Evolution and use of mobile devices in higher education: A case study in Portuguese Higher Education Institutions between 2009/2010 and 2014/2015

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Abstract: Mobile devices' popularity, particularly tablets and smartphones, has increased over the last years as a result of their versatility and multifunctionality. That consequently led to a wide daily use by everyone and especially among young people. Since 2010 the sales market for mobile devices has not stopped growing. This is justified by the fact that these devices present many advantages, namely usability, portability, versatility, adaptability and an ability to customize individual experiences. In the context of the teaching-learning process, mobile devices allow overcoming the temporal and physical boundaries of the classroom, since information is omnipresent and no longer limited to a specific time and place for learning, thus promoting the mLearning. In this way it is important to analyze the use of mLearning, particularly the acceptance rate and uses of mobile technologies devices in higher education Portuguese institutions. In order to answering this issue, this paper analyzes the evolution and trends in the use of mobile technologies in higher education institutions in Portugal (North region) between 2009/2010 and 2014/2015.

Keywords: Mobile learning, mobile devices, BYOD, Portuguese Higher Education.

1. Introduction

Society is undergoing a radical change in the way we communicate and act, since many sectors of activity are adopting the use of mobile technology to offer services. This change is only possible because the world is becoming more connected and mobile, a trend that will cause a (re)structuring of education.

Mobile technologies, particularly tablets and smartphones, are quickly becoming technologies powerful enough to override personal computers in several tasks with the advancement of wireless and mobile technology. While these technologies have dramatically

transformed our society in the way we communicate, create, retrieve and share information, collaborate and socialize each other, the application of these technologies is still relatively recent (West, 2014).

By the end of 2011, there were about 6 billion mobile subscriptions worldwide, and in developing countries most people access the Internet from their mobile devices (ITU, 2012). ITU (2013) shows that the world has almost as many mobile subscriptions as inhabitants. For example, mobile broadband subscriptions grew from 268 million in 2007 to 2.1 billion in 2013: an average annual growth rate of 40%. In 2020, digital technology will be incorporated and distributed in most objects. Personal artifacts such as keys, clothes, shoes, books and newspapers will have embedded devices which can communicate with each other (Daanen and Facer, 2007).
In this context, mobile technologies are being used to complete everyday tasks and to learn informally, by accessing the biggest information "library" of the world, the Internet. Thus, students can use mobile technology anywhere and at any time to access educational resources.
Mobile learning has become a research field of interest of practitioners in the different phases of education to facilitate learning in various contexts (Pachler et al., 2010). The key aspects of this interest is the growing importance and their use, in the day-by-day, by students in the most varied activities, and the increasing portability of these technologies, as well as the reduction in their cost and services (Vinu et al., 2011).

Today, mobile devices are all-purpose computing devices, including multi-core processors, high-resolution, touch-sensitive, with various sizes and network connectivity (WiFi, 3G, 4G, ...), and have a variety of sensors, such as cameras, accelerometers, etc, which increase their potential for use in education. Significant investments were made to provide infrastructure, content and resources related to the integration of mobile devices in learning environments (Johnson et al., 2011). These mobile devices have become a kind of personal ecosystem (Sharples, 2011).

In developing countries, people have more mobile phones than computers, since they are ignoring the phases of the personal computer and laptop computer and are directly adopting mobile phones as indicated by Leblois (2013), which has provided to the educational agents a unique opportunity to define new teaching-learning processes (TLP) through mobile devices.
Making use of this technology stimulates the interest in learning the taught content, becoming a promoter of learning factor that leading to the training of competent students, open horizons and predisposed to invest in innovation (Baran, 2014; Ross et al., 2010) and encourages their integration in the classroom. Kenney (2011) states that since technology is so present in the daily lives of adolescents, a class without their use is completely uninteresting.

In recent decades, it has been recognized the added value of the use of technological tools in the classroom and, since then, efforts have been made by different stakeholders in the field of education, including the scientific community and governments, towards their use and consequent TLP improvement. Shrivastava and Shrivastava (2014) state that "*while the emerging political economy of higher education suggests an increase in the diversity of educational contexts, technology assisted learning could indeed offer an important toolkit with which to increase choice and respond to the needs arising.*"

Naismith et al. (2004) agree with the argument that mobile devices offer motivating learning experiences, arguing that the devices can be used "*dynamically, in many different settings, giving access to a broad range of uses and situated learning activities*". The authors state that the personal nature of mobile devices means that they are able to engage students in individualized learning experiences, providing greater ownership and responsibility to the students about their own work.

