Received: 11 January 2018 | Accepted: 15 April 2018
DOI: 10.1002/cae.21979

SPECIAL ISSUE ARTICLE

WILEY

AIM-Mobile Learning Platform to enhance the teaching-learning process using smartphones

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Abstract

We developed the responsive environment AIM-Mobile Learning Platform, which permits to assess students using smartphones and to design online educational packets. We carried out a qualitative and quantitative study in Higher Education subjects using the case study and the triangulation data methods. Results demonstrated that the environment promotes a dynamic learning-teaching process inside class, increasing the motivation, participation, and attention of students and helping them to be more conscious of their self-learning process.

KEYWORDS

Bring-Your-Own-Device, learning platform, mobile learning, Responsive Learning Management Systems, smartphones

1 | INTRODUCTION

Mobile technologies have a strong presence and impact in our society, and consequently many experimental projects with mobile devices are arising in education, especially in Higher Education. M-learning (mobile learning) together with e-learning technologies are being applied in Education so that the learning process becomes more attractive for students and the teaching process much easier for teachers due to the integration and interaction with powerful educational software tools [9,31,51]. From the students' point of view mobile learning provides ubiquitous and unlimited access to information, portability, mobility, and flexibility [9,31,51]. In fact, the smartphones' potentiality in education is based on the students' higher motivation to continue their learning process outside schools and universities since they increasingly use their smartphones to access to educational resources from everywhere and at any time. Furthermore, m-learning gives students the chance of individuation of the learning process, since they can adapt their use according to their abilities and objectives. Finally, mobile technology permits students to move inside laboratories or classes without requiring computers at all locations. As a consequence, the term BYOD (Bring-Your-Own-Device), which refers to the use of personal devices (tablets, smartphones, laptops) in the workplace, is becoming a key point in many educational scenarios. Specifically, there are some educational activities for which students feel more confident with their personal smartphones, which becomes a strong point in the support for BYOD inside classes [19,40]. On the other hand, from the teachers' point of view m-learning and e-learning strategies allow to virtualize and automate certain tasks of the teaching process, such as the assessment of students [9,31,51]. In this way, teachers

immediately can send feedback to students regarding evaluable activities. In this line, virtual platforms permit to automatically collect and store a lot of data to follow the progress of students. Therefore, the integration and combination of virtual and traditional strategies creates a dynamic and attractive educational scenario.

In connection with it, Learning Management Systems (LMS) are becoming an essential support for these virtual and online methodologies since it helps to integrate e-learning and m-learning properties in an efficient way [39]. As a consequence, they are extensively used in Higher Education experiences. The integration of LMS software with mobile devices is evolving the communication between teachers and students, as this integration extends the connectivity and the relationship and it promotes social networking at everywhere and at any time [39]. Moreover, this integration is modifying the way to interact with learning resources and with some learning tasks regarding the evaluation of students since mobile LMS's allow a real-time access to educational contents and the students' data. In this new educational scenario Responsive Learning Management Systems, based on a responsive web design, are becoming crucial since they permit an easy viewing and interaction experience independently from the device (desktops, tablets, smartphones) chosen by students. Responsive LMS's encourage students to perform their day-a-day learning tasks using their personal smartphones [17]. Therefore, the design and implementation of sophisticated mobile LMS tools will improve the consolidation of mobile-supported educational services in Higher Education making easier to design courses and contents with e-learning and m-learning strategies.

As a consequence, we have developed a web-based virtual environment called AIM-Mobile Learning Platform. This virtual environment looks for a natural integration of mobile devices in the teaching-learning process to speed-up and to automate some tasks of the students' assessment. The platform allows real-time evaluation in which teachers send questions during classes and students should instantaneously answer to them using their smartphones. As the learning environment makes a real-time processing of every student' response, teachers can track the students' progress during the course achieving a real-time feedback inside class. Besides, the platform permits teachers to design learning books to be distributed through smartphones. These features seek to promote flexibility in the learning process, increasing at the same time the motivation and the self-learning process of students. A very preliminary and unfinished introduction of the responsive learning platform was presented in [14]. Finally, it is worth mentioning that the use of the virtual environment in different Higher Education contexts and in other educational levels can be direct due to the simplicity of both, the interface and the implemented functionalities. In this paper, we support these advantages with a case study carried out in several courses of Telecom degrees by means of an exhaustive qualitative and quantitative analysis. Therefore, our proposal aims to understand from a comprehensive point of view how students perceive the use of smartphones in class, and in particular the use of the AIM-Mobile Learning Platform. Moreover, we try to guess if the use of the learning environment helps students to interact with teachers inside class, if students increase their participation in class and if they appreciate the received feedback in class.

This paper is organized as follows. In section 2 we describe the state of the art in LMS tools. In section 3 we explain the AIM-Mobile Learning environment and its functionalities. Section 4 describes the methodology of the conducted educational research and the results. Finally, in section 5 we summarize the main conclusions of the analytical study.

2 | STATE OF THE ART IN E-LEARNING SOFTWARE ENVIRONMENTS

LMS software is extensively used in many Higher Education courses and there are a lot of alternatives. As a consequence, there are many publications that analyze different aspects of these platforms. The company Capterra [6], a software guidance company, carries out periodic studies to determine the most popular LMS applications used by academic institutions to design training programs by means of e-leaning and m-learning techniques. This study is based on the number of clients, number of users and the social network score (a combination of likes, followers and more). According to the most recent analysis of Capterra published November 17, 2017 [7] among the most popular LMS applications we can found Edmodo, Moodle, and Blackboard. Furthermore, the e-learning industry, the largest online community of professionals involved in the eLearning industry corroborated this data.

