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The Effects of Using a Fully Integrated Mobile Application to Access Learning Management Systems in Higher Education

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Abstract: The use of mobile devices in the classroom is increasingly frequent. However, the LMS are still not completely adapted to this format, preventing students from using all the LMS web-functionalities in their mobiles. Hence, we present and evaluate the use of a new mobile application fully integrated with Learning Management Systems (LMS). We examined access to LMS by 95 postgraduate university students, differentiating between the services accessed and the means used. Students belonged to four consecutive promotions. In the first two, access to the system was through the web, while in the third and fourth, an app fully integrated with the LMS was available. The results showed an overall increase in access to LMS, with a considerable reduction in access via the web in favor of access via the application. Significant differences were found in the access patterns to communication and assessment services depending on the students' age, gender, academic major and previous m-learning experience. Satisfaction with the LMS rose when the app was available, with greater growth within the academic major on IT and previous m-learning experience group. Finally, students with high performance accessed the system significantly more than those with low performance. In conclusion, the integration of the app with the system showed useful and efficient results. The app eased the use of the system, increased student satisfaction with LMS, and student performance improved with increased access.

Keywords: Mobile Learning, eLearning Systems, Higher Education, Learner Engagement, Learning Process, User Satisfaction
Categories: L.0.0, L.1.1, L.2.7, L.3.0, L.3.6, L.3.8

1 Introduction

The use of mobile devices is revolutionizing the world of education. At the outset, many authors considered mobile (m)-learning simply as an extension of e-learning that incorporated the added value of mobility [Georgiev et al. 2004]. However, in the places where it has been implemented, m-learning currently yields very favorable results. Recent studies have analyzed the main contributions in the m-learning field and their findings show the overall effect on students' performance. This performance is better when using mobile devices than when using desktop computers or not using any device at all [Talan 2020].

Several authors have argued that training delivered via a mobile device should not be considered a substitute for traditional training but rather should be a complement or support that provides students with the benefits of mobility and communication [Huang et al. 2010]. In higher education, the use of new technologies has surprisingly emphasized students' tendencies to adopt a passive behavior in class and promoting the participation and interaction of students is essential to improving academic results [Sanchez-Elez et al. 2014]. However, university students have integrated smartphones into their daily activities [Crompton and Burke 2018] and have demonstrated high levels of motivation, when they are not distracted by other smartphone functions while in class [Stowell 2014].

Such incorporation of mobile devices into classes has led to an increased access through them to other technologies that were previously incorporated into education, such as LMS, but mostly accessed through computers. LMS have traditionally been used to facilitate distribution of materials, academic management of students' data and student interactions with teaching staff and other students [Cabero-Almenara et al. 2019], but they now increasingly offer communication services, such as chats, forums, wikis or blogs. These promote a constructivist approach to learning [Castro 2018], achieving more active participation on the part of students. Importantly, these systems should be considered a means of facilitating learning rather than learning itself. Some studies have shown that the main values perceived by teaching staff and students are time-savings [Arkorful and Abaidoo 2015] and ease of handling course materials and documents [Iqbal 2011].

However, despite both LMS and mobiles are being used in the classrooms, most LMS have not been adapted to mobile access, and many of the functionalities presented above are not correctly visualized. Hence, this paper analyzes the effect of incorporating an app fully integrated with the LMS in terms of access to the LMS, use, satisfaction and performance.

2 Literature Review

Until recently, access to LMS has traditionally been through the computer, but the exponential penetration of mobile devices has led to increased access to LMS, even when these systems are not fully adapted. The constant updating of mobile devices and the creation of mobile applications, which are increasingly able to perform traditional tasks, make them increasingly able to replace computers. Mobile devices are often preferred over the computer because of the additional advantages offered, mainly

mobility. Taking this into account, the following paragraphs compile the literature review carried out, organized around four variables: access, use, satisfaction and performance. The last three variables were also related to age, gender, academic major and m-learning experience.

