exploring changes that can be introduced to improve our students’ learning. In our case, we first observed that the changes required by EHEA might involve more workload from the teacher side, particularly during assessment tasks. We are required to be more aware of our student progress, taking a more responsible and accountable approach. Then, considering the new concepts and capabilities provided by new technologies, we decided to explore an approach based on flipped classroom and on intensive continuous assessment supported by a specific tool. This tool is BeA (Blended e-Assessment), a web application that enables us to perform written exams in classrooms, in a traditional way, but to assess and review them online.

In this paper, we show how we have adapted our teaching in a Computers Architecture course to the EHEA principles supported by this tool, including the results obtained taking into account academic performance and students’ satisfaction. This process has involved the introduction of exercises in the subject organization, resources provided to the students, and assessment activities.

The structure of the rest of the paper is as follows. Next section is dedicated to the related work. Section III introduces the Computers Architecture subject, describing the traditional teaching method and the new flipped classroom one. Section IV talks about paper exams and the issues and concerns derived from their use in an intensive continuous assessment scenario. Section V focuses on our tool for Blended e-Assessment (BeA) that supports our experience. The experience, including the methodology, results, and discussion, is addressed in section VI. Finally, the conclusions and future lines are presented in section VII.

II. RELATED WORK
The objective of this section is to present works that are related to the two main methodologies used in the aforementioned course: “flipped classroom” and “intense continuous assessment”. Throughout this paper, “intense continuous assessment” will be referred to as the summative assessment process in which assessment exercises are carried out at least once every two weeks. The key of this intensive continuous assessment is twofold: (i) as we have just mentioned, the exercises carried out for the continuous assessment must be done at least biweekly throughout the entire course, which implies a considerable number of tasks; and (ii) all these exercises must have a summative character, that is, they count significantly towards the final grade of the course (as we can see below). Despite the multiple searches carried out, it has not been possible to find any work that uses a combination of these two methodologies: “flipped classroom” and “intensive continuous assessment”.

As a result, the objective of this related work section moved to show, on one hand, the latest works related to flipped classroom (or flipped learning) and, on the other hand, works that make use of an intense continuous assessment approach.

According to [1], summative assessment is the one whose purpose is to sum up and make a judgment about student learning (assessment of learning) in contrast to formative assessment, for which the intention is to enhance learning (assessment for learning). This opinion is generally accepted [2]: summative assessment is any assessment that is included in the final grade and that is an assessment of learning, often linked to certification, progress and accountability, while formative assessment is any assessment for learning, and is not included in the final grade classification.

Therefore, we consider:
• Formative assessment: The evaluation is done mainly with the objective of knowing how the student is doing in his/her learning process. For this, several "exercises" are usually proposed (jobs, presentations, practices, different types of exams, etc.). Its main characteristic is that they either do not count for the final grade, or they count a very small amount (i.e. the total grade of all the formative assessment exercises would comprise at most 10% of the final grade of the course).

• Summative assessment: The assessment is done mainly with the objective of grading the student to know what he/she knows about the subject (and if it is enough to pass the course). It is usually associated with a final exam, but not always (continuous summative assessment).

Both formative assessment and summative assessment involve the development of a continuous assessment activity. According to the Cambridge Dictionary (http://dictionary.cambridge.org/dictionary/english/continuous-assessment), continuous assessment can be defined as “the system in which the quality of a student's work is judged by various pieces of work during a course and not by one final exam”. That is, continuous assessment can be considered as one that involves more than one final exam. With one further examination in addition to the end final exam it would be enough, but normally more than two assessment acts are considered. Any continuous assessment can be considered (at least in part) as formative, since it allows both the student and the teacher to know how he/she is doing in the subject and take action if necessary. However, if we take into account that the grades of these intermediate exercises have a relatively important weight in the final grade, then we could say that the continuous assessment summative in this case, that is, we would actually be talking about continuous summative assessment (being this the case of the subject we are dealing with in this paper).

In the current literature, there are not many works about the development of continuous summative assessment experiences. Next, we present the works found in the literature, restricting the search to documents where assessment exercises are performed at least once every two weeks (which, as will be seen below, are scarce).

The research presented in [3] examines the effect of two testing strategies on academic achievement and summative evaluations in an introductory statistics course, using one of them a biweekly exam format. Over the course of the 16-week semester, six exams were performed after the 2nd, 4th, 6th, 8th, 10th, and 12th week of material respectively. The final course grade is comprised entirely of the six biweekly exams (60%) and a cumulative final exam (40%).

In [4] an audience response system is used to deliver daily quizzes in lieu of exams to students in a course on cell and molecular biology for engineers. Quizzes were performed daily during the first 15 minutes of the 75-minute class session. Each quiz covered material from the previous two lectures, ideally encouraging students to study each lecture twice. This amounted to 24 individual quizzes that accounted for 50% of their class grade. The lowest two quiz scores were dropped.

The authors of [5] have developed a first-year fluids course for a class of around 230 aerospace, civil and mechanical engineering students. The continuous assessment was summative in nature and involved a 10-minute test at the end of weekly one-hour tutoring sessions (for 9 weeks). Each test contained five questions related to key learning outcomes in the previous week’s lecture material. The marks from all nine tests counted towards 20% of the overall mark for the course. It was a condition for passing the course that a student must pass at least six of the nine tests.

In [6] a study which uses low-stakes, continuous, weekly summative e-assessment is presented. This assessment consists of weekly online tests taken in a virtual learning environment in the students’ own time, each worth 1% of the assignment grade.