In this way, Edmodo [18] is a free learning platform that uses the social network concept. Some educational prototypes use this platform, such as [27]. In this platform, students have to join to one closed group, so teachers cannot control that all students join to the subject. Furthermore, teachers share news, documentation and evaluable questionnaires to assess students. In case one subject is shared by several teachers, each teacher cannot visualize the educational resources and marks uploaded by the other teachers. Therefore, there is not a shared space for a subject. On the other hand, Moodle [37] is one of the most complete and extended educational platforms among universities and many of them use this platform in their classes [11,33,45]. It is a very powerful and versatile application with a great number of learning modules. However, this great number of modules makes the platform very complex to configure. Finally, Blackboard [3] permits

teachers to carry out evaluation tasks, management of resources and synchronous/asynchronous communication with students. We can find several studies that implement Blackboard in their classes [35]. However, this platform is commercial and it requires a payment for its use.

Apart from these learning platforms, there are other well-known applications, such as the project Google for education [23] which offers a set of educational facilities such as the Classroom application. It helps teachers to create and organize different tasks and to share documents and communicate with students by means of a Gmail account. However, since it is integrated in the Google Apps tool packet for Education, it requires to download several applications such as Google Calendar, Google Doc, Gmail, or Google Talk. Some educational experiences have used this platform in their courses [10,20]. Other applications, such as Socrative [44] and Kahoot! [32] can be classified as Classrooms Response Systems (CRS) systems that allow teachers to poll students for assessment purposes. They permit to send multiple choices questionnaires to students to be immediately answered using smartphones. After responses have come in, teachers can show the results in class. These applications lead to a real-time competition between them. However, both applications do not provide others functionalities of the learning-teaching process. There are many experimental prototypes that use these applications in their courses [15,25]. In conclusion, Table 1 summarized some important characteristics of the previous e-learning tools.

Analyzing these alternatives, it can be noticed that none of them comply with every desirable requirement, such as not commercial, integration of several educational functionalities, number of integrated functionalities, type of functionalities or easy to use. In contrast, our proposal focus on developing a virtual environment in which teachers can easily create contents and resources and they can carry out evaluation tasks mobile-oriented in an integrated way. The platform permits to share educational material with other teachers. Furthermore, it provides students with the desirable functionality of easy access to resources, contents and marks from every place and at any time. In line with it, the student's application is very fast ant it will ensure low data consumption. On the other hand, we seek to offer more interactive classes in which students can participate in a more dynamic way, increase their motivation and their real time interaction with teachers. As a consequence, the main objective of the platform is not focus on achieving learning gains; in contrast, it is focus on improving a real time relationship and feedback inside class between teachers and students. This feedback will help teachers to monitor classes and students and consequently they can modify or adapt their methodologies to enhance the quality of the learning-teaching process. Besides, we can check if students are more involved with classes, if they increase their motivation and if they were willing to receive real time feedback in class.

3 | THE VIRTUAL LEARNING ENVIRONMENT AIM-MOBILE LEARNING PLATFORM

3.1 | Global design and structure

The AIM-Mobile Learning Platform deals with the integration of important functionalities of the teaching-learning process:

1. To register and modify students, subjects and teachers.
2. To allow a real time evaluation and a virtual interaction with students in class by means of smartphones or tablets.
3. To schedule a noticeboard to announce events.
4. To design electronic books for classes and laboratories.

The AIM-Mobile Learning Platform consists of a server application (used by teachers) and a client application (used by students). The languages, frameworks and libraries used and the interaction between them are shown in Figure 1.

TABLE 1 Comparative table of different LMS systems

Instrument	Edmondo	Blackboard	Moodle	Classroom google	Kahoot	Socrative
Registration	X	X	X	X	X	X
License		X	X	X		
Authentication	X	X	X	X	X	X
Automated support		X	X	X		
Course management	X	X	X	X	X	X
Online grading	X	X	X	X	X	X
Content sharing	X		X	X		
Accessibility	X	X	X	X	X	X
File exchange	X	X	X	X		
Real-time chat	X	X	X	X		
Course template	X	X	X	X	X	X

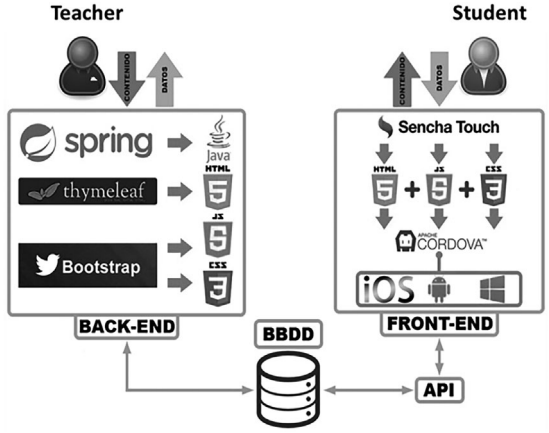

FIGURE 1 Architecture of the AIM-Mobile Learning Platform

The server application has been programmed in Java [29], using the framework Spring [43] and the Thymeleaf Java library (www.thymeleaf.org) (XML/XHTML/HTML5 template engine) [48]. Thymeleaf is better suited for serving XHTML/HTML5 at the view layer of web applications. Together with Thymeleaf, the view layer was programmed with bootstrap [4], which provides the CSS (Cascading Style Sheets) [8] and Javascript [30] options. On the other hand, the client application was programmed using the Apache Cordova platform [2], which allows to build native mobile applications such as Android, iOs, blackberry or windows phone. Finally, Sencha [42] provides HTML5-based app development tools and services for building universal apps that run on any device.

3.2 | Design and functionalities of the teacher application

The server application has been implemented for web access (HTML5) [28] and it is used by teachers to deal with their subjects and students. Once the administrator registers teachers in the platform, they can use the system functionalities specified for them. As it can be observed in Figure 2 the platform provides four functionalities: News, Book management, Question management and Course Management. These functionalities will be explained in the next sub-sections.

