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ORIGINAL

Ubiquitous Educational Use of Mobile Digital Devices. A General and Comparative Study in Spanish and Latin America Higher Education

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ABSTRACT
This study conducted a general and comparative analysis of how university students use mobile digital devices for educational purposes in various places and spaces both inside and outside university facilities in Spain and Latin America. It analyses a total sample of 886 students (442 Spanish and 444 Latin American) corresponding to five Spanish and five Latin American universities. The research methodology was based on factorial analysis and comparison between groups with parametric and nonparametric tests. The results show that educational use of mobile digital devices in the Hispanic world concentrates on the use of smartphones and tablets inside university facilities; primarily in college cafeterias, corridors, classrooms and libraries. Spanish and Latin American students used tablets in and out of University facilities for storing and retrieving information, and smartphones for sharing educational information and content.

KEY WORDS: MOBILE DIGITAL DEVICES, UBIQUITY, MOBILITY, HIGHER EDUCATION, SPAIN, LATIN AMERICA.

1 INTRODUCTION

Teaching-learning processes and social interaction among Higher Education students no longer takes place only in physical and determined spaces in university campuses, as was the case until a few years ago. The space and place where students are located is no longer a determinant factor for academic or personal interaction that can be a part of the teaching-learning process in current universities. This context of mobility and ubiquity is favoured by technological infrastructures for the connection of digital devices (Fryer, 2017; Mercier & Higgins, 2013; Sevillano & Vázquez-Cano, 2015). The analyses which have been conducted on ubiquity and use of mobile digital devices in various parts of the world, have primarily focused on the educational use and potential of these devices (Ahmed & Parsons, 2013; Cochrane, 2014; Keengwe, 2015), among many others. Likewise, the reports which several technology companies have conducted are mainly based on the analysis of patterns of use of the devices according to several variables: age and sex of users, number and nature of the applications installed and used, frequency, connection time range, duration of connection, etc. (Pearson, 2014; UNESCO, 2013).

In contrast, the analysis of the space and place where users employ mobile digital devices has mostly been limited to the geographical-urban aspect using geolocation applications (Liao, 2015). The influence of the space and place from which users connect to mobile devices and why they do so has barely been studied in the field of education (Dennen & Hao, 2014; Ponce, & Pagan-Maldonado, 2017; Vázquez-Cano, 2012). The implications of the study regarding the places from which university students use mobile digital devices could have deep repercussions to understand the new patterns of use of these devices on learning, to adapt and improve technological and spatial infrastructures in university campuses, to enhance group interactivity models for studying, to implement contents adapted to the place and needs of students, to adapt the format of educational contents to various devices and, in short, to provide a better technological, content and social response to students using mobile digital devices as another resource for study and social interaction from multiple locations. Therefore, the objective of this study is to analyse the spaces and places where Spanish and Latin American university students use their mobile digital devices (smartphones, tablets and laptops) for educational purposes and establish the different patterns and places of use between the two geographical areas comprising the Hispanic world.

1.1. Learning in the ubiquitous society

Ubiquitous learning is a new educational paradigm in which students confront learning with a more global perspective and where physical space is not a determinant variable for learning (Garcia, 2014). Non-formal environments and places —cafeterias, streets, modes of transport, home, social networks, game environments, media and popular culture, workplaces, etc.— become new learning settings (Barbosa, Barbosa, & Wagner, 2012; Buckingham & Ferguson, 2012; Keengwe, 2015; UNESCO, 2013). Higher Education is still in the process of trying to understand, analyse and adapt to this new social and educational setting, however, what is certain is that universities cannot ignore this new context of mobile computation (Dennen & Hao, 2014). In this social and educational context, ubiquity is leading to profound changes in the learning experience of students and providing them with the necessary competences

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and skills both for education and social and work environments (Ahmed & Parsons, 2013; Taylor, 2015). Therefore, ubiquity in the learning process requires considering the massive use of mobile devices. The most advanced theories about learning maintain that learners do not passively absorb personally significant knowledge, but rather create it actively, based on their experience of the world (Cope & Kalantzis, 2009). From the moment we use web technology to give meaning to the world around us, through blogs, wikis, mash-ups, podcasts, social software, virtual worlds, etc., we recreate a real world based on the virtual one, blending the two, which mutually feedback on each other (Sevillano & Vázquez-Cano, 2015; Vázquez-Cano, Fombona, & Fernández, 2013). Current research on educational ubiquity systems are experimenting with personalised student services based on their context, a trend which has been termed: "context-sensitive u-learning" (Yahya, Ahmad, & Jalil, 2010). Regarding the use of mobile devices on higher education, they can also create new and unprecedented educational opportunities. This integration can result in situated awareness that connects knowledge from formal learning settings more directly with informal learning practices and, in turn, makes these educational experiences more readily available for later reflection and discussion in the classroom (Vázquez-Cano, 2013). Recent studies indicate that hybrid designs facilitated the learners' reconciliation of the different levels of knowledge and experience across formal and informal learning environments. A number of studies support the observation that "mobile documentation" in authentic environments enhanced "situated awareness" and immediate engagement (Pimmer, Mateescu, & Gröhbiel, 2016; Uzunboylu et al., 2009). The authors stated that these differences were explained by the mobile phone features that allow more immediate and situated engagement. Furthermore, posing questions and disseminating activating exercises for formative assessment via mobile devices was reported to stimulate and activate learners in the lecture hall (Wang, Novak, & Pan, 2009). Beyond instructionist affordances, there is some mostly qualitative evidence that mobile devices lend themselves to supporting learners on the move by allowing them to capture ephemeral thoughts, in the form of audio recordings related to work situations (Wang, Wiesemes, & Gibbons, 2012), quick noting of ideas (Schepman et al., 2012; Taylor et al., 2010) and photographs as instant reminders (Pimmer, Mateescu, & Gröhbiel, 2016; Chaves-Barboza et al., 2017).

