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ARTICLE

M-learning patterns in the virtual classroom

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Abstract

Mobile devices are everywhere to be found on university campuses. This has changed the nature of higher education and led to a new mobile form of e-learning known as m-learning. The aim of this article is to assess the penetration of mobile devices for learning purposes in higher education and to identify the main usage patterns. To that end, the study used two complementary methodologies: web usage mining and a questionnaire survey. Web usage mining was performed to collect data from the university's learning management system (LMS) in order to explore this new technology's usage trends in the past four academic years and to identify the main patterns of behaviour. A questionnaire survey of 460 university students was conducted to find out about the student-declared level of m-learning penetration. The results are conclusive: 25% of accesses to the LMS were made from mobile devices and 75% of the students used these devices for learning purposes. The findings of this study have significant implications not only for researchers and lecturers, but also for institutions intending to implement this teaching/learning methodology.

Original title: *Patrones de m-learning en el aula virtual*

Keywords
m-learning, mobile devices, web usage mining, Moodle, learning management systems

Patrones de m-learning *en el aula virtual*

Resumen
*Los dispositivos móviles se han vuelto omnipresentes en los campus universitarios, lo que ha cambiado la naturaleza de la educación superior y ha proporcionado una nueva forma de aprendizaje electrónico móvil (*m-learning*). El objetivo de este trabajo es evaluar la penetración que tienen los dispositivos móviles para el aprendizaje en la educación superior e identificar los principales patrones de uso. El estudio utiliza de forma complementaria dos metodologías. En primer lugar se realiza un ejercicio de minería web en la plataforma virtual de la universidad, a través del cual se exploran las tendencias del uso de esta nueva tecnología en los últimos cuatro cursos académicos y se identifican los principales patrones de comportamiento. En segundo lugar se lleva a cabo una encuesta a 460 estudiantes universitarios para conocer el nivel de penetración del* m-learning *declarado por los estudiantes. Los resultados son concluyentes, el 25% de las entradas al sistema LMS (Learning Maganament Systems) se realizan con dispositivo móvil y el 75% de los estudiantes utilizan estos dispositivos con fines de aprendizaje. Las implicaciones de este estudio son importantes tanto para investigadores y profesores como para las instituciones que pretendan implantar esta metodología de estudio.*

Palabras clave
m-learning*, dispositivos móviles, minería web, Moodle, Learning Maganament Systems*

1. Introduction

Mobile devices are everywhere to be found on university campuses owing to their low cost and improved technical capabilities, and to falling Internet service charges. This has changed the way in which students behave, interact with their environment and approach their learning tasks. This reality, which lecturers perceive on a daily basis on university campuses, has had a major impact on higher education, giving rise to an emergent teaching/learning concept based on user mobility, which is increasingly widespread in society: mobile e-learning or m-learning. A wide range of m-learning definitions can be found in the literature (Park, Nam, & Cha, 2012; Hwang & Tsai, 2011), yet they all have the same idea in common: mobile devices play an important role in learning activities, irrespective of where such activities are carried out.

Furthermore, it is now very usual to find courses that blend the traditional face-to-face methodology with an online platform, mainly based on the use of a learning management system (LMS). LMSs have modular features that enable lecturers to deliver content and practical activities to students, as well as multiple configuration options for online course management.

The three most commonly used LMSs by Spanish universities are[1] Sakai, Blackboard and Moodle. The developers of the three systems are aware of the impact that m-learning has on students, and

1. See Prendes (2009) for more information on the use of LMSs by Spanish universities.

have therefore evolved their systems by incorporating new technical features to enable adaptation to mobile technology. Thus, Sakai, which comes under Project Keitai, has been developing new functions to enable adaptation to mobile technologies since 2011 (Sakai Mobile). Blackboard has developed the Blackboard Mobile application (app), an interface that provides students and lecturers with the content of their courses in a way that is compatible with a wide variety of devices, including iOS, Android, BlackBerry and Smartphone Web OS. Moodle (Modular Object-Oriented Dynamic Learning Environment), the most commonly used LMS by Spanish universities, has also adapted to this technology. In the latest versions of this open source LMS, a mobile device app has been incorporated to adapt the user interface to desktop and laptop computers, tablets and mobile phones in order to display information in a user-friendly way (Arjona & Sánchez, 2013).