Several studies have analyzed the use of LMS, differentiating web access and mobile access. [Modritscher et al. 2012] analyzed one of the most intensively used platforms worldwide, taking the LMS logfile from only one day in an examination week. Two target groups were identified: (a) web users, who accessed the web-based entry point of the LMS, and (b) mobile users, who browse the mobile LMS site. Their findings showed that assessment services and assessment resources were the most accessed, followed by personal pages and communication services in both groups, and mobile access was 1.3% of overall access.

[Casany et al. 2012] analyzed a complete semester, and their data noted that mobile and tablet access made up 3.76% of overall access. They studied which actions mobile users and web users performed in the LMS. The most frequently used LMS activity modules were information services (course and user profile) and communication services (forum) in the case of mobile users and documentation services (resources) and assessment services (quiz and assignment) in the case of web users.

Similarly, [López and Silva 2014] analyzed access to LMS in their University along four complete academic courses. Their results showed that mobile access rose from 1.42% in the first course selected (2009/10) to 23.26% in the last year (2012/13). They concluded that mobile users tend to quickly look up the information required, while web users browse longer and deeper, looking for more course-specific functionalities.

The aforementioned studies have shown that mobile accesses have increased every year. Besides, in the studies that analyze the implementation of a mobile application, results showed that the total number of access to the LMS increased while the number of access from traditional web browser decreased [Hung et al. 2015].

Relationships between use and other variables, such as age, gender and m-learning experience were also analyzed in previous studies. [Villalobos and Campos 2009] showed that students between 26 and 35 were the most active users, followed by younger users and older users. However, most of the reviewed studies have not considered age because the population belonged to the same course or the amplitude of the sample was not wide enough, although some studies analyzed the course year without relevant findings [Naveh et al. 2010]. Moreover, no significant differences were found in the use of LMS in terms of gender [López and Silva 2014] [Rees and Noyes 2007][Cavus 2011]. Concerning m-learning experience, according to Han and Han, mobile LMS nonusers were aware of the benefits of mobile LMS. Nevertheless, they did not use them because they perceived complexity and resistance [Han and Han 2014]. These perceptions were motivated by loss of comfort, familiar habits, limited understanding of the new opportunities offered by the system and resistance to change [Mahali et al. 2019]. On the contrary, students having previous experience with smartphones are more efficient in m-learning [Al-Emran et al. 2016] and students with technological academic majors have shown to reduce the gap and use this technology more easily [Iqbal et al. 2017]. However, [López and Silva 2014] and [Taleb and Sohrabi 2012] did not find significant differences regarding LMS use and previous m-learning experience.

The level of satisfaction with the LMS could be considered indicative of LMS success, although some authors found a low correlation between use and satisfaction of the users [Naveh et al. 2010]. Factors related to satisfaction, such as age, gender, m-learning experience, academic major and means of access have also been the subject of study. Several studies found significant differences in terms of age and years of study in traditional LMS [Naveh et al. 2012] [Horvat et al. 2013]. However, no relevant results were observed regarding the gender of students, which was also found by [Cavus 2011], who included m-learning experienced users. Concerning academic major, some studies have shown that technological ones are more prone to use new technologies [Iqbal et al. 2017]. Finally, regarding the means of access, the availability of mobile access influences satisfaction only if students meet their expectations [Naveh et al. 2010], but they greatly appreciate their integration with LMS [Cavus 2011].

Relationships between use and academic performance have also been analyzed in previous studies. According to [Chanchary et al. 2008], although greater use of LMS does not mean greater efficiency or better outcomes, students with low access rates obtained poorer grades. [Jo et al. 2015] observed that the overall logins in LMS had a significant correlation with the final grades. [Martin and Ertzberger 2013] showed that mobile learning kept the learners engaged, and achievement and attitude data revealed positive significant increases. Moreover, [De-Marcos et al. 2010] identified an experience in which students who used their mobile devices to access self-assessment tests improved their achievement. Nevertheless, [Filippidi et al. 2010] observed that even students with poor performance often access LMS resources, and no significant differences in use were found with respect to students with higher performance. On the contrary, [Darus et al. 2017] proposed an application that was especially beneficial for the students that had a poor academic performance.. [Cavus 2011] showed that perceptions of students with a mobile LMS were positive but also that no significant differences were observed in terms of academic performance. With regards to age, gender, academic major and m-learning experience, [Johnson and Galy 2013] indicated that age and course grade have a negative relationship with performance. [Sáiz and Zorrilla 2012] and [Santomil et al. 2015] did not find a relationship between gender and performance in their different analyzes. Finally, [Chanchary et al. 2008] concluded that the background of students is very important for becoming comfortable and familiar with web resources for learning purposes, and previous usage of ICT could aid in efficient use of the resources, leading to improved class performance.