Finally, the most recent study [7], addresses a project that started with three summative quizzes delivered throughout a semester, comprising 30% of the final course grade. Later (the next academic year) those three quizzes were replaced with low weighted, weekly summative quizzes (for 10 weeks), which comprised 10% of the final course grade.

Once the papers concerning to intensive continuous assessment were addressed, we focus on the works related to flipped classroom (especially those presented in the recent last years).

In 2012, two professors, Jonathan Bergman and Aaron Sum, published a book titled “Flip Your Classroom: Reach Every Student in Every Class Every Day” [8], in which they explained their experiences applying this new method of learning, i.e. flipped learning. That same year, these two professors created the non-profit organization Flipped Learning Network (FLN) [9], whose objective is to offer a place to meet, collaborate, and disseminate everything relevant to flipped learning. According to FLN, “Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter.” [10]

In flipped classroom the core idea is just to flip the common instructional approach, where the instruction that used to occur in the lecture room is now available at home (with videos and interactive lessons), in advance of actual lectures. Therefore, the lecture room becomes the place to work through problems, advance concepts, and engage in collaborative learning [11].

At present, we can find in the literature a large number of contributions related to Flipped Learning (FL) or Flipped Classroom (FC). So, as we said before, we will try to focus...
on some relevant ones along the history of this methodology and the latest ones to see the evolution of the flipped methodology.

Authors of [12] present an interesting report comparing the effectiveness of FL with respect to traditional methods over three areas: (i) content coverage; (ii) student performance on traditional quizzes and exam problems; and (iii) student observations and perception of the FL format.

In [13], the challenges, definition, characteristics, and learning objectives of FL are introduced. Besides, a model of “seamless flipped learning” is proposed. This model integrates the features of mobile and wireless communication technologies into the FL model. The objective is to provide a guide for researchers and educators to develop effective FL activities and plans for helping students learn seamlessly across contexts.

There are some relevant studies focusing the perceptions, difficulties, preferences, workload, and perspectives of students participating in experiences based on flipped learning. Surveys [14] (563 undergraduate and postgraduate students and 10 conveners participating in flipped teaching) and [15] (84 undergraduate students) gather the survey respondents’ perspectives regarding flipped classroom and investigate their readiness levels for flipped learning. The study presented in [16] analyzes perceptions and difficulties in applying flipped learning with an interview method grounded on understanding and experience in science lectures. The work in [17] assesses the impact of flipped instruction on students’ out-of-class study time, exam performance, preference, motivation, and perceptions.

The paper [18] is a report on the findings of a two-year funded project conducted on the impact of adopting a flipped classroom approach on first-year undergraduate engineering students’ learning in a New Zealand university. Information was collected through student achievement data, surveys, focus group interviews, observations, and video analytics of student video-watching behavior.

We can also find several works comparing the flipped learning approach with other more traditional ones. A study that addresses lecturers’ and students’ perception and their achievements in traditional classroom and flipped classroom is conducted in [19]. Authors of [20] constructed a sequential procedure of pre-class, during-class, and after-class steps of a flipped classroom teaching model, carrying on a contrastive experiment between the flipped classroom and the traditional teaching. The study in [21] examines the differential impact of studying in a Flipped Classroom setting, as compared to a Blended Learning, a Traditional Learning, and an E-Learning setting on learning performance, self-efficacy beliefs, intrinsic motivation, and perceived flexibility. A research study is presented in [22], which follows a between-subject design strategy and attempts to identify whether a departure from a direct instructional teaching strategy towards a flipped learning pedagogy results in increases in student performance over time.

Two studies address the impact of the flipped classroom teaching strategy. In the first one [23], focused in college level technology courses, a within-subjects experiment design approach is used to assess self-efficacy and perception based on learning style preferences. The second study [24] focuses on student learning outcomes in relation to a set of moderating variables including student levels, publication types, study durations, and subject area.

Finally, there are three interesting reviews describing the current state of the flipped learning approach. The objective of [25] is to describe the current state of knowledge and practice in the flipped learning approach in engineering education and to provide guidance for practitioners by critically appraising and summarizing existing research. Articles published between 2000 and 2015 were reviewed, and 62 articles were included for a detailed analysis and synthesis. [26] summarizes the findings and guide future studies related to flipped classroom. Thirty-seven peer-reviewed articles were collected from a systematic literature search and they were analyzed based on a categorization of their main elements. The study in [27] presents a large-scale systematic review of the literature on the flipped classroom, with the goals of examining its reported advantages and challenges for both students and instructors, and to note potentially useful areas of future research on the flipped model's in and out-of-class activities. The full range of Social Sciences Citation Indexed journals was surveyed through the Web of Science site, and a total of 71 research articles were selected for the review.

We can conclude that the flipped classroom methodology is being used more and more, and that there are few works focused on an intense continuous assessment, understood as the performance of weekly exercises (or every two weeks) in which the grades obtained have an important weight in the final grade of a subject. In addition, and specifically for the purposes of this paper, no works have been found that, as in our case with Computers Architecture, describe the simultaneous use both methodologies.

III. THE SUBJECT

A. OUTCOMES AND CONTENTS

The course “Informatics: Computer Architecture” belongs to the first year of the degree in Telecommunication Technologies Engineering taught at the Telecommunication Engineering School at the University of Vigo, Spain.

This course has a profile of basic training for students, which means they will:

- Understand the fundamentals of the techniques needed to use and acquire intellectual habits of scientific reasoning and learning.