Furthermore, the use of digital devices can involve hybridization, which promotes "situated awareness"; that is, connecting learning situations from the users' life worlds with more formal learning environments through orchestrated collaboration. Context crossing also incorporates the integration of formal and informal learning environments. This aspect is frequently stressed in mobile learning literature (Cook, Pachler, & Bradley, 2008, 2008) and also in other related domains, such as personal learning environments (Dabbagh & Kitsantas, 2012). Confirming previous reviews, the broad majority of mobile and ubiquitous learning studies showed positive effects. However, empirical evidence that would favour a broad application of mobile and ubiquitous learning in higher education settings is still limited. Also, there is some mostly qualitative evidence that mobile devices lend themselves to supporting learners on the move by allowing them to capture ephemeral thoughts, in the form of audio recordings related to work situations (Wang et al., 2012), quick noting of ideas (Schepman et al., 2012; Taylor et al., 2010) and photographs as instant reminders for later use and connect their observations with concepts and knowledge from formal education (Pimmer, Mateescu, & Gröhbiel, 2016). Universities and higher education institutions must advance in teaching processes in multiple formats accessible anywhere, anytime so that both the teaching and the learning processes are enriched by the possibility of a learning process that is continuous, hyper-connected, highly collaborative and allows feedback. A learning structure that must stem from the natural learning processes in the ubiquitous society. The labour and business world demands a new type of worker, highly flexible and competent in a changing world, highly hyper-connected with collaborative, multiplatform and ubiquitous work skills. This drives universities to generate new techno-educational structures and formats that are more flexible and adapted to current social and professional situations, taking into account that probably ten years from now, the current teaching-learning system will have a completely different configuration where mobile and ubiquitous learning will take an important role in and outside traditional the educational scenarios (Freeman, Adams, Cummins, Davis, & Hall, 2017).

The use of mobile digital devices to connect to and use the web is growing exponentially around the world. In Latin America, in a sample of more than 50 million users in the first semester of 2014, the use of computers fell 11.3%, while the use of smartphones grew 70.1% and tablets 32%. The studies carried out show that the use of mobile devices is being strongly established, representing 25.9% of total annual traffic in Latin America. Likewise, in Spain, penetration and use of smartphones and tablets is very high. Over 20 million Spaniards connect to the Internet through their smartphone. They are multi-screen users: 98% of users employ several devices on the same day, and 90% use various screens sequentially. 36 million Spaniards (89%) over the age of 13 have a mobile telephone and of these, over 20 million use smartphones. This makes Spain the European country where this type of terminal has spread the most, with a penetration of 118.2%. For the first time, smartphones are positioned as the preferred medium to access the Internet in Spain (85.5% of users) (Ditrendia, 2017). Given this social-digital context pervading almost all ages and social levels, studies are required to analyse the ubiquitous educational use of mobile digital devices in university contexts so that new technological designs can be decided on and developed for educational infrastructures and methods that improve the teaching-learning processes and the necessary competences for the future professional and social development of graduates. These initiatives are already taking over certain universities, for example, Brunel University in London, The University of Western Australia and even King's College in London, have renewed their infrastructure to meet the demand for connection with "BYOD" among their over 6,000 employees and almost 23,500 students. Universities such as the University System of Georgia have developed specific regulations to support BYOD initiatives and Ryerson University (Canada) has improved the security and privacy processes to support these initiatives on its university campus. Others such as Northern Illinois University deliver courses to their students to use their own digital devices for educational purposes. This trend generates a new training context mediated by mobile and ubiquitous devices on university campuses, which could provide a significant opportunity to generate new environments and ways of learning (Roschelle & Michalchik, 2017; Usman, 2017).

2 METHOD

The main objective of this research was to determine the most frequent places where Spanish and Latin American students made an educational use of digital devices (laptops, tablets and smartphones). For this purpose, we established a list of places: inside the classroom and outside the classroom (cafeteria, corridors, leisure areas, library, habitual residence, workplace, street, and transport). Furthermore, a list of three macro categories in relation to educational activities with mobile devices was proposed (Ferrari, Punie, & Brecko, 2013):

1. Inform: Identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose. Activities: 1.1 Browsing, searching and filtering information, 1.2 Evaluating information, 1.3 Storing and retrieving information.
2. Communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness. Activities: 2.1 Interacting through technologies, 2.2 Sharing information and content, 2.3 Engaging in online citizenship, 2.4 Collaborating through digital channels.
3. Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licenses.

Activities: 3.1 Developing content, 3.2 Integrating and re-elaborating, 3.3 Copyright and Licenses, 3.4 Programming.

We developed a comparative study on the ubiquitous use of mobile digital devices in Spain and different countries in Latin America. This Universities involved in this research were part of the project entitled: “Ubiquitous Learning with Mobile Devices: Preparation and Implementation of a Competence Map in Higher Education” under funding by the Spanish Ministry of Education. Participants comprised a total sample of 886 university students (442 Spanish and 444 Latin American) corresponding to five Spanish universities and five Latin American ones, as shown on Table 1:

Table 1. Participating Universities

Universities	Num. protocols
	Spain
Madrid. Universidad Complutense de Madrid	42
Vigo. Universidad de Vigo	46
Oviedo. Universidad de Oviedo	169
Granada. Universidad de Granada	77
Madrid. Universidad Nacional de Educación a Distancia (UNED)	108
Total	442
	Latin America
Chile. Universidad del Libertador Bernardo O´Higgins	98
Peru. Universidad Nacional Hermilio Valdizán. Huánuco	52
Colombia. Universidad de Cartagena	110
Panama. Universidad Pública de Panamá	79
Mexico. Universidad Veracruzana. Xalapa	105
Total	444

Table 2. Sample educational characteristics

	Variables	Spanish Students	Latin American Students
Gender	Male	108	142
	Female	334	302
Age	18-20	108	128
	21-23	146	151
	24-27	44	69
	28-31	27	54
	Over 31	119	42
Studies	Arts-Humanities	58	67
	Sciences	101	90
	Social Sciences	189	201
	Health Sciences	50	46
	Architect.-Engineering	44	40
Total	(N=442-51%)	(N=444-49%)	