Although all of these LMSs usually provide statistical reports such as logs of course activity, the data that these reports provide do not help to draw useful conclusions about student behaviour or study habits (Zorrilla, Menasalvas, Marín, Mora, & Segovia, 2005), or even about the type of device that students use to view information. This limitation can be overcome by incorporating web usage mining techniques. These techniques have been used massively in e-commerce and are now an emergent methodology in education (Castro, Vellido, Nebot, & Mugica, 2007; Romero & Ventura, 2007). However, while the main objective of web usage mining (and data mining in general) is to increase an e-commerce firm's sales and profits, the objective in the field of e-learning is to improve teaching and learning. Some examples of the use of this research methodology in education are the studies by Pahl (2004) and, in Spain, by Casany et al. (2012).

In order to identify patterns of student behaviour, survey-based studies are by far the most usual because they enable a direct evaluation of a considerable number of important aspects of this technology.

In this study, both methodologies were used complementarily with the aim of finding out about the penetration of mobile devices in higher education and of identifying patterns of behaviour when this technology is used. On this point, it is important to highlight that, while the students' use of mobile devices is generally associated with the term 'm-learning', students do not always use them in a university environment for learning purposes. Rather, they almost certainly use them more often simply to view items like their notes, for example.

With this aim, web usage mining was performed first of all to examine the monitoring logs of basic activities undertaken by the students on the LMS, with a focus on identifying patterns of behaviour regarding accesses made from mobile devices and comparing them with accesses made from classic devices. Then a survey was conducted, in which the university students were asked directly about the adoption of this technology as a learning method.

1.1. Increased research into m-learning

M-learning is a hot topic in the educational technology-related literature. As the implementation of these techniques is relatively new, most contributions are very recent. Nevertheless, a high number of articles on this topic can be found. On an international scale, three very recently published literature reviews (Hwang & Tsay, 2011; Hung & Zhang, 2012; Wu, Jim Wu, Chen, Kao, & Liny Huang, 2012) and a

couple of editorials in one of the highest impact journals in the field of education (Rushby, 2012; Pachler, Ranieri, Manca, & Cook, 2012) have highlighted the scientific community's growing interest in this topic.

In Spain, the level of research into the penetration of these devices in Spanish universities is very limited when compared to that of other countries, despite having similar levels of student demands and high, sustained growth in terms of both the percentage of classrooms with Wi-Fi connections (more than 85%) and the number of mobile Internet connections.

Nevertheless, it is possible to find some initiatives where certain universities with a non face-to-face orientation stand out, such as the Open University of Catalonia (UOC), Spain, and the National University of Distance Education (UNED), Spain, which are paving the way for the incorporation of m-learning into higher education and consider it as one of the new horizons (Martín, Díaz, Plaza, Ruiz, Castro, & Peire, 2011). The SCOPEO (2011) report also presented a complete view of the m-learning situation in Spain, as did the recent HESTELO (2013) report that focuses on analysing the results of a survey of 111 students from the University of Valladolid (UVa), Spain. In addition, several experiences or case studies of various Spanish universities have been published.

2. Method

2.1. Population

In order to find out about the penetration of mobile devices in higher education and to identify usage patterns for this technology, this study focused on students enrolled at the Technical University of Cartagena (UPCT), Spain. Founded in 2001, the UPCT is the most modern of Spain's four technical universities. Besides 15 of its own bachelor's degree or master's degree courses, 22 Engineering and 1 Business Administration and Management bachelor's degree courses are taught at the UPCT. It is a small university with a highly technological profile. In the 2012/2013 academic year, it had 7,310 students, most of whom were enrolled on technical degree courses (Engineering), although quite a high percentage was enrolled on the bachelor's degree in Business Administration and Management course and a small proportion on the university's own bachelor's degree or master's degree courses.

2.2. Instruments Data collection

Firstly, a statistical exploration was done on the accesses made to the UPCT's Moodle-based LMS. The information was organised into four annual periods, each from 1 September to 31 August. Web usage mining served to indirectly identify certain behaviours associated with the use of this type of device.

Secondly and complementarily, a questionnaire survey of 460 university students enrolled on the various degrees courses taught at the UPCT in the 2012/2013 academic year was conducted. Convenience sampling was used to gather relevant data from the population, such as gender, degree type and year. In total, there were 460 responses, representing 6% of the population.

The questionnaire was divided into two sections. The first section was used to identify the demographic aspects of the students; it also contained questions to find out about the penetration of mobile devices for learning purposes. The second section contained three questions to evaluate levels of satisfaction regarding Moodle use when mobile devices were used. The answers were given on a Likert scale from 1 to 7, where 1=Strongly disagree and 7=Strongly agree.