The study of the student behaviour in traditional LMS has been very helpful for designers, teachers and e-learning professionals. Recent studies have incorporated m-learning in their analyzes, and their findings show an exponential growth of mobile users, mostly with positive values. It is therefore interesting to examine the effects of availability of a mobile app, which eases the usability of accessing LMS without a browser and takes advantage of mobility.

3 Method

3.1 Objectives of the study

The purpose of the study was to analyze the effects of the availability of an app fully integrated with the LMS. Specifically, the researchers wanted to investigate its

relationship with LMS use, satisfaction and performance of the students and possible differences depending on student age, gender, academic major and m-learning experience. The objectives of the research questions examined here were the following:

1) To identify differences in the frequency of LMS use based on the availability (or not) of a mobile app by which to access it and the differences in the use of each service provided. We also aimed to identify differences in the frequency of use as a function of gender, age, academic major and m-learning experience.

2) To identify differences in LMS use satisfaction and overall satisfaction based on the availability (or not) of a mobile app by which to access it. We also aimed to identify differences in use satisfaction as a function of gender, age, academic major and m-learning experience.

3) To identify academic performance differences (through several indicators) based on the use of LMS with and without a mobile app by which to access it. We also aimed to identify differences in academic performance as a function of gender, age, academic major and m-learning experience. Finally, we aimed to test if there was a significant relationship between the overall frequency of LMS use and overall performance.

3.2 Procedure

This study was developed for students working towards a Master's Degree in Business Administration (MBA) and a Master's Degree in Information and Communication Systems (MDSIC) at the Universidad Politécnica de Madrid (Technical University of Madrid). Both programs are one year long and are given over the same period of time, with weekend classes delivered in a blended learning format (60% face-to-face, 40% online). During the course, students must complete objective assessment tests, questions and cases on a learning management system (LMS) developed in-house. The system provides students with access to all the documents used, in 'pdf' format, presentations and other downloadable documents. It also enables students to contact teaching staff for further clarification, exchange opinions with other students, visualize the course program on a calendar and see their academic progress in the marks file. During the study, no improvements or updates were developed in the system. Except for the app connection in the third year of the study, only maintenance actions have been performed.

In the first and second year (2014/15 and 2015/16), hereinafter Cohort 0, all material was given to students in printed format in a folder before each class, and subsequently students could download them in digital format by accessing the LMS via the web.

In the third and fourth year (2016/17 and 2017/18), hereinafter Cohort 1, a new mobile application to connect to the LMS was available, and the web access remained traditional. This native Android mobile application was developed in-house fully integrated with the services of the LMS. At the beginning of the course, students were given an Android mobile tablet to easily access materials, assessments, information, calendar and communication services, and all documents could be downloaded at the beginning of the class using the application. Only essential class materials were printed.

Throughout the four academic years, there were no significant changes to the methodology or the class development. Table 1 shows the descriptive data of six variables, indicating changes between cohorts. The number of teaching staff involved was constant, but five of them changed between Cohort 0 and 1. The number of

assessments carried out also remained constant at 105, consisting of 39 objective tests, 9 individual questions, and 23 team cases. There were slight variations in the number of documents delivered to students, with a small reduction in Cohort 1. Lecture rooms were the same in both cohorts, the infrastructure connection did not vary, and Wi-Fi access was granted along the courses.