FIGURE 2 Main menu of the AIM-Mobile Learning platform

3.2.1 | News section

This functionality permits teachers to design a virtual noticeboard to schedule events for each subject. Furthermore, teachers can copy the same advice for different subjects.

3.2.2 | Book management section

This functionality allows to design electronic books containing didactic resources. As it can be observed in Figure 3, teachers can visualize the electronic books, which are classified by subjects (in tab system).

To design one new electronic book, teachers have to fill some fields with the subject it belongs to, the book name and a short description. Then, they press the "Add" button and it appears a new panel to insert pages by means of an editor that easily permits to add text, images, or videos.

3.2.3 | Question management section

In this section, teachers can design test questions to evaluate students in class using smartphones. In order to configure a test question (Figure 4) teachers need to fill the statement of the question and to press the button "Add." Then, it appears a new panel ("solution page") in which they insert the answers with their corresponding solution (true or false). The test question can be used in different subjects and several times, depending on teachers. Moreover, teachers can discard or modify every designed question. Once teachers launch one question it keeps active for a period of time set by the teacher in the application and students have to instantaneously answer it using the application installed in their smartphones. Every answer of students is automatically collected by the teacher's application and stored in a database, providing a feedback that allows a real time assessment of students. To allow this feedback, the teacher's application instantaneously draws graphics and shows statistics of the results of every question (Figure 4). Even more, there is a repository of questions with its corresponding results and teachers can be able to download a summary of the results. On the other hand, this version of the learning environment only permits to launch questions one by one, but in the next version we are implementing a new functionality in which teachers can design a bank of questions to be launched at the same time.

As a consequence, our proposal promotes a real time interaction between students and teachers inside class that seeks for increasing the motivation and participation of students. The virtual learning environment does not only provide an individual assessment of students, but also it permits to monitor the progress of the class.

FIGURE 3 Book management section

3.2.4 | Course management and administration section

The learning platform allows teachers to deal with subjects and students, so they can upload students, access to information and marks of students or visualize the noticeboard and the electronic books.

3.2.5 | Design and functionalities of the student application

The student's application has been programmed in Cordova and Sencha, so it is ready for several mobile operating systems (Android, iOs, and web browsers). Moreover, it follows a Responsive Web Design, so it allows an optimal viewing, easy reading and navigation with a minimum of resizing, panning, and scrolling for a wide range of smartphones and tablets. The installation of the application is similar to any other available in the market. Once the application is installed, it is launched and it appears the log panel, as it can be observed in Figure 5a. The students' application provides a set of functionalities by means of an easy menu (Figure 5b). In fact, a noticeboard section, an electronic books section and a questions section. To visualize the content of each section, students have to press on the title of the section and navigate inside it.

One of the most interesting functionalities is the book section, in which students can access to a set of integrated didactic resources such as video-tutorials, mounts or descriptions for laboratory sessions or lectures (Figure 6a, b). Moreover, as the study performed in this article focus on the real time and continuous evaluation of students in class,

FIGURE 4 Question Section: results and statistics of one test question

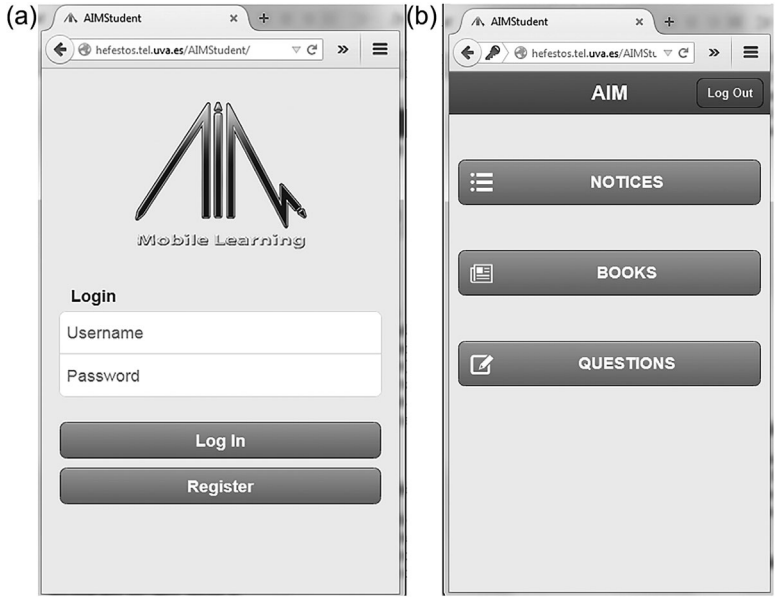

FIGURE 5 Student's application (a) Login panel (b) Main menu

students are provided with a question management section to answer these evaluable questions (Figure 7a,b).

4 | METHODOLOGY AND RESULTS

4.1 | Methodology of the conducted educational research

Regarding the study case, focused on assessing the benefits and impact of the proposed learning environment in different subjects, we applied a mixed research model, taking into account a combination of qualitative and quantitative data. This widespread model has been proposed and studied by many authors such as Yin [52], Stake [46], Grandon [24], Flick [21] or Denzin and Lincoln [16]. Our case study is focus on detecting if the use of the learning environment helps to improve the real time interaction and feedback between students and teachers in class. Moreover, we try to detect if this real time feedback helps to evolve and to improve methodological strategies. Finally, we want to check if the