- Acquire a fundamental understanding of the technologies of the course (this training should be basic and general).

The common learning outcomes in this type of course are the following:
• Acquiring knowledge of the main concepts related to computer architecture and capacity for its management through models.
• Ability to manage systems representing information used in computers.
• Knowledge of the most representative types of instructions, the most important instructions, and the ability to determine the implications of its use as programmers of conventional machines.
• Knowledge of the main addressing modes in assembly language and ability for efficient management of them.
• Acquisition of skills on algorithm design and construction of programs at conventional machine.
• Knowledge of the principles and fundamental components of Operating Systems (OS) and Databases (DB).

According to this, the general scheme of the course is shown in Table I.

The course is arranged according to the European Higher Education Area (EHEA) comprising 6 ECTS (European Credit Transfer and Accumulation System), 3 for the theoretical part (usually assigned to type A Bologna classes) and 3 for the practical part (usually assigned to type B Bologna classes). The ECTS measures the hours of work for a student, that is, the hours of teaching, of theoretical and practical sessions, of study, of attending to seminars, of works, practices and the hours dedicated to exams and evaluation tests. Usually each ECTS has an equivalence of 25 to 30 hours. In the University of Vigo, it is equivalent to 25 hours. The lectures are delivered during the course of 14 weeks, corresponding to the first term of the freshman year. As in any other educational situation, the classroom hours are exactly measured and established, but the hours of the student outside of the classroom are estimated. However, considering that classroom attendance is not mandatory, classroom hours could be seen as estimated as well.

B. THE TRADITIONAL METHOD
The 3 ECTS of the theoretical part in the traditional method, that we call Traditional Classroom (TC) in analogy with FC, are distributed in 28 hours of face-to-face sessions (2 hours each week) and in 47 hours of work outside the classroom. During the first week of the term, double sessions are administered (4 hours this first week). These sessions are used to explain the teaching methods of the subject and to provide the theoretical knowledge needed to begin the practical sessions the following week in the lab rooms. In this case, the assessment is done through a continuous assessment methodology, by carrying out two mid-term exams along the course, in two theoretical sessions. The 3 ECTS of the practical part are distributed in 26 hours of face-to-face sessions (laboratory in this case) and 49 hours outside the classroom. During these practical hours the students must perform a series of practical programming tasks using assembly language every week, demonstrating the

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acquisition of the theoretical knowledge provided in the theoretical sessions. In this case, the assessment is also done through a continuous assessment methodology by carrying out three practical exercises along the course. Two of these exercises are performed during the practical sessions, and the third one is performed in the day reserved for the final exam. All the students not following continuous assessment can do a complete final exam instead, involving both theory and practice.

C. THE NEW METHOD

In the flipped classroom mode used in the theoretical part, the first week is carried out as in the traditional method. During such first week, the teacher introduces the FC method and divides students into groups to follow the FC along the rest of the term. The proposed FC methodology involves the reduction of the 2 hours of face-to-face classroom per week to just 1 hour. In the other hour, students need to watch the videos where theoretical concepts are presented and explained. The weekly face-to-face hour is used to perform tasks of the FC methodology (they will be described next) and an assessment task (according to the intense continuous assessment). In this way, the proposed methodology is not strictly a pure FC, because the 2 classroom hours are not interchanged to be performed at home. Instead, just 1 hour is interchanged and the other hour is used to perform support activities (e.g. problem solving, clarification of doubts) and assessment tasks.

At this point, it is worth mentioning that according to EHEA students should devote 1.5 hours of out of the classroom work for each hour of classroom work. Nevertheless, in previous courses we observed that this rule is not true for most of our students, because they usually invest less time in out-of-the-classroom activities. This way, when flipping the classroom, it makes sense not to change hours outside of the classroom with hours inside the classroom directly, because this will imply an increase of work for the students that follow the FC approach. The proposed arrangement of reducing the number of face-to-face hours to just 1 per week and the provision of videos to be watched by students in another hour per week outside the classroom has worked well. Of course, the students will need to spend more time of study and work outside the classroom to review, reflect and do other activities in order to understand the concepts and reinforce learning. Finally, the number of hours to be invested is the same, but the face-to-face classroom hours are not used for lectures, but to provide support and perform assessments.

Therefore, with the FC implementation, students now have 1 face-to-face hour and 1 hour to see videos outside the classroom, but the workload for the student is maintained. However, the workload of the teacher is reduced, since it goes from 2 hours per week of face-to-face class to only 1 hour. At this point, we did another change in the classroom sessions, in such a way that the teachers still have 2 hours of face-to-face session per week, but with a significant advantage. This change implies the split of a group of students into two, in such a way that each subgroup has 1 hour per week in the classroom, and thus teachers continue having 2 hours per week. The benefit we get from this change is having less students (half of them in particular) in each face-to-face session, with the benefits that it brings [28] (for example, in terms of personalized attention that can be provided to students), and thus avoiding the problems associated with classes with a larger number of students [29].