The advent and use of mobile technologies have led to the emergence of the concept of Bring Your Own Device (BYOD). This concept appeared in 2007, in a business context, as "*the practice of allowing employees of an organization to use their own computers, smartphones or other devices for work purposes*" (Dictionaries, n.d.). This practice has surpassed the organizational barriers and began to be used widely. According to Akuity (2014), IDC indicates that in 2016 there will be 480 million phones throughout the world and 65% of these devices will be used to BYOD. It is also expected an increase of 181.39 billion dollars in the BYOD market in 2017. Taking into account that this market was worth only 67,210 million in 2011, i.e., it is expected an increase of 200% in six years.

Learning supported by mobile technologies is becoming a new approach towards education, and it is unique in the way that offers opportunities to learn anywhere and anytime (Lee and Salman, 2012), (Pachler et al., 2011). On the other hand, collaborative learning has long been believed to hold great value for education, but creating a collaborative learning experience inside and outside of the classroom is a challenge with which teachers continue to struggle, since there are several obstacles e.g. their own preparation for the introduction of this learning approach (DGEEC, 2012). Additionally, there are no consensuses in interpreting collaborative learning; it varies in focus according to the literature (see section 2.1). However, new educational application – educational apps (Google, n.d.) have, at least in some contexts, begun to transform the way teachers teach, students learn, and teachers and students interact.

The main goal of this study is the evaluation of the adoption and usage trends of mobile devices in the TLP in Higher Education Institutions (HEI) in Portugal (North region) between

2009/2010 and 2014/2015, being an evolution of the work (Ferreira et al., 2015) where more general results have been analyzed and discussed.

In order to achieve the proposed goal was adopted as research methodology a quantitative approach with a fundamentally rationalist basis. Regarding data collection instruments, we used a closed questions survey questionnaire and the necessary statistical procedures, and tools (IBM SPSS Statistics 20.0) to analyze its results (Baran, 2014). This questionnaire entailed a set of closed questions (16 questions), aiming to assess developments and trends of the mobile devices utilization.

The paper is structured as follows. Section 2 critically examines mLearning and collaborative learning. Section 3 presents the state of the art in collaborative learning with mobile devices in Portugal in HEI. Section 4 presents the methodology. Section 5 summarizes the results and discussion of the research and lastly, section 6 presents the study limitations and 7 presents the study conclusions.

2 mLearning – anytime, anywhere, … anything

The concept of Mobile Learning (mLearning) is not new, but it is important to analyze its "origins" and evolution. Georgiev et al. (2004), among others, consider the mLearning as an evolution of distance learning (dLearning) and electronic / digital learning (eLearning). In this context, it is possible to assess that eLearning and mLearning are two interconnected concepts; however, the ubiquity and sensitivity to context are mobility aspects that made the mLearning a single and unique approach in TLP. It is therefore important to analyze the evolution of the mobile market since this technology is the mLearning support and leads directly to its evolution.

2.1 Evolution and utilization of mobile devices

The evolution of the mobile market in the EU has had an accentuated growth, and the origin of this increase can be analyzed in different perspectives, such as the type of devices, the use of the Internet and / or use of mobile Internet, potentiated by mobile vs age range. Thus, the interest in tablets and smartphones is higher (and growing) when compared to PCs or even laptops. This dynamic led to a significant increase in the sales of the former and their consequent massification (Seybert, 2012).

Analyzing the perspective of the use of Internet (see graph in Figure 1 (Seybert, 2012)), it is possible to realize that the percentage of individuals who use the internet anywhere is very high when the average rate in the EU is more than 70%.

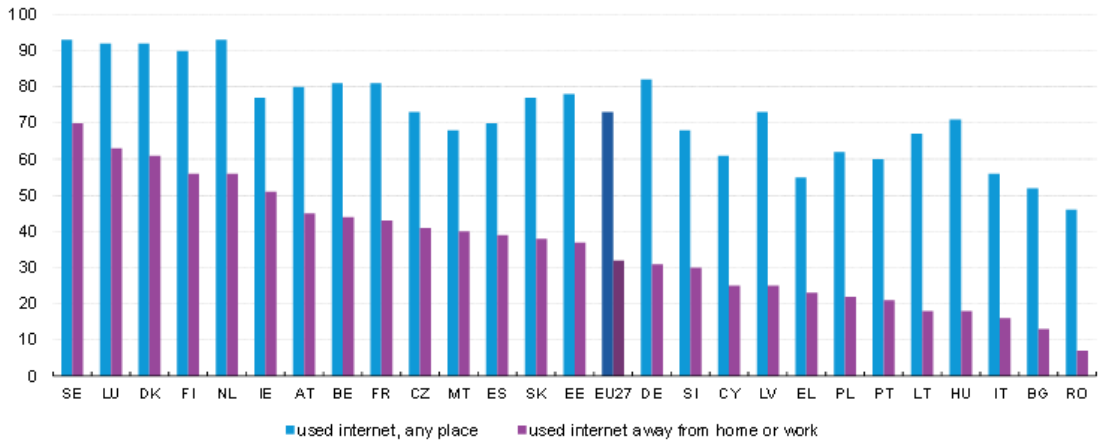

Figure 1. Individuals who used the internet, at any place and away from home or work, 2012 (% of individuals)