3. Accesses to the LMS from mobile devices

Activity on the UPCT's LMS has continued to increase owing to the intensive use made of it by the students and lecturers, and it is now an essential tool in university teaching. Monitoring this LMS since 2009 represents an excellent tool to get an in-depth knowledge of changes in m-learning mobile device usage and of the patterns of behaviour of students accessing the website from such devices. Once again, it is important to note that not all accesses logged on the LMS are for learning purposes, as many are simply for viewing administrative items like timetables and notes, for example.

Attention shall be focused on the type of device used to access the system, with the main aim of finding out about the evolution that has taken place in recent years. Table 1 gives details of various relevant access data for the last four periods in which data was available.

Table 1. General access data, by year and device type

		Period			
		2009/10	2010/11	2011/12	2012/13
Total (includes mobile devices)	Number of visits	668,937	1,031,478	1,308,187	1,584,192
	Number of pages visited	5,277,737	7,509,552	10,317,962	12,297,842
	Pages per visit (mean)	7.89	7.28	7.89	7.76
	Time (mean)	5 m 34 s	5 m 50 s	6 m 58 s	7 m 15 s
	Bounce rate (%)	9.27%	10.14%	11.07%	14.38%
Mobiles (Smartphones)	Number of visits	9,495	49,090	156,945	309,720
	Number of pages visited	42,699	240,766	747,744	1,376,974
	Pages per visit (mean)	4.50	4.90	4.76	4.45
	Time (mean)	7 m 57 s	5 m 14 s	4 m 44 s	4 m 26 s
	Bounce rate (%)	12.79%	12.05%	18.14%	12.96%
	Mobiles / Total visits (%)	1.42%	4.76%	12.00%	19.55%
	Mobiles / Total pages (%)	0.81%	3.21%	7.25%	11.20%
Tablets	Number of visits	0	0	11,088	58,730
	Number of pages visited	0	0	56,413	337,364
	Pages per visit (mean)	--	--	5.09	5.74
	Time (mean)	--	--	4 m 36 s	6 m 05 s
	Bounce rate (%)	--	--	15.57%	17.85%
	Tablets / Total visits (%)	--	--	0.85%	3.71%
	Tablets / Total pages (%)	--	--	0.55%	2.74%

The data shown in Table 1 highlight a number of points. First, the increase in the total number of visits was spectacular, almost tripling in the analysis period. Thus, in the 2012/2013 period, the UPCT's LMS received a total of 1,584,192 visits with 12,297,842 pages visited, whereas in the 2009/2010 period there were only 668,937 visits with 5,277,737 pages visited. Despite this spectacular increase, the mean pages per visit remained constant in every period at nearly 8. Also worthy of note is the increase in the mean time that a visit lasted, which rose from 5 minutes 34 seconds in the first period to 7 minutes 15 seconds in the last period. This sustained increase might be due to the multiplication of content that the lecturers incorporated into their courses.

Second, Table 1 breaks down the data by the two most common mobile devices: smartphones and tablets. These data are the most relevant to this study, as they allow the evolution of accesses from these mobile devices to be observed. While only 1.42% of accesses (9,495 visits) were from smartphones in the 2009/2010 period,[2] the percentage had risen to 19.55% in the last year. The same increase was observed for accesses from tablets, which rose from 0% to 3.71%. Taking the two types of mobile device together, the number of visits from them in the last period accounted for nearly one quarter of accesses to the LMS.

When compared to the results obtained in the study by Casany, Alier, Mayol, Galanis, and Piguillem (2012) on another technical university, those obtained here are very different. Thus, in September 2011, 96.21% of accesses were from desktop or laptop computers, while 3.48% were from mobile devices and only 0.28% from tablets.

There are other characteristics that should be highlighted when exploring accesses from different types of device. First, the mean number of pages per visit was much lower when access to the LMS was from a mobile device than when it was from a classic device (desktop or laptop). Moreover, albeit with minor fluctuations, this pattern was sustained over the four analysis periods. For example, in the last period (2012/2013), the mean number of pages per visit was 7.76, irrespective of the device used, compared to a mean number of 4.45 from smartphones. It should also be noted that the mean number of pages per visit from tablets was between both figures (5.74). Second, the mean time that a visit lasted was greater when a desktop was used (7 minutes 15 seconds) than when a smartphone or tablet was used (4 minutes 26 seconds and 6 minutes 05 seconds, respectively). The impression is that there is a strong relationship between these two indicators (mean number of pages, mean time) and the size of the screen from which the LMS is accessed. Those users who access from mobiles tend to look for the required information quickly, whereas those who access from classic devices have longer and more in-depth browsing sessions as regards the number of pages visited. These results coincide with those obtained from other studies (Mödritscher, Neumann, & Brauer, 2012), including those conducted on Spanish universities (Casany et al., 2012).