Another one of the benefits that appears with the application of these new methodologies is related to the feedback provided by the students. On the one hand, we have the feedback associated with the FC model itself, and the use of face-to-face time with students dedicated to solve doubts that they may have after watching the videos. Through these questions that students raise in class we can extract at least two types of feedback, such as: (i) the one related to the students’ knowledge about the subject they should learn; and (ii) the one related to the videos themselves, and their suitability transmitting correctly the corresponding knowledge. On the other hand, we also have the feedback provided by the Intensive Continuous Assessment. This type of feedback is usually associated with formative assessment, but in this case, it is provided by summative assessment. At this point, it must be taken into account that a summative assessment of this type, carried out in a traditional way by means of paper exams (by means of all types of questions: multi-choice test, short response, and open response) usually involves an arduous load of work that could turn out to be unfeasible to assume on the part of the teacher. However, in our case, this workload is largely mitigated by the use of our Blended e-Assessment (BeA) tool [30, 31], which makes it possible to carry out this type of assessment with minimal cost (both at the time of preparing the exams, and in its delivering, grading, and subsequent reviewing by students).

The knowledge acquired through the theoretical hours has one fundamental characteristic in its cumulative nature. This means that all the contents are strongly related and depend on previous ones, in such a way that the knowledge that is provided as the course advances is essential to be able to continue progressing in it. This is something that is especially convenient, as we will see later, when applying the intensive summative assessment.

IV. PAPER EXAMS

Nowadays in Spain (and especially in our University) it is common to use handwritten examinations that students must answer using pen and paper to avoid known problems (student identification, cheating) related to online examinations.

Some of the immediate benefits that we can highlight from written exams versus online ones are the following:

- Greater flexibility regarding the type of questions that the teacher can include in the exam. In a written exam, there are no restrictions on the types of questions and/or exercises that the teacher decides to include in the exam.
- Greater comfort and ease on the part of the students when answering the different questions of the exam. Students are very used to doing written exams and do not need to learn how a new tool works facing the exam.
• Less chance of failures during the exam and easy solution in case they occur. Performing an online exam always brings about the possible failure of infrastructures: equipment and network failures (both electrical and data), with difficult or impossible solution.

• There is no need for spaces dedicated explicitly for exams (just the typical classroom). In the majority of the cases, the performance of exams on electronic devices requires the use of computer rooms to carry them out. This implies a greater space than a traditional classroom, which in the case of an exam with a high number of students would involve the use of a greater number of classrooms. This causes two major problems: (i) there may not be enough rooms available to accommodate all the students, which would require several shifts (with the possibility of having to perform different exams for each shift to avoid cheating); and (ii) a greater number of teachers would be needed to attend the exam.

• The possibility of cheating is minimized more easily. When doing the exam on a computer, the possibility of cheating among students can be increased, for example, because it is easier to see the screens of near students, or having access to the Internet, it is possible to make inquiries on the web. Trying to minimize this effect supposes an extra effort when preparing the exam (even greater in the case of open-questions exams).

However, it is assessing these exams when the teacher is involved in a cumbersome process that consumes a large amount of time. These problems are worsened when the number of students who take the exam and the number of assessment activities is high.

Some of the problems that teachers usually find during the process of assessing written exams are the following:

• The storage of the exams. It is possible to misplace some of them when being assessed. So, this assessing must be done in the place where they are stored, usually the office of one or more professors. In addition, it is necessary to take into account the distribution of questions of the exam for assessing by the corresponding teacher (in case more than one teacher participates in the exam). This is something that can be troublesome if the exam sheets are stapled, or there are several questions (belonging to different teachers) on the same sheet.

• Same errors. Continuously finding repeated errors in the different student exams makes the assessment process tedious by having to highlight, explain, and rate the same mistakes over and over again.

• Equity in the scoring of exams. It is a topic to consider, since after assessing a certain number of exams it can happen that the professor does not penalize similar errors in the same way. It is frequent, therefore, that the teacher has to go back consulting previous exams to remember how he scored certain questions with specific types of errors.

In addition, there is the review process of the exams that the teacher has assessed. This implies having to stay at a certain place and date to carry out such a review, in which all the teachers involved must be present together with the students who wish to review their exam. It is worth highlighting the importance of this review process, mainly from a formative point of view, because students can check their mistakes and ask for explanations.

BeA (see next section for more information) provides solutions to all these problems, and even offers other features that make these tasks very simple to carry out. Next, we will present some of the most relevant advantages of the use of our system:

• Online assessment of the exams. As the exams are scanned and uploaded to the platform, their assessment by teachers is done online, allowing this task to be done from any place with an Internet connection, and at any time.

• Several types of exam assessment are allowed. The exams can be assessed per student (the entire exam of one student is assessed before moving on to the next) or per question (the same question is assessed for all exams before moving on to the next question).

• Simplified error handling. The system offers the possibility of defining errors (with its corresponding explanation and identical penalty on the score), which can be applied immediately when needed. In addition, these errors are exportable, to be used in the correction of future exams if necessary (saving us the work of having to redefine them).

• Fast distribution of students and exams in the classroom. Our system can print each exam in a personalized way for each student, with his/her name previously printed on it, and with the position that the student must occupy in classroom to take the exam. This also ensures that the distribution of students is random and dynamic for each exam (avoiding the formation of groups of like-minded students who are always close to each other).

• Dynamic reviews. The review of the assessed exams is also done online. Thus, students are able to review their exams anytime, anywhere. In addition, BeA has a message system associated with the assessment tool, which allows students and teachers to communicate through it to solve their doubts about the assessment.

• Transparency. Students can show their assessed exam to their classmates, and thus verify how the assessment has been done in an equitable way, assigning the same penalties to the same errors.

• Flexibility of exam questions: All types of exam questions are allowed. Since the exams are done in paper, and BeA was specifically developed for processing these traditional paper exams, the...
platform is able to work with absolutely all types of exam questions that can be asked in written form. This is a clear advantage over systems that only support test exams with the typical single/multi-choice questions, yes/no questions, etc. (for example: Moodle).