	Cohort 0	**Cohort 1**
Total Lecturers	65	65 (5)
Total Assessments	105	105
Total Documents	649	606
Printed material	Yes	No
LMS Available	Yes	Yes
App Available	No	Yes

Table 1: Differences between cohorts

3.3 Participants

The study was conducted over the course of four consecutive academic years, 2014/15, 2015/16, 2016/17 and 2017/18, and the sample consisted of a total of 168 students. Table 2 gives details of the sample by cohort. All students were university graduates. Most of them held a technological academic major, and the rest held degrees in social sciences or other sciences. A t-test showed that the ages of the two cohorts were not significantly different ($p=0.637>0.05$), and a chi-square test showed that the distribution of gender was also not significantly different between cohorts ($p=0.779>0.05$).

	Cohort 0	**Cohort 1**
No. students	78	90
% technological academic major	78.20%	81.11%
M-learning experience	17.94%	43.33%
Age (Mean (SD))	32.07 (4.62)	30.22 (5.48)
Gender (Male/Female)	53 / 25	64 / 26

Table 2: Description of study participants

3.4 Variables

In this context, we analyzed the use, satisfaction and academic performance of the students using the following study variables:

1) Cohorts. Nominal variable. (0: academic courses 2014/15 and 2015/16 and 1: academic course 2016/17 and 2017/18 with availability of the app..

2) Type of technology used to access the LMS. Nominal variable (0: via the web and 1: via the mobile app). In both cases, the server saved access logs distinguishing the technology and the service used.
3) Gender. Nominal variable. (0: male and 1: female). Extracted from the student file.
4) Age. Ordinal variable. Extracted from the student file.
5) Academic major. Nominal variable (0: technological background and 1: other sciences). Extracted from the student file.
6) M-learning experience. Nominal variable related to previous experience with mobile and LMS (0: m-learning users and 1: m-learning non-users). Extracted from an initial survey at the beginning of the course.
7) Usage behavior and service type. Ratio variable. Extracted from access logs of the servers. Number of accesses to different services. Cohort 0 only has web accesses, and Cohort 1 has overall, web and app accesses.
   a. Number of accesses to Documentation services.
   b. Number of accesses to Assessment services.
   c. Number of accesses to Information services.
   d. Number of accesses to the Calendar.
   e. Number of accesses to Communication services.
8) Satisfaction. Ordinal variable Collected in a final course survey and scored on a 5-point Likert scale, from 1 (very unsatisfied) to 5 (very satisfied).
   a. Satisfaction with the LMS.
   b. Overall satisfaction with the Master.
9) Academic Performance. Scale variable. Results obtained in the different modules of the master. All marks on the scale of 0-10. Average values are collected from different professors.
   a. Objective tests (individual).
   b. Individual assignment marks.
   c. Team assignment marks.
   d. Final marks. Weighted average.

3.5 Data Analysis

Over the four academic years, the LMS recorded access to the various services in Cohort 0 and Cohort 1, distinguishing between access via the web and access via the mobile application in Cohort 1. These data were exported for statistical analysis. A descriptive and comparative analysis among the cohorts was developed to answer the research questions. Accesses to LMS were compared in all services, distinguishing the technology used. In addition, differences were tested with a multifactorial ANOVA analysis looking for the effects of age, gender, academic major and m-learning experience.

Student satisfaction was collected with a questionnaire administered in the classroom on the last day of class for each course. Using a single-item format, students were asked about their overall satisfaction and their satisfaction with the LMS. A total of 153 completed questionnaires were collected (response rate: 91.07%). A first comparative analysis was performed to study the different variables, and a

multifactorial ANOVA was later used to study the relationship with age, gender, academic major and m-learning experience. Analysis of the relationship between satisfaction and use was not possible because the questionnaire was anonymous.

Final marks were compiled at the end of each academic year. In the marks file of the LMS, all data were available for analysis. The procedure was similar to that executed previously: firstly, a complete descriptive and comparative analysis was developed, followed by a multifactorial ANOVA to study effects of age, gender, academic major and m-learning experience. Nevertheless, to analyze the relationships between performance and use, students were divided into quartiles using the final marks. Students with final marks higher than Q3 were considered high-performing students, and students with final marks lower than Q1 were considered lower performers. With this new classification, another multifactorial ANOVA was computed.

4 Results

4.1 LMS Usage

The histogram in Figure 1 shows the results obtained for the variables recorded by the system in the two cohorts. Because the number of students varied each year, mean values are shown for ease of comparison. Cohort 1 shows a high increase when the mobile app was available, with the app accesses shown on top.