Finally, the bounce rate, referring to the number of visits in which only one page of a website is viewed before leaving it, was slightly higher for mobile devices. This may be due to factors such as design (small screen) or the students, who, taking advantage of the ubiquity of their mobiles, use them to get one-off pieces of information (notes, for example) and leave the site after viewing just one page.

2. It should be noted that, in the first two periods, there were no accesses from tablets as these devices had yet to become popular.

3.1. Time patterns: m-learning study habits

Access behaviour from mobile devices also displays time patterns that can be described by assessing accesses to the LMS. In this sub-section, detailed information has only been given for the last period (2012/2013).

Table 2 shows the percentage distribution of accesses by device type, taking into account the most significant periods into which an academic year can be considered divided: classes, exams, holidays and summer break. Some important variations were found. Thus, the highest percentage of accesses from mobile devices occurred at exam time, almost certainly due to one-off access when students were looking for specific information. In this period, the demand for information using mobile devices was higher than 30%, compared to the 25% as an overall indicator. The results obtained by Casany et al. (2012) were comparable. A similar behaviour was also identified in the distribution of accesses by device type in the summer break. This increase might be due to the sociodemographic characteristics of the Region of Murcia, a Spanish autonomous community that has a high number of second homes that do not have landline Internet access, thus forcing the students to use their smartphone data connections.

Table 2. Access, by period and device type (2012/2013)

	Classes	*Exams*	*Holidays*	*Summer break*	*Total*
Desktop / Laptop	81.4%	69.1%	81.1%	68.1%	76.7%
Mobile	15.1%	27.2%	15.6%	29.1%	19.9%
Tablet	3.4%	3.7%	3.3%	2.8%	3.4%

Classes: 30 weeks of lectures; Exams: official times from February to June; Holidays: two official periods for Christmas and Easter; Summer break: no lectures.

In addition, other studies have documented differences in the times of day when accesses occur. Selecting the same times as those in the study by Casany et al. (2012), access to the LMS was assessed by the type of device. Table 3 shows the results.

Table 3. Percentage distribution of accesses, by time and device type (2012/2013)

	0-7am	*8am-1pm*	*2pm-4pm*	*5pm-8pm*	*9pm-12am*	*Total*
Desktop / Laptop	71.3%	73.1%	87.7%	79.8%	76.2%	76.7%
Mobile	24.4%	23.1%	10.3%	17.3%	19.9%	19.8%
Tablet	4.3%	3.8%	2.0%	3.0%	4.0%	3.4%

This highlights two points. First, mobile device activity was slightly higher at night, thus coinciding with the results obtained by Casany et al. (2012). It was also higher in the morning (8am-1pm), and lower in the third time span (2pm-4pm)..

Finally, the percentage distribution of accesses by day of the week is shown in Table 4. No important variations were found either between days of the week or at weekends.

Table 4. Percentage distribution of accesses, by day of the week and device type (2012/2013)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
Desktop / Laptop	76.1%	75.8%	77.1%	76.5%	75.2%	77.7%	80.1%	76.7%
Mobile	20.7%	20.8%	19.7%	19.9%	21.3%	18.8%	16.3%	19.9%
Tablet	3.2%	3.5%	3.2%	3.7%	3.5%	3.5%	3.6%	3.4%

4. Questionnaire survey results

The second analysis tool was a questionnaire survey conducted on 460 students at the UPCT. The main objective of this second analysis was to quantify the penetration of mobile device use, understood as the percentage of students using a mobile device for learning purposes.

4.1. M-learning penetration

Table 5 shows the main demographic characteristics of the sample analysed.

Table 5. Demographic data of the students and m-learning use

	Number (N)	Percentage (%)
Q1: Gender		
Male	324	70.4%
Female	136	29.6%
Q2: Type of degree course		
Engineering	337	73.3%
Business Administration and Management	93	20.2%
University's own bachelor's or master's	30	6.5%
Q3: Year in which you are enrolled		
First	160	34.8%
Second or higher	300	65.2%
Q4*: Do you have any of these mobile devices?		
Smartphone	374	91.0%
Tablet	104	25.3%
iPod	56	13.6%
iBook	33	8.0%
None	30	7.3%
Q5: Have you ever used any mobile devices for studying?		
No	115	25.0%
Yes	345	75.0%

* The sum of percentages may be higher than 100%

The students were technologically well-equipped; 91% had smartphones and only 7% did not have a mobile device with an Internet connection. Also worthy of note is that 25% of the students had a tablet; a high percentage when taking into account the newness of these devices and the difficulty of gaining access to them owing to their cost.