- Possibility of automatic assessment. In the case that the type of all the exam questions is multiple choice, BeA offers the possibility of assessing them automatically without teacher intervention.

All these features allow the assessment process to be carried out quickly and efficiently. The time consumed in the process is drastically reduced, from the moment in which the exams are distributed for their performance in the classroom to the moment in which the exams are assessed and the grades are made available to students.

The support provided by BeA is fundamental, and this is what has allowed us to carry out the experience of applying an intense continuous assessment in an adequate and uncomplicated manner.

V. BeA (BLENDED-E-ASSESSMENT) TOOL

Technically speaking, BeA (Blended e-Assessment) [30, 31] is a Java-based web application. It uses MySQL for data management, and HTML, JSP, JavaScript and JQuery are used in combination as front-end technologies. At the core of the application, Apache Struts is used so that the implementation could be performed following a Model-View-Controller design pattern. The web application runs on an Apache TomEE server, an extension of Tomcat with additional Java EE functionlity.

We can say that BeA is an e-assessment solution that supports both teachers assessing and students accessing and reviewing their assessments online, anytime and anywhere. Students perform their exams in paper, but the assessment made by teachers, the reporting of results to students and the review of the assessment by students is performed online using scanned copies of the papers (Fig. 1). But BeA is much more than that, as we can see in the present section.

The typical process to perform assessments with BeA is described by the following steps [31]:

1. The exam can be created using any text editor. There are certain rules related to the margins of the document to be observed. In the header of the paper, a 5 cm. margin is needed to include some info to identify the exam, the page number and the student. This info can be included as a QR code to facilitate the automatic identification by BeA. Questions in the same paper need to be separated by 1 cm. to avoid possible scanning mistakes. In addition, each question should include some empty space where the student is going to provide the answer. Once the exam is edited according to the previous rules, a PDF has to be generated. Such PDF file can be uploaded to BeA, where the identification data to be included in the header can be added to every page of the exam automatically. The header (Fig. 2) can include the following elements: (i) a QR code for identifying the specific page of the exam (located on its left side); (ii) several fields with the data of the student and (iii) on the right side, an identifying QR code of the specific student. There are other options for the header: it can include just the QR code of the exam with no student identifier, so the student should write by hand his/her name as in traditional exams (no automatic identification is performed in this case and the teacher has to identify students online during the assessment stage); or students can be provided with identifying QR stickers to be included in this empty space (in this case, automatic identification is possible). In addition, another option is to include a matrix of numbers where students can mark the ID number. This also enables automatic identification. Each one of these options has advantages and drawbacks, mainly depending on the number of students attending to the exam, but they can be easily managed on the platform.

2. After the previous stage, the professor can download a PDF with the exam and print it. Depending on the type of student identification used, this PDF could include just one piece of the exam for a generic student, or all the pieces of the exam for all the students, with each piece identifying each student.

3. The professor prints and delivers the exam on paper to the students in the classroom. Once the exam is finished, all the pages with the answers of the students are scanned, converted to PDF format, and uploaded to BeA for assessing.

4. Prior to proceeding with the assessment, the professor has to mark out the area occupied by each question/answer, and so, BeA is able to know the area that has to be assigned to every question. Additionally, at this point, the professor can upload
the solved exam and indicate the maximum mark of the questions. Therefore, after these steps and before the assessment, a student can gain access to both his/her answered exam and to the solved one.

5. Next, the professor can perform the assessment per-student or per-question. The per-student approach is as in the traditional paper-based assessment, taking all the answers provided by one student before going to the next one. In the per-question approach, BeA provides a view based on the questions instead of the students. This way, the professor can assess all the answers to one specific question at the same time. When he/she finishes the assessment of one question, he/she can move to the next one. BeA follows an atomistic assessment approach. Namely, initially all the answers are considered correct and the exam gets the maximum mark. As the teacher identifies errors, he/she adds penalties to the score. The teacher can re-use previous errors already identified and defined, or identify and define a new error. All the errors are included in a list of errors, defined with its specific penalty score and description. To re-use an error, the professor only needs to click with the left button of the mouse over the error. The penalty will be automatically applied and the identifier of the error shown over the student answer. Additionally, the professor can highlight the area of the exam that corresponds to the error and provide some specific explanation. Of course, all the exams are stored in BeA, and they are accessible through any web-enabled device. So, the assessment can be carried out from everywhere, and the professors do not have to take the paper exams wherever they go to assess them. Figure 3 is a screenshot of the BeA tool during the assessment of a question by the teacher. Three areas have been identified: the (A) area includes the wording of the exercise; the (B) area shows the right answer provided by the teacher; finally, the (C) area shows the answer of a student. The panel on the right shows the maximum score that is assigned to the exercise (1.0 in this case) and the possible errors that can be identified by the teachers. For example, Error (E-1) corresponds to a specific mistake in the exercise and its penalization is 1. Notice this error code has been assigned to the current student answer in the (C) area.

6. The preliminary grades are the sum of the scores in every single question. Although the professor has assessed by focusing on questions, when observing the preliminary grades, he/she has the option to see the full exam of a student with all the questions. At this point, it is possible to add the comments and adjustments considered. From our experience, it is very useful for the professor to have a global view of the student's exam, especially when the score is in the limits of passing the exam and making decisions in consequence. Once the exam is completely assessed, the professor can give access to the students to see their marks and results and advance to the reviewing stage.