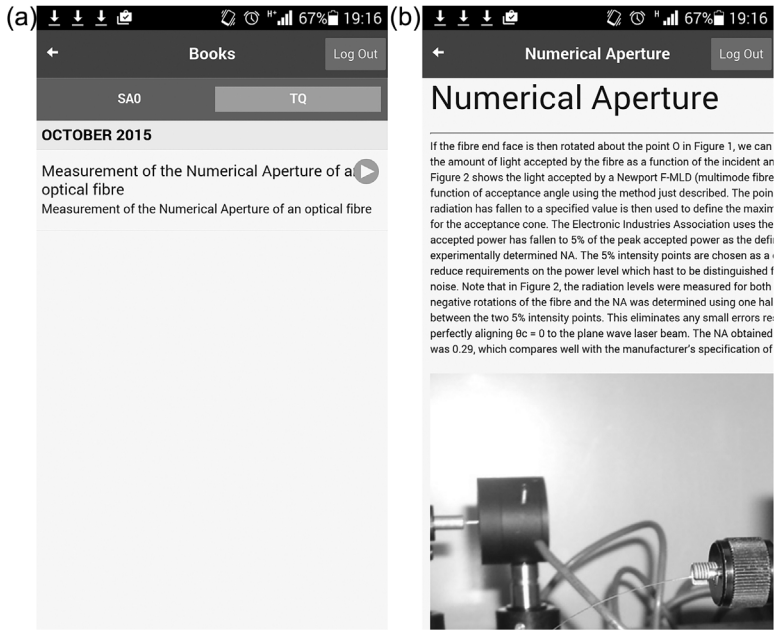

FIGURE 6 (a) Name and description of the book (b) Page of one book

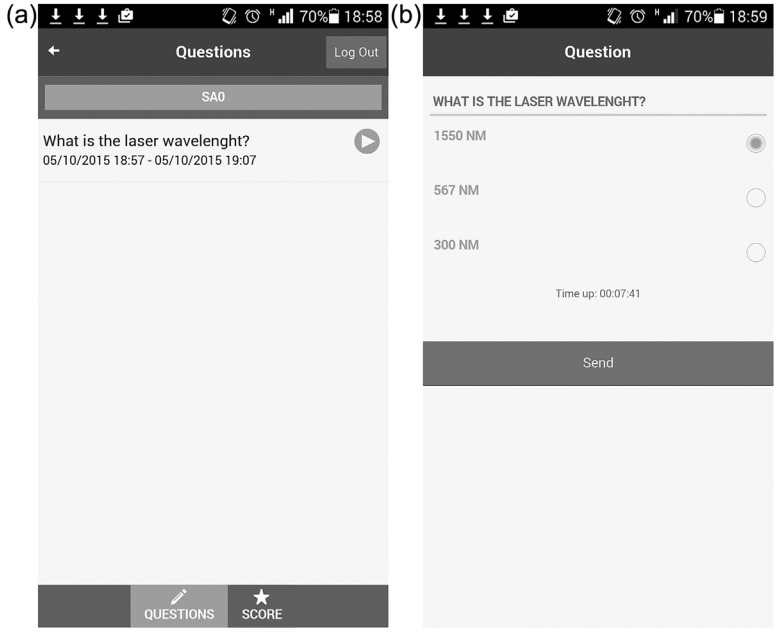

FIGURE 7 (a) Title of the test question (b) Solutions of the test question

learning environment improves the attention and motivation of students inside classes. To carry out this study, we developed a triangulation process of the data [12], which combines both the qualitative and the quantitative perspectives in the global analysis [13,26]. This methodology has permitted us to be closer to the analyzed problem since we have integrated perceptions and opinions of students by means of interviews, which also helped to reinforce the conclusions of the quantitative results. Besides, this triangulation strategy made easier to correlate and to corroborate in the same study the qualitative and quantitative data at the same time [38]. This research has been supported in part by the University of Valladolid, Teaching Innovation Groups 2015/2016 and 2016/2017. The project, called AIM-Mobile learning platform, belongs to a competitive call inside the university.

Then, the conducted educational research was applied in three optical communication subjects during the academic course 2016–2017. Every subject belongs to the third course of two four years degrees (Bologna process) in the Telecom School. In fact, two subjects are specialized in Telecom Technologies, Guided Communication Systems (GCS) and Optical Communication Systems (OCS) and another subject in Telecom Systems (Optical Communication Networks and Systems [OCNS]) [47]. Every subject is taught in the second semester. GCS is compulsory and OCS and OCNS are both optional, with a total of 47 students. All subjects share some objectives and the knowledge and skills that students should acquire at the end of the subject are [1,34]:

1. To know the principles of the fiber propagation.
2. To know characteristics of basic optical components.
3. To describe optical fiber propagation problems.
4. To design optical network systems.
5. To manage optical network simulators an optical instrumentation to carry out experiments to analyze fiber parameters and network performance.

The subjects consist of lectures and laboratory sessions regarding theoretical and experimental optical concepts. The learning environment was used by teachers to follow the evolution of students, to assess the acquisition of knowledge and how the real time feedback impacts on the learning-teaching progress. In this way, along the semester, teachers launched questions during the classes to the students. Then, students answered these questions in a few minutes using their smartphones. Once students answered the questions, the application used by the teacher collected and processed every data and students and teachers could visualize the statistics and the graphs with the final results. However, in the case that students do not answer a question, this will be marked as zero.

In this way, students know in advance the educational methodology used by teachers and they answered to questions freely and individually using their smartphones, tablets, or desktops. The students' responses were evaluated by teachers increasing their global mark in the theoretical part up to 5%. In case students did not use the online system they cannot achieve these extra points. Therefore, we enhance the continuous evaluation of students in class and we promote that students attend to classes and take part of the learning process in a proactive way. Moreover, students were conscious of their mistakes instantaneously and teachers were able to follow the mean progress of the class and to detect the weakest points of the teaching-learning process.

Furthermore, this case of use promoted a real time feedback in class between teachers and students.

On the other hand, the impact of the AIM-Mobile Learning Platform has been assessed following the triangulation process of data required in every qualitative research [36,49]. This strategy involves the use of multiple data sources in an investigation to produce understanding. Therefore, in our study we collected qualitative and quantitative data to support the benefits of our learning environment. Furthermore, we analyzed the consistency of different data sources at different points in time, that is, at the beginning and at the end of the semester (as the triangulation method states). Finally, we compared the point of view of different agents involved in the teaching-learning process, the opinion of students and teachers.