The questionnaires were delivered by university teachers during the 2015-16 academic year in the various Spanish and Latin American universities. These universities were participating in the Project of the General Directorate for Research and Management of the National R&D Plan (Ubiquitous Learning with Mobile Devices: Preparation and Implementation of a Competence Map in Higher Education), which was funded by the Spanish Ministry of Education (EDU2010-17420-Subprogramme EDUC). The questionnaire consisted of 26 items with two possible types of questions: polychoric and tetrachoric; which required a mixed factorial method (Bonett & Price, 2005). The correlation between two questionnaire items or variables depends on their substantial similarity (the content of the item), but also on similarities in their statistical distributions (Bernstein, Garbin, & Teng, 1988, p.398). This means that items with similar distributions have a greater correlation than those with different distributions (McLeod, Swygert, & Thissen, 2001). For example, items that are easy to answer are grouped with more difficult ones, even though all items measure the same latent variable (Nunnaly & Bernstein, 1994, p.318). Applying a factorial analysis without first ensuring this is not the case can lead to factors based only on the similarity of distributions and not on a true latent variable that substantially summarises said items or variables (Bartholomew, 1987). In this situation, scientific literature recommends calculating means and standard deviations of the items for each factor once these have been found (Hair, Anderson, Tatham, & Black, 1988; Ferrando, 2009). If it is found that a factor mostly has items with high values, another one has medium values and a third has low ones, it would be justified to believe that factors have a statistical origin and not a natural one. Therefore, we conducted an initial factorial analysis with the programme SPSS 19 to generate factors that were more representative of the ubiquitous use of mobile digital devices in the total sample (Spain and Latin America). Next, we checked whether the factors obtained had normal distributions to calculate possible differences between the groups. Normality was calculated with a “Kolmogorov-Smirnoff” test and the factor normality results allowed us to analyse with parametric and nonparametric tests (Mann Whitney and Student’s t-distribution) the difference between groups to compare the results of the two geographical areas.

3 RESULTS AND DISCUSSION

First, we evaluated the reliability of the questionnaire used with Bartlett's sphericity test and a KMO sample suitability test (Table 3).

These results showed that the initial correlation matrix for the sample with which we were working was appropriate to conduct the factorial analysis. The KMO sample appropriateness test shows a value close to 1 (0.847), therefore the partial correlations of our variables are very small. We adopted the principal axis method as the best way to unravel the latent structure we were looking for in the variables (Bartholomew, 1987). According to this criterion, and given the greater number of initial variables (26), the number of factors with eigenvalues higher than 1 is 6. Eigenvalues are listed on Table 4.

Table 3. Questionnaire Reliability

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.847**
Bartlett's sphericity test	Chi-square approximation	4947.298
	gl	325
	Sig.	.000

Table 4. Total Variance Explained

Factor	Initial Eigen-values	Extraction Sums of Square Loadings	Rotation Sums of Squared Loadings				
	Total	% o variance	Cumulative %	Total	% ofvariance	Cumulative %	Total
1	6.867	26.413	26.413	6.509	25.033	25.033	5.897
2	4.692	18.046	44.458	4.338	16.683	41.717	4.519
3	2.186	8.408	52.867	1.681	6.467	48.183	3.122
4	1.527	5.875	58.741	1.027	3.951	52.134	1.347
5	1.310	5.037	63.779	.767	2.949	55.083	1.998
6	1.099	4.225	68.004	.697	2.682	57.765	.951
7	.957	3.679	71.683				
8	.803	3.088	74.771				
9	.702	2.702	77.473				
10	.641	2.464	79.936				
11	.616	2.370	82.306				
12	.546	2.101	84.407				
13	.502	1.932	86.339				
14	.496	1.906	88.246				
15	.439	1.687	89.933				
16	.371	1.428	91.361				
17	.367	1.412	92.773				
18	.318	1.225	93.998				
19	.267	1.028	95.025				
20	.247	.952	95.977				
21	.223	.860	96.837				
22	.207	.797	97.633				
23	.181	.696	98.330				
24	.159	.611	98.941				
25	.156	.598	99.539				
26	.120	.461	100.000				

Extraction Method: principal axis factoring.

We have also included a scree plot clearly showing six factors that can be selected. Considering the information provided in Table 4, the six factors explaining 68.004% of common data variability (commonalities):

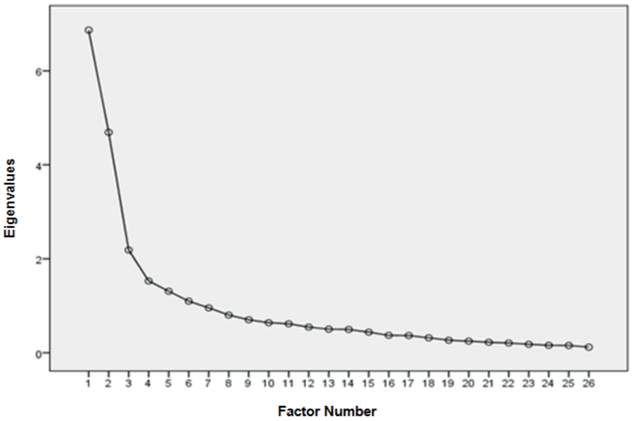

Figure 1. Scree plot

In these circumstances, we carried out an oblique rotation of factors. For interpretation of oblique rotation, the two matrices need to be considered, so that construction of factor significance is slightly more complex than for factorial rotation. The results of the configuration and the structure matrices are shown in Figure 2.

Interpretation of the six factors according to total variance and significant incidence in the two geographical groups is the following:

Factor 1. Educational use of tablets in university facilities:

- College cafeteria (.767)
- College corridors (.806)
- Classrooms (.856)
- Library (.784)

Factor 1 represents a total variance of 26.413%, with significant results of educational use of tablets among Spanish and Latin American students at university facilities. Particularly relevant is the use of this device in university classrooms (.856), college corridors (.806), libraries (.784), and college cafeterias (.767). This shows that in the two geographical areas, the use of this device for educational purposes by university students at university facilities is significant. The main educational uses with tablets in University facilities are in relation with macro category 1 "Inform" and 3 "Create and edit new content": 1.1 Browsing, searching and filtering information 1.3 Storing and retrieving information and 3.2 Integrating and re-elaborating. Similarly, in ubiquitous learning studies, mobile and portable technologies are conceived either as tools that allow learners to access information irrespective of their physical context, for example on a bus (Liu & Hwang, 2010). This trend can be a complement to a number of studies focused on analysing how a mobile system could facilitate learning during lectures by posing questions and activating exercises via mobile devices (Wang et al., 2009).