Table 3 shows more detailed results for all the variables analyzed. Cohort 1 shows a significant increase ($p<0.001$) of 42.4% in overall access with respect to Cohort 0, and the app accesses represent 51.7% of the overall accesses. Considering web access, Cohort 1 showed a significant decrease ($p<0.001$) with respect to Cohort 0, and significant differences were found in the accesses to all services except assessment between cohorts.

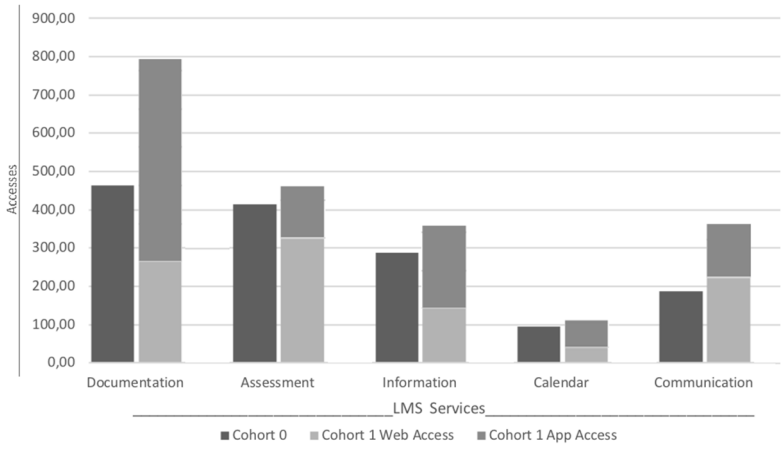

Figure 1: Histogram of the services analyzed according to cohorts, distinguishing the technology used

		Cohort 0 (N=78)		Cohort 1 (N=90)		Signific.
Service	**Tech.**	**Mean**	**Std dev**	**Mean**	**Std dev**	**p-value**
Document.	Web	462.45	59.34	264.73	28.61	0.0001***
	App	-	-	530.04	102.38	-
Assessment	Web	415.49	163.27	323.52	94.43	0.461
	App	-	-	135.51	32.92	-
Information	Web	287.73	107.61	142.90	26.78	0.0001***
	App	-	-	216.23	62.27	-
Calendar	Web	94.38	15.22	39.52	19.86	0.0001***
	App	-	-	66.67	21.59	-
Communic.	Web	188.87	19.73	220.02	56.74	0.0001***
	App	-	-	140.02	51.02	-
Total	Web	1448.92	327.96	990.70	141.78	0.0001***
	App	-	-	1068.47	233.21	-
	Overall	1444.92	367.19	2079.16	206.32	0.0001***

*** $p<0.001$

Table 3: Results for access to different services of LMS by cohorts

Looking first at documentation services, there was a considerable reduction in the number of connections established via the web, while a substantial number of connections was established via the new mobile application. Table 3 gives the means, standard deviations and significance (p-value) of these differences. In this case, access to documentation was significantly lower ($p<0.001$).

There was also a reduction in access to assessment, although this did not reach statistical significance ($p=0.461>0.05$). The case for the information service was similar to that of documentation services, with a significant reduction compared to previous years ($p <0.001$). The calendar service also obtained a significantly lower mean ($p<0.001$) than previous years. However, this figure is not entirely accurate since the mobile app includes the possibility of integrating the calendar in the device via Google Calendar, rendering it impossible to detect all instances of access to the calendar. Finally, there was a significant increase in access to the communication services ($p<0.001$) compared to Cohort 0, even though a significant amount of access was established via mobile devices.

A more in-depth analysis of the results was conducted, differentiating between the cohorts according to age, gender, academic major and m-learning experience. Concerning age, no significant results were found. However, the multifactorial ANOVA showed that both men and women presented a similar profile, reducing their web accesses in Cohort 1. Similar results were obtained via the study of specific accesses to documentation, assessment, calendar and information services. No significant results were found by gender for any of those instances except in communication access. Women had a greater increase than men, and the total accesses

showed the opposite growth. In this case, differences between gender were significant ($F=28.76$ and $p<0.001$). The post-hoc analysis showed that women in Cohort 1 achieved the highest increase, with statistically significant differences ($p<0.001$) compared to women and men in Cohort 0. Men in Cohort 1 also increased with significant differences ($p<0.05$) compared to women in Cohort 0.