In fact, we designed a questionnaire for students regarding the advantages and disadvantages of the platform. This questionnaire was delivered at the beginning of the semester (once students used the platform one week) and at the end of the semester, to contrast the same data at different times. Table 2 shows the questions and the items that students had to evaluate from "1" (not agree) to "5" (totally agree). To complement this quantitative research we carried out one interview guided by a pedagogical teacher at the middle of the semester with some volunteer students (six students) to integrate qualitative data in the educational research [22]. In this interview, students were asked for aspects regarding the utilization, objectives, advantages and disadvantages of the learning environment.

On the other hand, it was designed another questionnaire to analyze the teachers' point of view to follow the triangulation method. Teachers were asked about the impact of the AIM-Mobile learning platform on teachers and students. Table 3 shows the items they had to evaluate from "1" (totally disagree) to "5" (totally agree). It was complemented with a qualitative analysis to better support and to justify the responses. The number of teachers that participated was 7.

Both questionnaires were ad doc designed according to our particular study case and it was reviewed by external evaluators taking into account (1) the adequacy of questions according to the objectives of our research (2) an equilibrated structure of the questions and questionnaires (3) the questions could cover every key element or essential issue (4) to avoid superficial or repetitive questions (5) to check any item one by one (the statement of the question, other possible alternatives, purpose in the questionnaires. . .). On the other hand, the interview was made by means of an organized and planned dialogue between the external teacher and six students. In this interview, students were asked for their perception of the learning environment during 40–60 min. The interview was recorded and then it was analyzed by a pedagogical expertise.

TABLE 2 Designed questionnaire to evaluate the AIM-Mobile Learning Platform from the students' point of view

Questions	Items
Question 1: What advantages does the learning platform provide for students?	Item 1: To promote a more dynamic and attractive learning-teaching process inside class. Item 2: To promote an online access to resources/marks whatever they are. Item 3: To increase the motivation, responsibility, attention and work capacity of students inside class. Item 4: To promote a real time virtual interaction between teachers and students inside class. Item 5: To promote a constant feedback inside class, so students can know their answers and mistakes immediately. Item 6: To permit the acquisition of TIC skills.
Question 2: What disadvantages does the learning platform cause students?	Item 1: Lack of concentration in class for using mobile phones Item 2: Lack of knowledge about technology to deal with the learning platform Item 3: Lack of interest/ motivation of students toward these virtual methodologies Item 4: Lack of mobile phones to access the mobile application

Finally, Table 4 summarizes the main categories and issues covered by each instrument used in the conducted educational research, that is, the initial and final questionnaires and the interview.

4.2 | Results of the impact of the educational learning prototype

Figure 8 shows a graph with the mean value given by students to any response of Table 2 (from Item 1 to Item 5) at every subject (GCS, OCS, and OCNS), when comparing the initial and the final questionnaires regarding the advantages offered by the learning platform. It can be noticed that the mean value for every response given at every subject is quite high, near 4, except for Item 5 (3.20). Regarding Item 1, students think that the use of the virtual platform in class highly promotes the

TABLE 3 Designed questionnaire for the teachers

Questions	Items
Question 1: What advantages does the learning platform provide for teachers in their teaching process?	Item 1: To improve a real time feedback of knowledge inside class Item 2: To automatize the collected data to carry out a real time and continuous evaluation of students inside class Item 3: To avoid monotony in class Item 4: To promote interactivity and communication between teachers and students Item 5: To promote an effective control of the students and class progress along the semester
Question 2: What advantages does the learning platform bring students?	Item 1: To promote a more dynamic and attractive learning-teaching process inside class Item 2: To promote an online access to resources/marks whatever they are Item 3: To increase the motivation, responsibility, attention and work capacity of students inside class Item 4: To promote a real time virtual interaction between teachers and students inside class Item 5: To promote a constant feedback inside class, so students can know their answers immediately Item 6: To permit the acquisition of TIC skills
Question 3: What disadvantages does the learning platform provide for students?	Item 1: It requires much time and effort to manage the learning platform Item 2: Their use involves a lot of time in class Item 3: It highly depends on technology and the Internet access Item 4: Lack of motivation, interest and effort of teachers Item 5: Lack of knowledge about technology to deal with the learning platform
Question 4: What disadvantages does the learning platform provide for the learning process of students?	Item 1: Lack of concentration in class due to the use of mobile phones Item 2: Lack of knowledge about technology to deal with the learning platform Item 3: Lack of interest/ motivation of students toward these virtual methodologies Item 4: Lack of mobile phones to access the mobile application

learning process in a dynamic and attractive way, since they gave a mean value near 4 in every subject. In fact, it can be observed that students increase their mark at the end of the semester, especially in the GCS subject. Furthermore, students perceive very useful the online access to resources and marks through the platform (Item 2), with a mean value of 3.62. Indeed, students of OCS and OCNS notably increased their score at the end of the semester. For Item 3, students think that the learning platform helps them to pay more attention inside class, as the average mark in every subject is around 3.8. As it can be noticed, this perception increases along the semester in every subject, especially for OCNS. In this line, students states that the use of the platform inside class allows a better real time interaction between teachers and students (around 3.70), and this value moves up at the end of the semester for every subject. Regarding Item 5, students find very appealing the use of the learning environment to keep a constant feedback inside class because they have available their answers and marks instantaneously. Indeed, this advantage is the best appreciated by students as the average value for every subject is around 4.25. Moreover, it can be observed that students slightly increase this perception at the end of the semester (except for GCS). Finally, Item 6 is the less appreciated by students of every subject (mean value around 3.2), probably because they have their TIC (Technology Information Communication) skills quite developed as they study Telecom engineering.