7. In the reviewing stage, each student can see the assessment of his/her exam. Of course, identified errors, explanations and comments are shown. At this point, the student can maintain an asynchronous conversation with the professor using a bulletin board. Figure 4 shows a screenshot of BeA during the review of an exam. The figure shows two questions and the answers provided by the student. In the panel on the right side, a conversation between the student and the teacher is shown, as in any chat tool. In this way the student can ask for clarification to the teacher about his/her answer and the error marked by the teacher. Then, the teacher provides further explanations.

8. After the reviewing stage, the grades become permanent. BeA allows exporting the grades as a CSV file to facilitate the transfer to other tools, such as a student administration system.

9. Once the grades are permanent, the exams and assessments with all the generated information are saved. As the tool saves scanned exams and also their assessments and comments by the professor and the student, the exam can be reconstructed as the original one submitted by the student, or with the assessment scores and comments. A PDF file can be generated with all this information.

As a result of the acquired experience and lessons learned from using BeA during the last few years, three additional features have been recently added which make the implementation of intensive continuous assessment much easier and more manageable:

1. The ability to import a question’s assigned area. As seen earlier in step 4, one of the actions that must be performed is defining the scanning area for each question. If a question is similar to another one present in a previously configured exam, its scanning area can be copied over so that the teacher does not need to manually set it. If the exam as a whole is similar in structure to another exam, all of the questions’ areas can be imported at once. This speeds up the configuration of exams with similar layouts.

2. Importing error definitions from other exams. As it was explained in step 4, the teacher needs to define an error list for each question, with an associated penalty and description. This feature allows the teacher to import errors which have been defined in another exam. This way, errors can be reused without needing to define them again. As with the previous feature, there is an option to import the errors from all the questions of a previous exam if its structure is similar. This facilitates the task of assessing several similar exams.

3. Defining the distribution of students’ seats in the classroom (Fig. 5). BeA allows the signup of students for each exam, which can be done by either
the teacher or the students themselves. Once the list of signed-up students is known, they can be assigned seats in the classroom. BeA represents classrooms in a grid-like manner. The teacher can choose which rows and columns to use, or he/she can select seats manually. BeA then randomly distributes students in the selected seats. Once this is done and approved by the teacher, BeA can send an e-mail to each student, indicating his/her location in the classroom. This information can also be checked online in BeA at any point in time. Each time that a student distribution is requested, BeA randomly generates it. However, there is the possibility of importing a previous exam’s student distribution. This feature saves setup time before the exam starts, since the students know exactly where to sit before they enter the classroom. This information is also known by the teachers, who can preemptively print the exams with the students’ personal information already in them. Each exam can then be easily placed in the corresponding student’s seat. This feature also minimizes the risk of cheating via collaboration, as
random layouts minimize the risk of students sitting near close friends or colleagues, and their seats can be made public at whichever time the teacher wants.

To finish, we would like to comment that BeA has been in use since the course 2009/2010 in the Computer Architecture subject. Along these years, the tool has been subject of several changes and improvements, but the basic functionality of online assessment has always been available. Every year, at the end of the term, students have been surveyed about their preferences related to the assessment with BeA or with the paper-based traditional method. The answers have been clearly positive, as it can be seen in Figure 6.

VI. THE EXPERIENCE
A. METHODOLOGY
The experience described in this paper was carried out during the 2016/2017 academic year, through an experimental group and a control group. After observing positive results, the methodologies were applied once again during the 2017/2018 academic year.

Usually, within a specific cohort, students are divided into several groups by the engineering school’s administration, following an alphabetic ordering criterion. In this case, three theory groups were defined. In the 2016/2017 academic year, the first of these groups was set to be the experimental group, where the flipped classroom system (FC) would be implemented, and the remaining two groups were set as control groups, implementing a traditional teaching approach (TC). In the next 2017/2018 academic year, the three groups were converted to the FC system.

As previously described, during the first week of classroom sessions, every group attended four one-hour long lecture sessions. These sessions’ contents included the description of teaching and evaluation methods used in the subject, as well as basic theoretical content necessary for laboratory sessions, which began the following week. For the experimental group, two sub-groups of students were defined so that flipped classroom sessions could be imparted starting the second week of the course. As explained earlier, having a reduced number of students can be advantageous, and more beneficial for their learning.

Weekly lectures were imparted throughout the 12 following weeks, adhering to either the FC or the TC method.

In the TC groups, lectures consisted in the explanation of theoretical contents, as well as examples, exercises and problems. Students were assessed in either two midterm exams or a single one at the end of the course.

In the experimental group (2016/2017) and all the groups in 2017/2018, the flipped classroom system was implemented. Each week students needed to spend an hour outside of the classroom watching the videos that covered the contents of that specific week. The remaining hour was spent in the classroom. In this case, assessment is performed via short exercises, lasting 10 to 15 minutes, performed in each one of the in-classroom sessions, for a total of 12 assessment tasks.

Around 100 videos were made available to students in order to cover the theoretical contents of the 12 FC sessions, as well as some practical exercises. Previous experience and feedback on class recording were essential for producing the videos. Each one usually had a duration of 10 minutes, with a few longer exceptions.