According to academic major, students with a technological background in Cohort 1 had a greater reduction of web accesses than the rest of students. This profile was similar for documentation, calendar and information services, but the results were not significant. In the case of assessment and communication, accesses grew, but no differences were found according to academic major.

Finally, students with previous experience in m-learning had the greatest reduction of web access in documentation, calendar, communication and information services. It is noteworthy that in Cohort 1 the usage of assessment services made by the experienced users was the opposite of that made by non-users, as the former accessed less through the web in favour of the app, and the latter maintained the traditional access to these services. In this case, differences between m-learning experienced users and non-users were significant ($F=82.14$ and $p<0.001$). The post-hoc analysis showed that m-learning experienced users in Cohort 1 achieved the greatest decrease, this difference being statistically significant ($p<0.001$) compared to non-users in Cohort 0 and non-users in Cohort 1. Finally, in both cases, total accesses were increased.

4.2 Satisfaction

With regards to satisfaction, no significant differences were found for the questionnaire item pertaining to overall general satisfaction. However, significant differences were obtained for the item analyzing satisfaction with the LMS ($p<0.05$) among cohorts, where the mean rose from 4.07 to 4.63. Table 4 shows the mean and standard deviation for the satisfaction values.

Although the questionnaire used was anonymous, students' gender and m-learning experience were registered. With a multifactorial ANOVA, no significant results were found in any satisfaction variables related to gender. Nonetheless, in m-learning experience, significant differences were shown between m-learning experienced users and non-users in terms of satisfaction with LMS. M-learning experienced users raised their satisfaction with the LMS to a greater extent than non-users ($F=7.24$ and $p<0.05$), and the post-hoc analysis also confirmed statistically significant differences ($p<0.05$) between m-learning experienced users in Cohort 1 and all users in Cohort 0.

	Cohort 0 (N=78)		**Cohort 1 (N=90)**		**Signific.**
	Mean	**Std dev**	**Mean**	**Std dev**	**p-value**
Satisfaction with LMS	4.07	0.78	4.63	0.53	0.006*
Overall Satisfaction	4.02	0.71	4.15	0.87	0.771

* $p<0.05$

Table 4: Results of satisfaction levels by cohort

4.3 Performance

Finally, Table 5 shows the results obtained from an analysis of the final marks as indicators of performance. An objective test, individual assignment questions and team cases were distinguished in the study. The objective test was the only variable in which significant differences were found ($p<0.005$). With regards to the relationships between performance and use, the multifactorial ANOVA showed that students with high performance (students with final marks above Q3) accessed more frequently, with a mean of 1386.64 (254.36) accesses in Cohort 0 and 2121.41 (166.73) in Cohort 1, than those with low performance (students with final marks under Q1) with a mean of 1467.09 (288.94) accesses in Cohort 0 and 1978.13 (257.43) in Cohort 1 ($F=3.22$ and $p<0.05$). The post-hoc analysis showed that students with high performance in Cohort 1 accessed significantly more ($p<0.05$) than students with low performance in Cohorts 0 and 1 and with high performance in Cohort 0. A similar analysis with a multifactorial ANOVA relating these variables with age, gender, academic major and m-learning experience showed no significant differences.

	Cohort 0 (N=78)		**Cohort 1 (N=90)**		**Signific.**
	Mean	**Std dev**	**Mean**	**Std dev**	**p-value**
Objective test	8.25	1.67	8.89	1.12	0.003 **
Individual questions	8.93	1.14	8.55	1.01	0.294
Team cases	9.16	1.23	9.21	1.82	0.976
Final Score	8.56	0.59	8.79	0.56	0.196