Factor 2. Educational use of smartphones at university facilities:

- College corridors (749)
- Classrooms (812)
- Library (742)

Factor 2 accumulates a variance of 18.046% and shows the incidence of the educational use of mobile telephones at university facilities. In spite of the apparent prohibition or recommendation of many teachers not to use mobile telephones in the classrooms, both in Spain and in Latin America, their use in these places is significant (.812). Similarly, they are used quite frequently in college corridors (.749) and libraries (.742). Smartphones for educational uses at University facilities are related to macro category 2 "Communicate": 2.1 Interacting through technologies and 2.2 Sharing information and content. Along this line, Frohberg et al. (2009) observed that although mobile phones are primarily communication devices, communication and social interaction played a surprisingly small role in mobile learning projects.

Configuration Matrix ª	Factor 1	2	3	4	5	6
Educational use of laptops in college cafeteria						.301
Educational use of tablets in college cafeteria	.702					
Educational use of smartphones in college cafeteria	.401					
Educational use of smartphones in college corridors		.731				
Educational use of laptops in college corridors						-.356
Educational use of tablets in college corridors	.732				-.487	
Educational use of smartphones in classrooms		.688				
Educational use of laptops in classrooms				-.370		.301
Educational use of tablets in classrooms	.827				-.495	
Educational use of smartphones in outdoor leisure areas						
Educational use of laptops in outdoor leisure areas			.619	-.372		.301
Educational use of tablets in outdoor leisure areas					.320	
Educational use of smartphones in habitual residence			.512			
Educational use of laptops in habitual residence				.510		
Educational use of tablets in habitual residence					.598	
Educational use of smartphones in workplace			-379			
Educational use of laptops in workplace						
Educational use of tablets in workplace					.437	
Educational use of smartphones on the street			.498			
Educational use of laptops on the street				.620		-355
Educational use of tablets on the street					.412	
Educational use of smartphones in library		.699				
Educational use of laptops in library						
Educational use of tablets in library	.645					
Educational use of smartphones in modes of transport			.600			
Educational use of laptops in modes of transport				.573		
Educational use of tablets in modes of transport						

Extraction Method: Principal Axis Factoring. Rotation Method with Kaiser Normalization.
a. Rotation converged in 14 iterations.

Structure Matrix	Factor 1	2	3	4	5	6
Educational use of laptops in college cafeteria	.370					.370
Educational use of tablets in college cafeteria	.767					
Educational use of smartphones in college cafeteria	.389					
Educational use of smartphones in college corridors		.749				
Educational use of laptops in college corridors						-.340
Educational use of tablets in college corridors	.806				-.400	
Educational use of smartphones in classrooms		.812				
Educational use of laptops in classrooms	.336			.402		.336
Educational use of tablets in classrooms	.856		.378		-.373	
Educational use of smartphones in outdoor leisure areas			.715			
Educational use of laptops in outdoor leisure areas	.301			.439		-.309
Educational use of tablets in outdoor leisure areas			.401		.419	
Educational use of smartphones in habitual residence			.657			
Educational use of laptops in habitual residence				.678		
Educational use of tablets in habitual residence					.726	
Educational use of smartphones in workplace			.549			
Educational use of laptops in workplace						
Educational use of tablets in workplace					.501	
Educational use of smartphones on the street			.506			
Educational use of laptops on the street						-301
Educational use of tablets on the street					.401	
Educational use of smartphones in library		.742				
Educational use of laptops in library						
Educational use of tablets in library	.784		.386		-.491	
Educational use of smartphones in modes of transport			.795			
Educational use of laptops in modes of transport						
Educational use of tablets in modes of transport					.631	

Extraction Method: Principal Axis Factoring. Rotation Method with Kaiser Normalization.

Figure 2. Configuration and structure matrices.

Factor 3. Educational use of smartphones outside university facilities:

- Educational use of mobiles in modes of transport (.795)
- Educational use of mobiles in outdoor leisure areas (.715)
- Educational use of mobiles in habitual residence (.657)
- Educational use of mobiles in workplace (.549)
- Educational use of mobiles on the street (.506)

Factor 3 significantly diminishes its impact on explained variance (8.408%) and shows educational use of smartphones outside university facilities. Their use is far less intense than the use of tablets and mobile telephones within university facilities. Educational use of smartphones concentrates primarily on three areas: modes of transport (.795), outdoor areas (.715) and habitual residence (.657). In this category results coincide with factor 2. In addition, other studies (Solvberg & Rismark, 2012) found students also gathered in groups at other locations on the campus, where they followed the lecture through smart phones and laptops. Furthermore, studies like Chang et al. (2011) show that integrated mobile delivery formats that include text, sound and images were also found to have significantly positive knowledge outcomes for computer science and language learning students. Similarly, language students who audio-recorded their reflections on their academic experiences clearly preferred to use mobile phones rather than a studio because this allowed them to make recordings in familiar environments (Kessler, 2010). This confirms results from other studies in which the students subsequently discussed their documented learning experiences with peers via chat and suggested solutions for overcoming environmental problems (Uzunboylu, et al., 2009).

Factor 4. Educational use of laptop outside university facilities:

- Educational use of laptop in habitual residence (.678)
- Educational use of laptop in outdoor leisure areas (.439)

Factor 4 represents 5.875% of total explained variance, corresponding to the use of laptops for educational purposes outside university facilities. The main educational use takes place at students' habitual residences (.678) and to a lesser degree in outdoor leisure areas (.439). The use of laptop outside the University facilities for educational purposes is in relation to macro category 3 "Create and edit new content": 3.1 Developing content, 3.2 Integrating and re-elaborating and 3.4 Programming.