The applied recording methods were as follows [33]:
- (T&B) Teacher writing on a blackboard, with the focus on both teacher and blackboard alike
- (SC) Teacher using a screen (screen capture from a computer, tablet, etc.), where the teacher does not appear in scene.
- (T&B&SC) Mixing of previous options (T&B and SC).
- (CR) Actual classroom recording.
In classroom sessions, students may ask questions about the content, the most common mistakes in the last continuous assessment exam are pointed out, the most important ideas displayed in the videos are highlighted, and exercises can be proposed for the students to solve individually or in groups. At the end of the session, an intensive continuous assessment exam is performed, typically lasting between 10 and 15 minutes. This small exam covers contents corresponding to the present week and last week’s videos. As it can be seen, these activities require an efficient use of classroom time. The use of BeA greatly helps in optimizing assessment time.

The acquired experience throughout last years has allowed us to minimize the time it takes to do specific tasks, such as exam setup, result analysis, presenting assessed exams to students and the review of exams. For the latter, an online communication channel between students and teachers is available within BeA, avoiding the need of face-to-face reviews at the teacher’s office.

The distribution of students in the classroom by BeA achieves two basic objectives: (i) on the one hand, students do not choose where they sit, likely among friends and close colleagues, and (ii) on the other hand, this distribution makes exam setup quicker and more efficient.

The random distribution minimizes the risk of cheating in exams, since students are placed in random seats, which they are notified via an e-mail sent by BeA before the session starts. The exact timing is specified by the teacher, who can choose it to be hours, days or even mere minutes before the start of the session. On top of preventing cheating, this allows the formation of random teams for group-based problem solving activities during the in-classroom sessions.

In addition, this kind of distribution allows the printing of exams with students’ identifying data already on them. Additionally, they are sorted depending on their seat in the classroom. This speeds up the time it takes for students to find their assigned seat and it saves them having to fill in their names and other identifying information. Exam processing by BeA is also more effective, since QR codes that identify students are pre-printed instead of added on through a sticker [31], which greatly reduces the chance of errors occurring during scanning.

Once the exam has been performed, the answer sheets are scanned and sent to BeA. This task can be performed by the teacher or an assistant. Once scanned and uploaded to BeA, the teacher can assess the exams using his/her computer, anywhere and at any time, since he/she can access them through the Internet. Once assessed, the exams are made public to students, who can see their grade and errors, and a review period starts. Students can access this information through the Internet, and if they do not agree with any of the errors that were assigned to them, they can communicate with the teacher thanks to the review feature, without the need of going to his/her office in person. This greatly shortens revision tasks, since they are not required to be performed in the presence of the teacher and with printed exams at hand.

These BeA features allowed short exams in intensive continuous assessment to be done in 10 to 15 minutes, which are almost entirely dedicated to the task itself instead of setup. Without BeA, it would be rather difficult to apply an intensive continuous assessment system with printed exams.

**B. RESULTS**

As results of this experience, we have focused on the following aspects, differentiating the FC students and TC students in 2016/17 academic year:

1. Students’ attendance during the course (retention): percentage of students who attended the last session out of the students who attended the first session (see table II).
2. Students’ passing grade percentages for the theoretical part (see table II).
3. Students’ opinion about this new method (table III), focused on the intensive continuous assessment and the flipped classroom.
4. Students’ opinion about the most useful format of videos (fig. 7) and the devices where they prefer to watch them (fig. 8).
5. Students’ general opinion about video length, format and clarity (see table IV).

Table II shows the subject’s passing grade percentages for academic years 2013/2014 through 2017/2018 for the theoretical part. Additionally, statistics for students who regularly attend classroom sessions are presented separately. For the 2016/2017 academic year, data for the experimental (FC) and control (TC) groups are also individually displayed. These data were obtained from the academic records of these courses and represent aspects 1 and 2 in the previous list.

Tables III, IV and figures 7 and 8 show the opinion of the students on the aforementioned aspects (3, 4 and 5). They were obtained from surveys.

**C. DISCUSSION**

It can be seen in table II that the TC lectures had an average attendance of 50 to 60 students per group, although this number tends to drop as the course advances. Moreover,
the decrease in attendance during the academic year 2016/17 seemed to be more accentuated than in previous years, most likely due to the availability of the FC videos.

The average attendance for the FC sub-groups during the first week of the course (2016/2017) was 57 students, as opposed to 50 in the case of the TC groups. In the next academic year, 2017/2018, the average attendance for each subgroup was 31 students, equivalent to 62 students per TC group (remember that a TC group is divided into two FC subgroups).

The attendance of the FC groups remains high throughout the course. It can be seen that retention of attendance in course 2016/17 is 84% in FC groups compared to 20% in traditional groups, although this 20% is very low compared to previous years and can be justified due to the influence of the videos, since the students were able to access videos of FC and this implied a low attendance to classes. However, in comparison with previous years, it can still be seen that the retention was significantly higher (the best result in previous year was 45% in course 2013/14).

Another good result in this year 2016/17 was the increase in the percentage of students who passed the theoretical part (61.4%), when the highest in previous years was 47.71%.

As stated earlier, the good results of the experimental group with respect to the control group in 2016/2017 academic year led us to apply the FC methodology to the next 2017/2018 one.