Furthermore, we have complemented this quantitative research with a qualitative analysis by means of an interview done to six students (from student 1 [S1] to student 6 [S6]) guided by a pedagogical teacher. In this interview, students supported with their opinions regarding the qualitative responses. For example, several students think that the platform makes classes more interesting (Item 1) with arguments such as S1: "... I think that the platform makes classes more amusing ...", S3: "I think the same, it helps to break the monotony of classes ...," S4: "Classes are quite boring since subjects are quite technological ... and the platform makes classes more attractive ..." and S6: "The use

TABLE 4 Main issues covered by every instrument used in the research

Instrument	TIC skills and platform management	To understand concepts	Kind of classes	Motivation and involvement	Participation in class	Feedback	Continuous evaluation
Initial questionnaire	X		X	X	X	X	
Final questionnaire	X		X	X	X	X	
Interview	X	X	X	X	X	X	X

of technology motivates more . . .." For Item 2, some students highlighted the online access to resources and contents, for example, S4: ". . . I would emphasize the immediate access to contents and resources, it is very fast by means of a easy menu in the application . . ." and S6: ". . . The access to contents is faster than the official web page of the university . . .." Furthermore, the interviewed students supported that the platform increases responsibility and attention (Item 3) with comments such as S1: "The use different methodologies imply that attention increases, and the virtual application promotes to attend more in class . . .," S6: "In fact, the application makes you pay more attention because questions are taken into account for the continuous evaluation . . ." and S5: "The platform helps to fix concepts because when you know that you will be evaluate in class you pay more attention . . .." Regarding Item 5 students consider that the virtual environment promotes an important feedback inside class with some responses such as S5: "I think very appealing and useful to achieve an instantaneous assessment of knowledge in class . . .," S2: "It is an useful application because questions are sent to every student and students receive an immediate feedback of their answers . . .," S4: "It is a good methodology to check if the class follows the contents of the subject . . .." Finally, regarding the lowest score item (Item 6) every student affirmed that the platform does not enhance their TIC skills because all of them answered that their studies are extremely related to technology.

On the other hand, Figure 9 represents the average mark that students gave to each disadvantage of Table 2 (from Item 1 to Item 4) in the three subjects. First of all, it can be observed that students do not perceive high disadvantages when using the virtual environment, since the average value is lower that 2 (except for Item 1). Indeed, students think that the use of smartphones in class does not badly impact on their concentration (Item 1), since the mean score is around 2. However, it is curious that this perception increases along the semester for OCS and OCNS, since students admitted temptations to access to WhatsApp, Facebook, or Twitter. Regarding Item 2, students found very easy to manage the learning platform, since the value at every subject is very low (around 1.5). Furthermore, students do not show lack of motivation and interest when using virtual methodologies (mean value 1.8). Finally, students think that the lack of smartphones is not a problem to use the learning platform in class (Item 4), with an average mark near 2, probably because everybody has smartphone or tablet.

Furthermore, this quantitative analysis has been completed with the interview data. Regarding the lack of concentration in class (Item 1) some students pointed out arguments such as S1: "Perhaps you have temptations to open

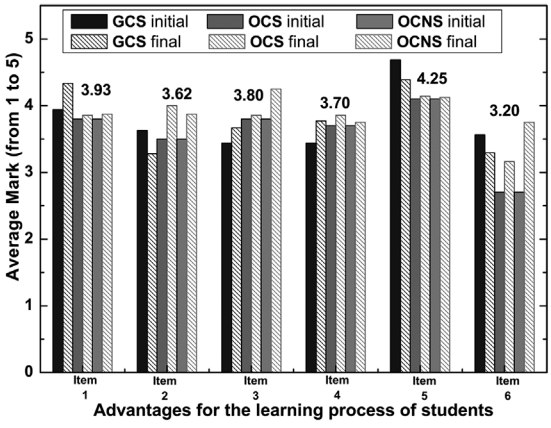

FIGURE 8 Advantages perceived by students in the questionnaires

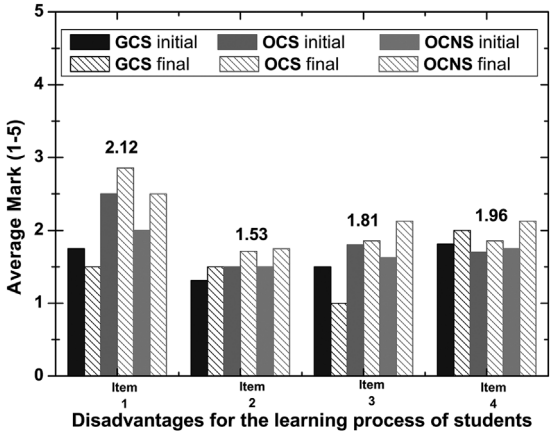

FIGURE 9 Disadvantages perceived by students in the questionnaires

WhatsApp, Facebook or Twitter to check if somebody writes you . . .," S2: ". . . It is true that you can get distracted from the explanations in class but it depends if the class is boring or difficult . . ." and S5: ". . . the platform does not have to be a distraction for students if you are concentrated on the questions . . .." In relation with the lack of knowledge about technology to deal with the platform (Item 2), students emphasized the easy access and use, supported with comments such as S1: ". . . the management and interaction with the application is easy and clear . . .," S5: ". . . the use of the applications is very easy . . .," S3: ". . . the application is useful and easy to manage . . ." and S6: ". . . the menu is intuitive and the navigation very easy . . .." Finally, students do not perceive problems with the access to the application (Item 4), with comments such as S3: ". . . it is not a problem because students have free wifi networks inside the university . . .," S4: ". . . students have their network data or free wifi networks . . ." and S6: ". . . everybody has an smartphone and free access to internet inside the campus . . .."