Factor 5. Educational use of tablets outside university facilities:

- Educational use of tablet in habitual residence (.726)
- Educational use of tablet in modes of transport (.631)
- Educational use of tablet in workplace (.501)
- Educational use of tablet in outdoor leisure areas (.419)
- Educational use of tablet on the street (.401)

Factor 5 represents 1.310% of total explained variance, and although there are several items involved, their significance is low. Educational use of tablets outside university facilities takes place primarily at students' habitual residence (.726) and in modes of transport (.631). The use of tablets outside the classroom for educational uses is in relation to macro category 1 "Inform" and 2 ·Communicate": 1.3 Storing and retrieving information, 2.1 Interacting through technologies and 2.2 Sharing information and content. Some of these educational activities are also reported in recent studies (Garcia, 2014; Sevillano & Vázquez-Cano, 2015).

Factor 6. Educational use of laptop at university facilities:

- Educational use of laptop in classrooms (.336)
- Educational use of laptop in college cafeterias (.370)

The educational use of laptops at university facilities is in relation to macro category 3: 3.1 Developing content and 3.2 Integrating and re-elaborating. This educational use can be added to other results as McKinney et al. (2009) who found that students who engaged with audio-synced PowerPoint slides on their own mobile devices in a classroom setting learned significantly more compared with students who watched the traditional lectures.

The resulting factors respond to criteria related to the variables and their relationships, and not to other unrelated matters (such as statistical distribution of variables). To confirm this, Table 5 shows descriptive statistics of variables.

Table 5. Descriptive Statistics

Variables	Mean	Standard deviation	Total
Educational use of laptops in college cafeteria	1.89	1.190	886
Educational use of tablets in college cafeteria	1.34	.933	886
Educational use of smartphones in college corridors	3.26	1.542	886
Educational use of laptops in college corridors	1.78	1.075	886
Educational use of tablets in college corridors	1.35	.928	886
Educational use of smartphones in classrooms	2.95	1.462	886
Educational use of laptops in class-rooms	2.36	1.395	886
Educational use of tablets in classrooms	1.39	.984	886
Educational use of smartphones in outdoor leisure areas	3.62	1.454	886
Educational use of laptops in outdoor leisure areas	1.95	1.219	886
Educational use of tablets in outdoor leisure areas	1.48	1.128	886
Educational use of smartphones in habitual residence	4.02	1.309	886
Educational use of laptops in habitual residence	4.29	1.091	886
Educational use of tablets in habitual residence	1.95	1.504	886
Educational use of smartphones in workplace	2.95	1.543	886
Educational use of laptops in workplace	2.65	1.553	886
Educational use of tablets in workplace	1.40	.973	886
Educational use of smartphones on the street	3.33	1.487	886
Educational use of laptops on the street	1.35	.805	886
Educational use of tablets on the street	1.19	.603	886
Educational use of smartphones in library	2.70	1.491	886

Educational use of laptops in library	2.63	1.383	886
Educational use of tablets in library	1.40	.943	886
Educational use of smartphones in modes of transport	3.03	1.531	886
Educational use of laptops in modes of transport	1.27	.629	886
Educational use of tablets in modes of transport	1.21	.664	886

Next, we checked whether the factors obtained had normal distributions in order to then calculate whether there were differences between the groups. To test normality, we applied the "Kolmogorov-Smirnoff" test (Table 6).

The first five factors had non-normal distributions and the sixth factor had a normal distribution, therefore we applied Student's t-distribution (Table 7) to check whether there were significant differences between the groups.

Significance was positive (.001) therefore there are differences between Spanish and Latin American students in Factor 6 (*Educational use of laptops at university facilities*). Since the rest of the factors obtained non-normal scores, we applied successive Mann-Whitney U tests among factorial scores to see the differences between the two groups: Spanish and Latin American (Table 8).

Table 6. Kolmogorov-Smirnov Test for one-Sample

N		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
		886	**886**	**886**	**886**	886	**886**
Normal Parameters[a,b]	Mean	-.00001	.00003	-.00002	.00000	.00001	.00000
	Std. Deviation	1.001580	1.001569	1.001544	1.001540	1.001543	1.001556
Most Extreme Differences	Absolute	.084	.079	.115	.331	.125	.057
	Positive	.071	.079	.115	.331	.125	.057
	Negative	-.084	-.056	-.080	-.274	-.088	-.043
Kolmogorov-Smirnov Z	1.507	1.418	2.062	5.951	2.242	1.019	
Asymp. Sig. (2-tailedl)	.021	.036	.000	.000	.000	.250	

a. Test distribution is Normal.

Table 7. Independent Sample Tests

		Levene's Test for quality of Variances		t-test for Equality of Means					
		F	Sig.	t	gl	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confid. Interval of the Difference	
									Lower	Upper
Factor 6	Equal variance assumed	.991	.320	3.435	321	.001	.377928	.110018	.161481	.594375
	Equal variance not assumed			3.404	298.571	.001	.377928	.111010	.159467	.596390

Table 8. Mann-Whitney Comparison Statistics

Test Statisticsa	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
U de Mann-Whitney	46418.500	55424.000	58107.500	61352.000	44577.000
Wilcoxon W	100703.500	126677.000	129360.500	115637.000	115830.000
Z	-5.770	-2.439	-1.446	-.246	-6.451
Asymp. Sig. (2-tailedl)	.0134	.000	.000	.000	.234

a. Grouping Variable: Country-Area

We found factors 2, 3, 4 and 6 showed differences between the groups. The results between the groups were the following:

- *Factor 1*: no statistically significant differences between Spanish and Latin American: *U* (866) = 46418,500, p = 0.134 (p>0.01).
- *Factor 2*: statistically significant differences between Spanish and Latin American: *U* (866) = 55424,000, p = 0.00.
- *Factor 3*: statistically significant differences between Spanish and Latin American: *U* (866) = 58107,500, p = 0.00.
- *Factor 4*: statistically significant differences between Spanish and Latin American: *U* (866) = 61352,000, p = 0.00.
- *Factor 5*: no statistically significant differences between Spanish and Latin American: *U* (866) = 44577,000, p= 0.234 (p>0.001).
- *Factor 6*: statistically significant differences between Spanish and Latin American: *t* (866) = 3.435, p = 0.01.

To confirm these differences, we prepared a contingency table to find the differences disaggregated by geographical areas and countries (Table 9).