With these data, it was no surprise to find that 75% of the students said that they used these devices for studying. This percentage is high when compared to those presented in the recent HESTELO (2103) study, in which nearly 50% said that they used m-learning.

In order to work out whether sociodemographic factors had an influence on any variations in this percentage, the following sub-section analyses the existence of differential behaviours by gender, year, degree type and the availability or not of mobile devices.

4.2. Sociodemographic factors

Table 6 shows the results for the relationship between demographic factors and m-learning use. Gender, year and degree type did not lead to any significant differences. In all cases, tests of independence based on χ^2 yielded null hypotheses.

Table 6. Demographic factors and m-learning use

		Uses m-learning			
		No	*Yes*	*χ2*	*p-value*
Gender	Male Female	26.5% 21.3%	73.5% 78.7%	1.39	0.238
Year	First Second or higher	25.6% 24.4%	74.4% 75.6%	0.08	0.775
Degree course	Engineering Business Administration and Management Master's	24.9% 21.5% 36.7%	75.1% 78.5% 63.3%	2.78	0.249
Mobile device availability	Does not have a smartphone Has a smartphone	78.9% 20.1%	21.1% 79.9%	64.29	0.000
	Does not have a tablet Has a tablet	30.2% 9.5%	69.8% 90.5%	19.92	0.000
	Does not have an iPod Has an iPod	26.4% 16.1%	73.6% 83.9%	3.01	0.083

However, mobile device availability did lead to significant differences. For example, the percentage of students doing m-learning reached up to 90% among those with tablets. In general, this suggests a positive relationship between the availability of the right devices and the adoption of m-learning. If students have the right devices, they use them for learning purposes.

4.3. Attitudes towards mobile device use

Finally, to find out about the students' perceptions of using the LMS when they accessed it from mobile devices, three questions were posed to rate accessibility to the UPCT's virtual classroom. It should be noted that, at the time of writing, the UPCT's LMS did not have the app for mobiles, so it was to be expected that the students would rate some aspects negatively. Table 7 shows the overall results only for those students who said that they used m-learning. Regarding the first two questions (Q6 and Q7), the ratings were surprisingly positive.

Table 7. Perception of accessibility to Moodle from mobile devices

	Mean	SD
Q6: It is easy to view virtual classroom (VC) content using a mobile device (MD)	5.01	1.81
Q7: It is easy to do VC activities (questionnaires, forums, messages) using an MD	4.34	1.80
Q8: It would be good to work with specific resources for mobile technology in the VC	5.34	1.61

The impression is that the students are prepared to use mobile devices despite the fact that universities do not facilitate access.

5. Conclusions

Mobile device use is increasingly commonplace among the Spanish university population. Students use these devices for everything, including study. There is no doubt that m-learning is an emergent learning technique that is taking root among university students.

The Moodle access data obtained in this study show how important the use of these devices in higher education is becoming. In the 2012/13 academic year, 25% of the UPCT's students accessed this LMS from mobile devices. In addition, the survey results show that 75% of the students used them for learning purposes. They even perceived Moodle's usability as acceptable, despite the fact that, at the time of writing, the UPCT had yet to adapt it to mobile devices. This would confirm that certain accesses were merely an extension of access to the e-learning platform from traditional devices, where the pedagogical methodology had not changed because it only provided access to content anytime and anywhere. However, the hope is that m-learning will provide new pedagogical models that can only be implemented by using these technologies. Although the future is uncertain, the tendency is clear, and these figures will almost certainly continue to increase in the 2013/14 academic year.

The results of this study show that there are various actions that university managers ought to pursue to meet this growing demand from the students. First, it is essential to adapt LMSs to facilitate access from mobile devices. At the time of writing, very few universities had rolled out this system. University students demand that content management systems (CMSs) be updated and adapted

to enable them to access them in a more flexible and efficient way from mobile devices. Second, as designers and creators of courses on LMSs, it is important for lecturers not to overlook the importance of providing a format that can be accessed from a range of devices, thus making their courses more user friendly.

In addition, most lecturers are opposed to the use of mobiles in their classes. Despite the ubiquity that these technologies permit and the unique type of learning that they facilitate (Mobilla, 2011), formal education systems usually ban them or pay no attention to them. This is indeed the case according to the latest HESTELO (2103) report, which asserts that 44% of students use mobile devices in class, though only 2% do so at the lecturer's request. Moreover, 17% are banned from using them. This opportunity should not be missed. The potential for learning that mobile devices offer is enormous, and they have the capability of being a support tool for solving some of the problems that higher education is experiencing.

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