With regard to the use of mobile Internet (potentiated by the mobile devices vs age range), the distribution focuses on formative period (between 16 and 24 years), where the highest values derive from the use of mobile devices.

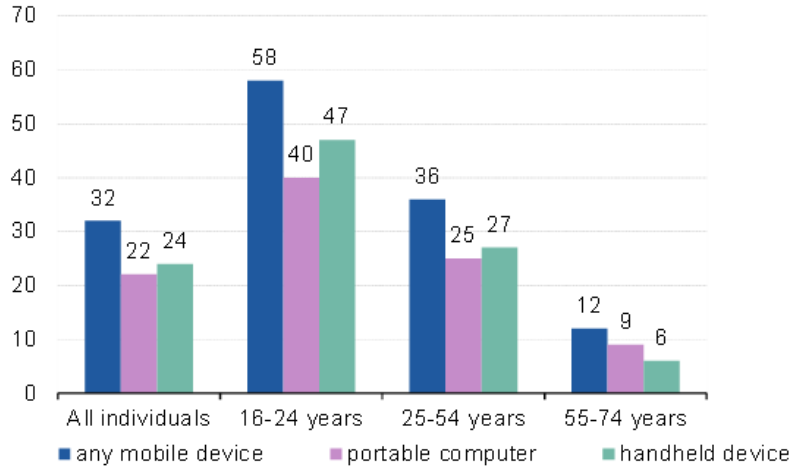

Figure 2. Individuals who used the internet away from home or work, by age group and type of mobile device, EU27, 2012 (% of individuals)

2.2 mLearning

When analyzing the evolution of mLearning concept, it is to highlight Viteli's (2000) article, written 15 years ago, and specifically the following statement: "*The concept of mLearning is yet very unknown. On 15th of September 2000 the Google provided 40 links to mLearning and 29.900 to eLearning.*", while Costa and Xavier (2014) by performing a search on Google in July 2014 found approximately 252 million links to eLearning and 231 million links to mLearning that demonstrates the interest and the work done around this topic.

Mobile Learning (mLearning) can be defined as a way of learning that makes use of mobile communication technologies and gives to the students the capacity to learn anywhere and anytime. This definition is based on the definition presented by (O'Malley et al., 2003) "*Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies*."

Mobile learning can be defined as the learning that occurs linked to mobile devices (Winter, 2006). Mobile devices include mobile equipment (laptops, tablets and smartphones) which has been undergoing a very strong evolution from the point of view of capacity, reliability and, at a more economic perspective, a great reduction in prices. They have come to endow their installations with wi-fi networks, which by on the one hand, promoting and fostering the use of those devices and, on the other hand, allow the evolution of the TLP.

mLearning, according to Traxler (2013), offers five features that potentiate new learning opportunities: (i) contextual learning allows students to respond and react to experiences lived in different contexts; (ii) located learning, learning occurs in the applicable environments; (iii) the authentic learning, with tasks directly related to the objectives that want to reach; (iv) the conscious learning of the context in which is informed by the history and objectives; and (v) personalized learning, that is, directed to the preferences of each student.

Oppositely to other kind of learning activities, the TLP with mobile devices began with the assumption that students are always on the go and have activities in line with the context in which they are. In this context, Looi, et al. (2010) argue that mobile devices provide the integration of education in school and beyond, with continued learning experience. In the same direction, UNESCO (2012) has prepared its guidance projects for mLearning and recognizes that the value of mobile technology is significantly higher when students continually learn from their mobile devices (BYOD) as ubiquitous mediators between types of learning, for example collaborative learning, that is part of the current educational paradigms that are closely related to the pedagogical theories (Naismith et al. 2004), such as constructivism (Jonassen et al., 1994), behaviorism (Phillips, 1998), situated learning (Lave, 1991), problem-based learning (Koschmann, 1996), learning-oriented context (Krause et al., 2006), social learning (Wenger, 2007) and collaborative learning (Dillenbourg, 1999).