Factor 2 (*Educational use of smartphones at university facilities)* showed significant differences between the two geographical areas. In Spain, smartphones are used more in classrooms. The accumulated percentage of Spanish students doing so "frequently" or "always" is 42%, in comparison, in other Latin American countries: Colombia (17.8%), Panama (21.4%), Peru (22%), Mexico (16.75%) and Chile (8.6%). Moreover, Factor 3 (*Educational use of smartphones outside university facilities*) shows a higher educational use by Latin American students than Spanish students. Average use of this device for educational purposes in the Latin American countries analysed is more intense ("frequently" and "always") (26.03%) than in Spain (16.65%). Factor 4 (*Educational use of laptops outside university facilities*) shows significant differences in the educational use of laptops among students in the two geographical areas. Spanish students use laptops outside university facilities more frequently than Latin American students (+13.6%). In contrast, Factor 6 (*Educational use of laptops at university facilities*) shows that Latin American students use their laptops for educational purposes more within university facilities than Spanish students do (+5.16%). Finally, it was compared if there were significant differences according to variables: gender, age and studies. Significant differences were found depending on age in Factor 3: "Educational use of smartphones outside university facilities" (Table 10 and 11).

Table 9. Factor Contingency Table Disaggregated by Countries

Countries	Factor 2. Educational use of smartphones at university facilities					
	Never	**Rarely**	**Sometimes**	**Frequently**	**Always**	**Total**
Spain	21.0%	8.6%	28.4%	21.0%	21.0%	100.0%
Colombia	58.1%	12.9%	11.3%	8.1%	9.7%	100.0%
Panama	32.1%	28.6%	17.9%	10.7%	10.7%	100.0%
Peru	38.0%	19.0%	21.0%	14.0%	8.0%	100.0%
Mexico	29.2%	8.3%	45.8%	12.5%	4.2%	100.0%
Chile	69.6%	13.0%	8.7%	4.3%	4.3%	100.0%
Countries	**Factor 3. Educational use of smartphones outside university facilities**					
	Never	**Rarely**	**Sometimes**	**Frequently**	**Always**	**Total**
Spain	13.3%	26.7%	26.7%	13.3%	20.0%	100%
Colombia	10.8%	5.4%	24.7%	31.2%	28.0%	100%
Panama	20.7%	10.3%	13.8%	31.0%	24.1%	100%
Peru	22.9%	17.1%	17.1%	22.9%	20.0%	100%
Mexico	37.1%	7.2%	16.5%	23.7%	15.5%	100%
Chile	14.0%	5.8%	16.3%	24.4%	39.5%	100%
Countries	**Factor 4. Educational use of laptop outside university facilities**					
	Never	**Rarely**	**Sometimes**	**Frequently**	**Always**	**Total**
Spain	2.9%	1.3%	5.5%	23.7%	66.6%	100%
Colombia	7.3%	10.4%	15.6%	30.2%	36.5%	100%
Panama	3.8%	3.8%	46.2%	19.2%	26.9%	100%
Peru	5.6%	5.6%	5.6%	38.9%	44.4%	100%
Mexico	16.7%	10.0%	23.3%	30.0%	20.0%	100%
Chile	16.7%	2.8%	11.1%	6.9%	62.5%	100%
Countries	**Factor 6. Educational use of laptop at university facilities**					
	Never	**Rarely**	**Sometimes**	**Frequently**	**Always**	**Total**
Spain	51.6%	22.6%	13.6%	6.3%	5.9%	100%
Colombia	23.0%	20.7%	25.3%	21.8%	9.2%	100%
Panama	40.9%	4.5%	31.8%	9.1%	13.6%	100%
Peru	32.1%	28.6%	17.9%	10.7%	10.7%	100%
Mexico	38.0%	19.0%	21.0%	14.0%	8.0%	100%
Chile	64.8%	11.3%	8.5%	5.6%	9.9%	100%

Table 10. ANOVA. Test of Between-Subjects Effects

Dependent variable: Factor 3. Educational use of smartphones outside university facilities					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	84123.567a	4	41321.311	20.877	.000
Intercept	7652345.7	2	76523451	2361.876	.000
Gender	22624.973	2	61289.213	29.987	.078
Age	25678.712	2	61289.213	30.245	.000
Studies	28153.167	1	93451.239	1.608	.083
Error	3456127.102	832	214.751		
Total	23476512.512	844			
Corrected Total	3152345.711	843			

a. R Squared = 0,42 (Adjusted R = .040)

Table 11. Multiple comparisons. Tukey HSD

Multiple Comparisons. Factor 3. Educational use of smartphones outside university facilities. Tukey HSD						
(I) Age	**(J) Age**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
18-20	21-23	-4.8723*	1.35671	.000	-8.3412	-2.1231
	Over 31	-22.1500*	1.35671	.000	-24.3126	-18.3412
21-23	18-20	4.8723*	1.35671	.000	2.1231	8.3412
	Over 31	-15.5000*	1.35671	.000	-19.7632	-13.5621
Over 31	18-20	22.1500*	1.35671	.000	18.3412	24.3126
	21-23	15.5000*	1.35671	.000	13.5621	19.7632

Based on observed means. Mean Square (Error) = 15.106 *. The mean difference is significant at the .05 level

Younger students (18-20) make less use of smartphones for educational purposes than older students (over 31).

4 CONCLUSIONS

The objective of this study was to analyse the spaces and places where Spanish and Latin American university students use their mobile digital devices (smartphones, tablets and laptops) for educational purposes and to establish main educational uses and possible differences among the various countries. Results of the statistical factorial analysis showed that educational use of mobile digital devices in the Spanish-speaking world focuses on two devices: smartphones and tablets. Tablets are the most widely used device for educational purposes at university facilities, especially in college cafeterias and corridors, in the classrooms and libraries. The main educational uses with tablets in University facilities are in relation to macro category 1 "Inform" and 3 "Create and edit new content": 1.1 Browsing, searching and filtering information 1.3 Storing and retrieving information and 3.2 Integrating and re-elaborating. Likewise, smartphones are the second digital device most used at university facilities for educational purposes. In this case, the most common places are college corridors, classrooms and libraries. Smartphone educational uses at University facilities are related to macro category 2 "Communicate": 2.1 Interacting through technologies and 2.2 Sharing information and content. Third, but with less statistical significance, is the educational use of smartphones outside university facilities primarily on modes of transport, outdoor leisure areas, habitual residence, workplace and the street with the same educational uses that at university facilities. Students also use laptops and tablets for educational purposes outside university facilities. First, from their habitual residence and in outdoor leisure areas and, second, from highly diverse locations: habitual residence, modes of transport, workplace, outdoor leisure areas and on the street. Mainly to Inform" and 2 Communicate": 1.3 Storing and retrieving information, 2.1 Interacting through technologies and 2.2 Sharing information and content. Some of these activities are also reported in recent studies. Finally, and to a lesser degree, the devices least used for educational purposes within university facilities are laptops, mainly in the classrooms and college cafeteria.