Figure 10 represents the mean value given by teachers to each response of Table 3 (from Item 1 to Item 5) regarding the benefits that the learning platform provides to their teaching process. Indeed, teachers perceive high advantages when using the platform, as the average mark is over 4 (except Item 4). The best mark was given to Item 5 that regards the effective control of the students and the class progress along the semester. In this line, teachers think very useful the platform to improve a real time feedback inside class, to automate the evaluation process of students and to provide an amusing way to teach and learn in class (Item 1, Item 2, Item 3). Finally, for Item 4 it can be stated that teachers find quite attractive the use of the learning platform to allow interactivity and communication with their students. These quantitative results have been supported by some qualitative comments. Regarding the real time feedback (Item 1) teachers affirm that "the use of platform permits to know if students understand concepts in class so teachers can adopt different strategies instantaneously," or "Sometimes basic concepts are not being understood by students and they cannot follow advanced concepts. The platform immediately allows to notice this kind of problems . . .." Regards the monotony in class (Item 3), teachers perceive that "the learning platform permits students to interact with teachers because they feel motivated with their smartphones," or "I perceive more relaxed classes and interaction with students." For the highest scored item (Item 5), teachers corroborate that "the learning platform helps to periodically monitor the classroom" or "the application makes easier to follow a real time progress of students."

Figure 11 represents the mean value given by teachers about the benefits that the learning platform provides students. Teachers think that it does not highly promote the acquisition of TIC skills (Item 6 achieves the lowest mark), since students are quite used to technology. This perception also accords with the students' point of view (Figure 8). Moreover, teachers corroborate their response with comments such as "students are quite used to technology and mobile applications," ". . . every student has their personal smartphone or tablet" or "students feel very confident with technology." On the contrary, teachers highly scored Item 1, 3, and 5 (average around 4.5). Therefore, teachers think that the platform provides a more attractive way to learn inside class, it increases the attention and responsibility of students during the classes and it generates a real time feedback in class since students can instantaneously check their knowledge and mistakes. In fact, for Item 1 teachers affirm that "classes are more amusing and interactive" or "the use of the platform promotes a funny interaction with students in class." Furthermore, teachers support Item 3 with some additional comments such as "students pay more attention in class because the results are taken into account in their continuous

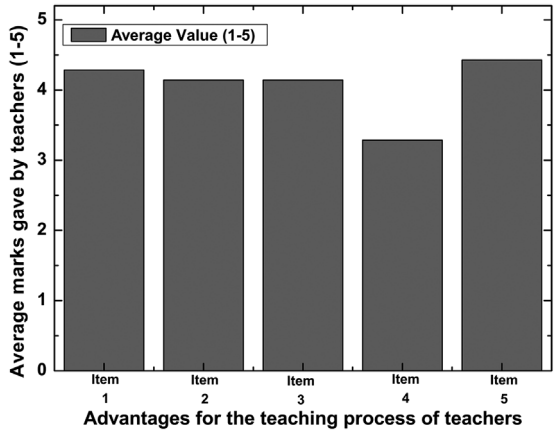

FIGURE 10 Advantages perceived by teachers for their teaching process

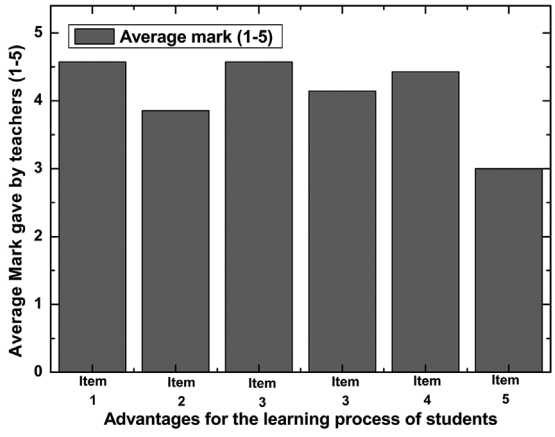

FIGURE 11 Advantages perceived by teachers for the learning process of students

evaluation . . .," "students like to know their mistakes and correct them, so I perceive more concentration in class . . ." or "students feel more motivated and concentrated because they check their knowledge during classes and they can ask teachers when they fail questions."

On the other hand, Figure 12 shows how teachers score some disadvantages regarding the impact of the platform on the teaching process (Table 3). Indeed, teachers do not highly perceive great disadvantages for their used in class, except for Item 3. Regarding this response, teachers think that it highly depends on technology and the Internet access, so some teachers state that "the use of the platform depends on the Internet network" or "it depends on the type of smartphones and Internet ...." However, this disadvantage can be overcome because the Internet access in the Campus is free and with high transmission rates. Furthermore, smartphones are becoming more powerful. In contrast, teachers recognized that the platform does not require much time to understand and they did not waste time when they used it in class (Items 1 and 2). Teachers emphasized that "the use of the learning platform is easy and intuitive," "the functionalities of the application are clear to use ..." or "the platform takes advantage of mobiles to redirect their use for didactic purposes."

Finally, Figure 13 represents the average mark of teachers regarding the disadvantages of the platform for the learning process of students (Table 3). One more time, they do not think that the virtual environment brings disadvantages for students. In fact, the average score to every item is around 2. The lowest mark is given to Item 2 in which students do not show lack of knowledge about technology to deal with the platform. In particular, teachers comment that "telecom students normally deal with technology and software applications" or "university students have enough technological knowledge to manage software applications." In contrast,