* $p<0.005$

Table 5: Results of performance by cohort

5 Discussion

5.1 Analysis of Research Questions

With regards to Research Question 1: Total access to LMS increased significantly in Cohort 1 compared to Cohort 0 with the availability of a mobile app. The percentage of mobile access was higher than in the reviewed studies but congruent with their growing trends. It indicates that users are shifting to use the mobile application instead of using web browser, corroborating findings from [Hung et al. 2015]. All services were accessed more in Cohort 1 than in Cohort 0. However, the use was not the same in the different services. Documentation and information had considerably reduced web access, and the number of accesses to documentation through the app was higher than through the web. In the case of assessment, access grew, but web access was similar to previous promotions, and variation in app access was not significant. Additionally, communication was the only service with an increase in web access, although app access was highly used in this service, as well. Regarding mobile accesses, the principal services used were documentation and information services, which are partially similar results to [Casany et al. 2012]. In their findings, information services were the most

used, but documentation services were accessed mainly via the web. In the case of [Modritscher et al. 2012], differences were also found because they showed that the principal accesses were to assessment services. This difference could be marked because they analyzed the logs of a day in an assessment week. Finally, results were similar to [Hung et al. 2015], who showed a noticeable usage of static information like browsing course files.

Regarding age, no significant differences were found in the use of LMS. As in most of the studies reviewed, the width of the sample was insufficient. [Villalobos and Campos 2009] showed that the most active users in their study were between 26 and 35 years of age, and in this case, most of the students belonged to this range. Gender only showed differences in the communication services, where the increase was higher for females than for males. These results were partially congruent with [Rees and Noyes 2007] and [Cavus 2011], who did not find significant differences in the traditional use of LMS. They were also congruent with [Tsai and Tsai 2010], although their study was conducted at undergraduate level and included more technologies than LMS. In this case, women showed higher skills in communication, as well.

In the case of academic major, students with a technological background were better adapted to the new system, like it has been shown in the findings of [Iqbal et al. 2017]. According to m-learning experience, the most relevant difference was found in assessment services, where experienced users in Cohort 1 reduced their web access in favour of the app access, and non-users maintained a similar access frequency. This result is consistent with [Han and Han 2014] and [Al-Emran et al. 2016], who showed that a high m-learning experience was favourable for m-learning use because the system was more familiar and comfortable for the user . Additionally, it complements the findings of [López and Silva, 2014], who did not find significant differences regarding m-learning experience. All these results add on previous studies, which relate mobile devices with the use of the LMS. All of them found that students used mobile devices to carry out quick actions and the web for specific functionalities. Although the accesses were, in this case, performed through a mobile app with more usability than the mobile browser, students showed similar profiles. They used the mobile app mainly for documentation, information and communication services, where students performed their purposes in a few “clicks.” However, in the case of assessment, the results were not the same. To use this service, students required more time to answer the questions, except in the objective test, where the results were consistent with this profile.

Regarding the Research Question 2: The results of the survey showed that, with the availability of the mobile app, students in Cohort 1 finished significantly more satisfied with the LMS than students of previous years. However, general satisfaction maintained similar values. The results are consistent with the findings of [Cavus 2011], who indicated that the perceptions of students with a mobile LMS had a positive effect on their satisfaction. No significant results were found according to age, in contradistinction to [Naveh et al. 2012] and [Horvat et al. 2013], who found differences in traditional LMS. However, in the same studies, no differences were found in terms of gender. In this case, the results are consistent because no differences were found in gender, and [Cavus 2011], who also included mobile learning, also did not find differences. Only m-learning experience showed differences, as m-learning experienced users enhanced their satisfaction with the LMS when accessing via app more than non-users. They are also congruent with [Han and Han 2014], who showed

that, regardless of the accesses, all users perceived the benefits of the mobile system. However, m-learning experience eased the adaptation.