The results of the parametric and nonparametric tests for comparison of the groups from the two geographical areas have helped us determine whether there are differences in use among the various countries. The "Mann-Whitney" statistics comparison showed significant differences between Spain and Latin America in three factors: Factor 2. *Educational use of smartphones at university facilities*, Factor 3. *Educational use of smartphones outside university facilities* and Factor 4. *Educational use of laptops outside university facilities*. Also, Student's t-distribution test showed significant differences for Factor 6. *Educational use of laptops at university facilities*. The most significant differences shown in the Contingency Table found that in Spain, educational use of smartphones is most frequent in classrooms, and of laptops outside university facilities. In contrast, in Latin America smartphones are used more frequently outside university facilities and laptops within university facilities, for educational purposes. These results show that university students in the Spanish-speaking world intensely use mobile digital devices for educational purposes both within and outside university facilities. This means that institutions, teachers and education managers need to continuously improve educational processes, contents and the formats these contents are offered in, as well as the forms of interaction and collaborative work. Understanding the pattern of connection in relation to the space and place where students connect their mobile digital devices for educational purposes can be leveraged to develop context-sensitive activities that enrich the learning experience and set the context for theoretical contents with resources such as augmented reality or crowdsourcing on the web. The possibilities are many and diverse, depending on the type of studies and subjects involved, although the challenges are also considerable, such as, privacy of communications, teacher training, investment in technological infrastructures and upgrading systems to advanced technical-educational designs related to society's current social and professional reality. Mobile learning can help to expand narrow and restricted educational curricula and connect learning within and outside higher education environments. Regardless of the use of technology, the consideration and integration of multi-faceted educational practice outside the classroom only minimally represents the reality of today's higher education, which is characterised by environments in which lecturing - i.e., classroom-based and one-directional communication, are the main route of education.

REFERENCES

Ahmed, S. & Parsons, D. (2013). Abductive science inquiry using mobile devices in the classroom. *Computers & Education*, *63*, 62-72. doi:10.1016/j.compedu.2012.11.017

Barbosa, J. L., Barbosa, D. N., & Wagner, A. (2012). Learning in Ubiquitous Computing Environments. *International Journal of Information and Communication Technology Education*, *8*(3), 64-77. doi:10.4018/jicte.2012070108

Bartholomew, D. J. (1987). *Latent Variable Models and Factor Analysis*. New York, NY: Oxford University Press.

Bernstein, I. H., Garbin, C., & Teng, G. (1988). *Applied Multivariate Analysis*. New York, NY: SpringerVerlag. doi:10.1007/978-1-4613-8740-4

Bonett, D. G. & Price, R. M. (2005). Inferential methods for the tetrachoric correlation coefficient. *Journal of Educational and Behavioral Statistics*, *30*, 213-225. doi:10.3102/10769986030002213

Buckingham, S. & Ferguson, R. (2012). Social Learning Analytics. *Educational Technology & Society, 15*(3), 3-26.

Chang, C.-C., Tseng, K.-H. & Tseng, J.-S. (2011). Is Single or Dual Channel with Different English Proficiencies Better for English Listening Comprehension, Cognitive Load and Attitude in Ubiquitous Learning Environment? *Computers and Education*, *57*, 2313-2321. doi:10.1016/j.compedu.2011.06.006

Chaves-Barboza, E., Trujillo-Torres, J., López-Núñez, J., & Sola-Martínez, T. (2017). Actions and achievements of self-regulated learning in personal environments. Research on students participating in the Graduate Program in Preschool Education at the University of Granada. *Journal of New Approaches in Educational Research*, *6*(2), 135-143. doi:10.7821/naer.2017.7.236

Cochrane, T. D. (2014). Critical success factors for transforming pedagogy with mobile Web 2.0. *British Journal of Educational Technology*, *45*, 65-82. doi:10.1111/j.1467-8535.2012.01384.x

Cook, J., Pachler, N., & Bradley, C. (2008). Bridging the gap? Mobile phones at the interface between informal and formal learning. *Journal of the Research Center for Educational Techology*, *4*, 3-18.

Cope, B. & Kalantzis, M. (2009). Multiliteracies: New Literacies. *New Learning, Pedagogies. An International Journal*, *4*, 164-195. doi:10.1080/15544800903076044

Dabbagh, N. & Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and higher education*, *15*, 3-8. doi:10.1016/j.iheduc.2011.06.002

Dennen, V. P. & Hao, S. (2014). Intentionally mobile pedagogy: the M-COPE framework for mobile learning in higher education. *Technology, Pedagogy and Education*, *23*(3), 397-419. doi:10.1080/1475939X.2014.943278

Ditrendia (2017). *Informe Ditrendia: Mobile en España y el mundo*. Retrieved from http://www.amic.media/media/files/file_352_1289.pdf

Ferrando, P. J. (2009). Multidimensional Factor-Analysis-Based Procedures for Assessing Scalability in Personality Measurement. *Structural Equation Modeling*, *16*, 10-133. doi:10.1080/10705510802561352

Ferrari, A., Punie, Y., & Brecko, B. (2013). *DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe. Luxembourg: Publications Office of the European Union*. Retrieved from https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-framework-developing-and-understanding-digital-competence-europe

Freeman, A., Adams Becker, S., Cummins, M., Davis, A., & Hall Giesinger, C. (2017). *NMC/CoSN Horizon Report: 2017 K-12 Edition*. Austin, Texas: The New Media Consortium.