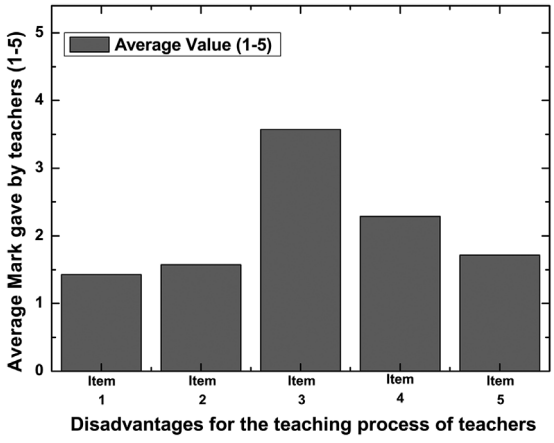

FIGURE 12 Disadvantages perceived by teachers in the teaching process

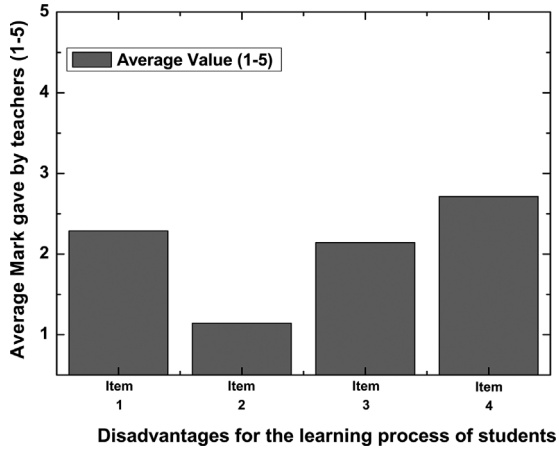

FIGURE 13 Disadvantages perceived by teachers for the learning process of students

the highest perceived disadvantage is related with the necessity of smartphones and tablets to access the application. However, teachers affirm that "students tend to have sophisticated smartphones," "this is not a problem because students have powerful smartphones or tablets" or "every student brings the smartphone to the university."

4.3 | Discussion of results

The results of the research have demonstrated that students and teachers have observed an improvement in the responsibility, capacity of work and attention of students inside class, since both of them have highly scored this item in Figure 8 (item 3 in Table 2) and Figure 11 (item 3 in Table 3). These results support the idea proposed by Unigarro y Rondo [50] that stated that Technology can promote that students take part of the learning process adopting a proactive approach.

Moreover, students opined that the learning environment has increased the motivation, attention and participation of students in class, making the teaching-learning process more attractive and dynamic (item 1). Students reinforced these results with positive comments collected in the interview described in section 4.2. These global results accord with the studies carried out by Brazuelo et al. [5] and Sanz et al. [41] which demonstrated that the 68.6% of students considered smartphones very motivating inside class and the 39% affirmed that mobile learning techniques permitted a constant feedback in class between teachers and students. The perception is the same regarding the online access to marks and contents (item 1 in Table 2) with a high average mark (Figure 8).

Furthermore, teachers and students have noticed that the platform has promoted a real time feedback and interaction between teachers and students, as it can be observed in Figure 8 (item 5 in Table 2) and Figure 11 (item 4 in Table 3) that the average value is very high. In fact, according to the comments

collected in the interview (section 4.2) and the score observed in Figure 11, students highly emphasized that the learning platform was able to promote the interaction between teachers and students and allowing an efficient feedback during classes since students could discuss their answers and check their knowledge in a real time and natural context. Besides, it is worth mentioning that the most important perception exhibited by teachers is the effective way to monitor classes and students along the course (item 5 in Table 3), as this characteristic was the best valued in Figure 11.

On the contrary, teachers have not notice high disadvantages for the learning and teaching process, as it can be observed in the corresponding scores of Figures 9, 12, and 13. In this line, teachers emphasized that they did not invest much time and effort to deal with the teacher's application inside classes and students founded easy and intuitive their application. Finally, teachers and students accorded with the idea that the learning platform did not promote the acquisition of TIC skills, probably because students belonged to Telecom degrees and they were quite connected to technology.

5 | CONCLUSIONS

In this paper a new RLMS learning environment, called AIM-Mobile Learning Platform, to efficiently integrate mobile learning strategies and to automate some tasks of the teaching-learning process has been proposed. One of the main purposes of the learning environment is to carry out a real time and an automatic assessment of students inside class though their personal mobiles and tablets. Indeed, the interactive environment is able to show statistics to measure and to control the mean level of the class and the progress of every student. Another interesting functionality is the design of electronic books that integrate different kind of resources for their distribution through mobiles or tablets, so that students can directly and rapidly access to every educational material. On the other hand, another important strength is the easy and potential management of students, teachers, subjects and resources inside the environment. The analysis of the virtual environment has been done in three subjects of Telecom degrees applying the case study method and the triangulation data process. Results of the quantitate and qualitative study have shown that the use of the virtual environment for evaluable activities increased the motivation, attention and participation of students during classes, making the teaching-learning process more attractive and dynamic. Students perceived that the learning platform promoted the interaction between teachers and students allowing an efficient feedback during classes. In this sense, students also concluded that the environment promoted their work capacity and attention in class. On the other hand, students founded easy and intuitive the application and they did not perceive problems with it. In this line, teachers stated that they did not invest much time and effort to understand and manage their application. On the other hand, teachers and students noticed that the learning environment did not promote the acquisition of TIC skills. In this way, in an immediate future the environment will be applied on different Higher Education disciplines and contexts to obtain an interesting feedback of their used in other scenarios. Finally, it has been developed a version of the learning platform that can be easily installed by users or institutions without high computer skills.

ACKNOWLEDGMENT

This work was supported by the University of Valladolid, Teaching Innovation Groups 2014/2015, 2015/2016 and 2016–2017.

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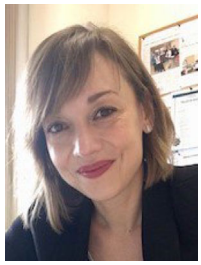

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How to cite this article: Merayo N, Ruíz I, Debrán J, et al. AIM-Mobile Learning Platform to enhance the teaching-learning process using smartphones. *Comput Appl Eng Educ*. 2018;26:1753–1768. https://doi.org/10.1002/cae.21979