Concerning Research Question 3: Significant results were not found when comparing final scores, but the analysis of the different assessments showed that students in Cohort 1 obtained higher marks with the availability of the mobile app than the other students in the objective tests. This effect did not alter the final marks, and the rest of the assessments showed similar values to Cohort 0. These results are congruent with [Cavus 2011], as no significant differences were found between the use of mobile devices and academic performance. Nevertheless, in [De-Marcos et al. 2010], students improved their achievement with self-assessment tests through mobile devices. The analysis of the relationship between use and academic performance showed that students with lower performance accessed less frequently than students with higher performance. These results match [Chanchary et al. 2008], who indicated that students with a lower number of accesses obtained poorer grades, and [Jo et al. 2015], who observed a correlation between total accesses and final grades. This is opposite to [Darus et al. 2017] results, who indicated that their application was more beneficial for students with a poor academic performance. No differences were found in terms of age, despite other studies such as [Johnson and Galy 2013] showed a relationship between age and performance. Regarding gender, no differences were found, reinforcing the findings of [Sáiz and Zorrilla 2012] and [Santomil et al. 2015]. Finally, although [Chanchary et al. 2008] indicated that familiarity with ICT could facilitate efficient use of the resources and better performance in class, no differences were found in this study regarding performance in relation with academic major nor m-learning experience.

5.2 General Discussion

Students rapidly assimilated the use of mobile phones and tablets for educational purposes. Access to the LMS through the mobile app grew, surpassing even web access for some services. This effect may have occurred because most students already used these devices in their personal and professional lives [Crompton and Burke 2018]. Tasks, such as checking email, organizing the agenda, reviewing social media or using the communication services, are fully integrated in the mobile devices. It is often difficult to separate personal and professional lives. This new lifestyle makes the integration of traditional educational systems to mobile devices necessary.

In this study, students quickly used their mobile devices to access services. In a few "clicks," they could download a document or view information. However, for more complex tasks, they continued using computers, as shown by [Modritscher et al. 2012] [Han and Han 2014]. For example, although assessment tasks could be completed on mobile devices, the increase in access to this service was not as clearly marked as for the others, and the majority of students continued to use the traditional system. Only students with m-learning experience used their mobile applications to access these services. Student assessment consisted of multiple-choice tests, questions and cases. Multiple choice tests are simple to complete since students only need to select an option and submit their answer, but in the case of questions and cases, it is necessary to use a word processor to write the answers and then send these via the system. The usability of mobile devices in this field is currently fairly limited.

During the study, the environment was always favorable, and no network problems, such as saturation or system outage, were detected. This was very important for a good

perception of the students, as [Stowell 2014] pointed out. In the previous year, students with technological background had expressed that LMS was rigid and poorly customizable. In addition, the usability of the application was adequate, and only a few corrections were marked to fix in the next version, improving compatibility and efficiency of navigation. The use of tablets and smartphones increased the use of technology, with marked growth in access to LMS, as shown by the results. Providing an alternative means of LMS access via mobile phones enabled students to perform small tasks, such as consulting documents, accessing course information or viewing marks, with the benefit of mobility.

5.3 Limitations

We must be aware of the limitations of the study. Cohort 0 and Cohort 1 have two principal differences: the first is the availability of the app, and the second is the absence of printed materials in the classroom. This effect could have forced students to access documents using their tablets during class to help them follow the lesson. Despite that, it is not considered significant enough because all materials needed in the class remained printed, and only documentation services were affected. The study has been developed between four different academic courses with a specific student profile. The high representativeness of students with technological academic major and the narrow spectrum of age could have limited the results. It would be interesting to extend the study with a wider and more varied sample and to simultaneously analyze a control and a study group.

In the future, a similar study could be conducted that includes the variable of time. It is important to know when do students connect to the system. In previous years, students mainly used their computers at home because few brought their laptops to class. However, when the app was available, students could connect anytime and anywhere. This facilitated communication and student-professor interaction as well as student-student interactions. In this case, there is a need to develop systems and methodologies that prevent cheating.

6 Conclusions

The most notable point of the current study is that the integration of the app with the system has shown useful and efficient results. The app has eased the use of the system, the satisfaction of students with LMS has risen, and student performance has improved with increase access. More studies would help to extend the results with other apps and develop them in a wider context.

New challenges are emerging, such as developing a similar application on other operating systems, developing an environment in which teaching staff can carry out their work using these devices, and improvement of the less usable services to obtain a self-sufficient application so that web access would not be needed. The integration of mobile devices with LMS has become essential to offer students more flexibility and to leverage the use of these devices in their daily lives for educational purposes.

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