Fryer, L. K. (2017). Building bridges: Seeking structure and direction for higher education motivated learning strategy models. *Educational Psychology Review*, *29*, 325-344. doi:10.1007/s10648-017-9405-7

Garcia, G. A. (2014). A comparative study of computer and mobile phone-mediated collaboration: the case of university students in Japan. Mobile Learning Applications in Higher Education. *RUSC. Universities and Knowledge Society Journal*, *11*(1), 222-237. doi:10.7238/rusc.v11i1.1898

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1988). *Multivariate Data Analysis*. New Jersey, NJ: Prentice Hall.

Keengwe, J. (2015). *Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies*. Hershey, PA: IGI Global. doi:10.4018/978-1-4666-6343-5

Kessler, G. (2010). Fluency and anxiety in self-access speaking tasks: the influence of environment. *Computer Assisted Language Learning*, *23*, 361-375. doi:10.1080/09588221.2010.512551

Liao, T. (2015). Augmented or admented reality? The influence of marketing on augmented reality technologies. *Information Communication & Society*, *18*(3), 310-326. doi:10.1080/1369118X.2014.989252

Liu, G. Z., & Hwang, G. J. (2010). A key step to understanding paradigm shifts in e-learning: towards context-aware ubiquitous learning. *British Journal of Educational Technology*, *41*, E1-E9. doi:10.1111/j.1467-8535.2009.00976.x

Mckinney, D., Dyck, J. L., & Luber, E. S. (2009). iTunes University and the classroom: Can podcasts replace Professors? *Computers & Education*, *52*, 617-623. doi:10.1016/j.compedu.2008.11.004

McLeod, L. D., Swygert, K. A., & Thissen, D. (2001). Factor analysis for items scored in two categories. In D. Thissen & H. Wainer (Eds.), *Test scoring* (pp. 189-216). Mahwah, NJ: Lawrence Erlbaum.

Mercier, E. M., & Higgins S. E. (2013). Collaborative learning with multi-touch technology: Developing adaptive expertise. *Learning and Instruction*, *25*, 13-23. doi:10.1016/j.learninstruc.2012.10.004

Nunnaly, J. & Bernstein, I. (1994). *Psychometric Theory.* New York, NY: McGraw-Hill.

Pearson (2014). *Pearson Student Mobile Device Survey 2014. National Report: College Students*. Retrieved from http://www.pearsoned.com/wp-content/uploads/Pearson-HE-Student-Mobile-Device-Survey-PUBLIC-Report-051614.pdf

Pimmer, C., Mateescu, M., & Gröhbiel, U. (2016). Mobile and ubiquitous learning in higher education settings. A systematic review of empirical studies. *Computers in Human Behavior*, *63*, 490-501. doi:10.1016/j.chb.2016.05.057

Ponce, O. & Pagan-Maldonado, N. (2017). Educational research in the 21st century: challenges and opportunities for scientific effectiveness. *IJERI: International Journal of Educational Research and Innovation*, *0*(8), 24-37. Retrieved from https://www.upo.es/revistas/index.php/IJERI/article/view/2449

Roschelle, J. & Michalchik, V. S. (2017). Cyberlearning. In K. Peppler (Ed.), *The SAGE encyclopedia of out-of-school learning* (pp. 179-199). Thousand Oaks, CA: Sage.

Sevillano, M.ª L. & Vázquez-Cano, E. (2015). The impact of digital mobile devices in Higher Education. *Educational Technology & Society*, *18*(1), 106-118.

Solvberg, A. M., & Rismark, M. (2012). Learning Spaces in Mobile Learning Environments. *Active Learning in Higher Education*, *13*, 23-33. doi:10.1177/1469787411429189

Taylor, J. D., Dearnley, C. A., Laxton, J. C., Coates, C. A., Treasure-Jones, T., Campbell, R., & Hall, I. (2010). Developing a mobile learning solution for health and social care practice. *Distance Education*, *31*, 175-192. doi:10.1080/01587919.2010.503343

Taylor, P. (2015, February 25). *Ubiquity University Reinvents Competency-Based Higher Education*. Retrieved from http://www.prweb.com/releases/2014/12/prweb12369734.htm

UNESCO. (2013). *UNESCO Policy Guidelines for Mobile Learning*. Paris: United Nations Educational, Scientific and Cultural Organization.

Usman, M. (2017). Does University-Industry Collaboration Matter for Innovation? *IJERI: International Journal of Educational Research and Innovation*, *0*(8), 1-23. Retrieved from https://www.upo.es/revistas/index.php/IJERI/article/view/2597

Uzunboylu, H., Cavus, N., & Ercag, E. (2009). Using Mobile Learning to Increase Environmental Awareness. *Computers and Education*, *52*, 381-389. doi:10.1016/j.compedu.2008.09.008

Vázquez-Cano, E. (2012). Mobile Learning with Twitter to Improve Linguistic Competence at Secondary Schools. *The New Educational Review*, *29*(3), 134-147.

Vázquez-Cano, E. (2013). The Videoarticle: New Reporting Format in Scientific Journals and its Integration in MOOCs. *Comunicar*, *41*, 83-91. doi:10.3916/C41-2013-08

Vázquez-Cano, E., Fombona, J., & Fernández, A. (2013). Virtual Attendance: Analysis of an Audiovisual over IP System for Distance Learning in the Spanish Open University (UNED). *The International Review of Research in Open and Distance Learning (IRRODL)*, *14*(3), 402-426. doi:10.19173/irrodl.v14i3.1430

Wang, M., Shen, R., Novak, D., & Pan, X. (2009). The impact of mobile learning on students' learning behaviours and performance: Report from a large blended classroom. *British Journal of Educational Technology*, *40*, 673-695. doi:10.1111/j.1467-8535.2008.00846.x

Wang, R., Wiesemes, R., & Gibbons, C. (2012). Developing digital fluency through ubiquitous mobile devices: Findings from a small-scale study. *Computers & Education*, *58*, 570-578. doi:10.1016/j.compedu.2011.04.013

Yahya, S., Ahmad E. A., & Jalil, K. A. (2010). The definition and characteristics of ubiquitous learning: A discussion. *International Journal of Education and Development using Information and Communication Technology*, *6*(1), 117-127.

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