### TABLE III

<table>
<thead>
<tr>
<th></th>
<th>% Strongly Agree</th>
<th>% Slightly Agree</th>
<th>% Neutral</th>
<th>% Slightly Disagree</th>
<th>% Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/17 FC</td>
<td>70.97</td>
<td>9.68</td>
<td>12.90</td>
<td>3.23</td>
<td>3.23</td>
</tr>
<tr>
<td>17/18</td>
<td>48.78</td>
<td>32.93</td>
<td>10.98</td>
<td>3.66</td>
<td>3.66</td>
</tr>
</tbody>
</table>

I consider that the structure of Intensive Continuous Assessment performed is better than other types of evaluation

I consider that having an exam every week forces me to take the subject up to date and I learn more

I think you could achieve the same objectives (take the subject up to date and learn) with an exam every two weeks

I believe that the methodology of Flipped Classroom should also be taken to other subjects

### TABLE IV

<table>
<thead>
<tr>
<th></th>
<th>% Strongly Agree</th>
<th>% Slightly Agree</th>
<th>% Neutral</th>
<th>% Slightly Disagree</th>
<th>% Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/17 FC</td>
<td>45.2</td>
<td>29</td>
<td>12.90</td>
<td>3.2</td>
<td>9.7</td>
</tr>
<tr>
<td>17/18</td>
<td>28.1</td>
<td>25.6</td>
<td>31.7</td>
<td>7.3</td>
<td>7.3</td>
</tr>
</tbody>
</table>

I believe that the format of the videos are the appropriate

I think that the contents of videos are easily understood

I think that the videos are...

<table>
<thead>
<tr>
<th></th>
<th>% Too Short</th>
<th>% Slightly Short</th>
<th>% Appropriate</th>
<th>% Slightly Long</th>
<th>% Too long</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/17 FC</td>
<td>0</td>
<td>0</td>
<td>64.5</td>
<td>29</td>
<td>6.5</td>
</tr>
<tr>
<td>17/18</td>
<td>0</td>
<td>4.9</td>
<td>58.5</td>
<td>30.5</td>
<td>6.1</td>
</tr>
</tbody>
</table>

FIGURE 7. The most useful formats of videos for students.

FIGURE 8. Devices preferred by students to watch the videos.
Therefore, in the following course 2017/18 the FC was applied to all groups and the results ratified what was pointed out by the experimental group of the 2016/17 course: a retention of students greater than with the traditional method (78% vs. 45% as the best figure in the traditional method), and the number of approved students in theoretical part was also better than in the courses with TC (56.44% compared to 47.71% as the best figure in TC).

We want to emphasize that the retention achieved is high, which makes students engage with the subject, keep the subject up to date, and therefore they can learn better. This was verified later when students were asked for their opinion on this methodology that is showed in table III. In this sense, it can be seen that the majority of students (96.77% in course 2016/17 and 86.58% in course 2017/18) agree with the opinion of "having an exam every week forces students to take the subject up to date and the students learn more". Similar results are obtained when asked if the same objectives could be achieved with an exam every two weeks instead of only every one-week, so we should study this possibility for future courses.

It is also noteworthy that more than 90% of students (93.54% in 2016/17 and 92.68 in 2017/18) prefer the intensive continuous assessment over other evaluation methods, and that a large majority (87.10% in 2016/17 and 74.59% in the 2017/18) believe that the Flipped Classroom methodology should be applied to other subjects.

The opinion of the students about the preferred format of videos and also about the preferred device they use to view the videos is shown in figures 5 and 6, respectively (in both figures, the students could give more than one answer). It is noteworthy that the preferred video format is the T&B&SC followed by the T&B, and the preferred device to watch the videos is the computer.

Table IV displays the students’ general opinion on video length, format and clarity. As it can be seen, the opinion about the understandability and format of the videos is clearly positive, and only about one third of the students consider the videos are either slightly or too long.

VII. CONCLUSION AND FUTURE LINES

During the last years, University education has been required to change in many different ways. This demand comes from different sources, such as the capabilities offered by new information and communication technologies, from the learning goals focused on competence development instead of knowledge acquisition and also from the students themselves, as millennials that are used to acquire information in small chunks through the performance of short activities and without a high resistance to frustration. New educational methods and approaches are also proposed to deal with some of these changes. The challenge is how to take advantage of these innovations in order to improve university education.

The experience introduced in this paper shows an approach based on the adoption of a Flipped Classroom and an Intensive Continuous Assessment model. Both concepts could be adopted independently, but their combination has been proved successful. As it can be seen in the results shown, the number of students that passed the theoretical part of the course has significantly increased. In addition, the dropout rates have been reduced. Both results are very positive, but the most important thing is that our students have accepted this model as the better one.

A key piece for this successful history is BeA. This tool involves a functionality that is not available in well-known e-learning systems, such as Learning Management Systems (LMS). Existing assessment facilities usually involve the performance of online tasks by learners and automatic assessment without the need of the professor intervention. From our point of view, the performance of pen and paper exams has some intrinsic values for learning, at least in traditional face-to-face universities. In addition, the assessment provided by a teacher cannot be easily replaced by the assessment that can be performed by an automatic tool, mainly in a scenario where different exams have to be produced each year for the students and in complex subjects such as Computer Architecture. Therefore, in this context we decided to search for a solution that facilitates us to innovate, but maintaining the key assessment activities of the subject. BeA allows us to perform this work in a comfortable way, providing both teachers and learners the advantages of the new technologies. The results shown in this paper demonstrate that the presented method and tool are positive for student learning and performance.

The use of BeA as a supporting tool is not restricted to the use of the educational models described in this experience. It can also be applied to other pedagogical approaches, from traditional ones based in lectures and final exams to new proposals of blended learning involving the use of Open Educational Resources (OERs), interactions on educational networks, external participants and experts, etc. BeA could be used in other educational scenarios in order to facilitate the review and marking of written exercises in pen and paper. In fact, we have been experiencing the use of BeA in courses developed in accordance to a traditional model and in the future, we plan to take advantage of it in more innovative scenarios.

REFERENCES