According to Panitz (1996), collaboration is an interaction philosophy and a personal lifestyle. In this context, it is possible to state that collaborative learning is more than a classroom approach; it is a way to deal with people that respects and emphasizes individual skills

and contributions of each member of a group. All group members share responsibilities and authority, thus giving a more active role to stakeholders in the learning process.

Group learning can be interpreted in several ways: (i) presential or virtual learning; (ii) synchronous or asynchronous. This type of learning allows the effort made by learners to be fully together or through the division of tasks. Therefore, the practice of collaborative learning may assume multiple characterizations, although there might be dynamics, and results, of learning to each specific context, namely when the means used are diverse, from personal computer to mobile devices.

Collaborative learning (Torres and Irala, 2014) is part of a set of pedagogical trends: (i) Movement of the New School; (ii) Theories of Genetic Epistemology of Piaget; (iv) Socio-cultural Theory of Vygotsky and; (v) Progressive pedagogy.

According to the same authors, the New School pedagogy and Progressive education, together with cognitive theories formulated by Piaget and Vygotsky, generates the foundations of collaborative learning, which have led to a shift from classes focused on the teacher, with static and repetitive contents to classes focused on the students and a critical apprehension of contents.

3 State of the art

According to the literature, the use of mobile devices for educational purposes using different methods and devices has been applied around the world. All across the globe, students from elementary school to high school are increasingly engaged with advanced wireless devices to collaborate with peers, access rich digital content, and personalize their learning experiences. Always-on, always-connected, smartphones and tablets provide today's students with a ubiquitous gateway to a new ecosystem of information, experts, and experiences, regardless of the physical assets and resources in their own communities.

The study of the evolution and trends in the use of mobile devices in the HIE in Portugal between 2009/10 and 2014/15 is interesting and has been the subject of extensive research, in particular as regards the comparison between the developed and developing countries, as will be shown in Table 1. However, as it will be shown, there is no study in Portugal nor abroad that could serve as a comparison to analyze the rate of adoption and trends of mobile devices in Portugal compared to other countries.

Before presenting some of the existing studies, it is necessary to verify that in developing and in developed countries the rate of adoption of mobile devices in society and education is very interesting. For example, Niess (2005) shows that one of the teachers' training goals in the US and UK (developed countries) is to encourage students to be active builders of knowledge

through the use of mobile technologies, successfully aligning a variety of models of learning. One of the models that are best suited to mobile technologies is the learning collaborative model.

In developing countries, the number of mobile broadband subscriptions is more than doubled between 2011 and 2013, from 472 million to 1.160 billion in 2013 and exceeded the number of developed countries ITU (2013). People in developing countries are investing in mobile education so that they can be active and interconnected in order to improve their quality of life. Despite the high cost of mobile connectivity, its absorption is greater than in developed countries (ITU, 2013). Many ongoing projects in developing countries are trying to bring education to people in remote locations that cannot afford the travel costs. In addition, many initiatives in various countries around the world are using wireless mobile technologies to achieve their educational objectives, as shown in Table 1, through some examples in developed and developing countries.

In this context, and based on the exhaustive study by Baran (2014), it is clear that there is no similar study to the one presented in this article, with the exception of the initial study presented in (Ferreira et al., 2015). To better understand the scope of the study (developed and developing countries), are presented in Table 1 some works based on the following criteria: (i) papers found for the period between 2009/2010 and 2014/2015; (ii) use of mobile devices: PDA, smartphone, tablet and laptop; and (iii) countries: developed and developing.

Table 1. Definition of some styles (adapted from Baran (2014)).

Date	**Reference**	**Technology**				**Countries**		
		T	PDA	SP	P	Country	DC	D1
2009	Aubusson, and Schuck (2009)			√		Australia	√	
2009	Kommers and Hooreman (2009)		√			Netherlands	√	
2010	Chen (2010)		√			Taiwan	√	
2010	Moreira, et al.(2010)			√	√	Portugal	√	
2011	Burton, et al. (2011)			√		EUA	√	
2011	Valtonen, et al. (2011)				√	Finland	√	
2011	Cushing (2011)			√		UK	√	
2011	Uzunboylu, and Özdamlı. (2011)			√		Turkey		√
2013	Hargis, et al. (2013)	√				EAU	√	
2013	Kearney and Maher (2013)	√				Australia	√	
2013	Schuck, Aubusson (2013)			√		Australia	√	
2013	Husbye and Elsener (2013)	√		√	√	EUA	√	
2013	Thomas and O'Bannon (2013)			√		EUA	√	
2013	Hossain and Quinn (2013)			√		EUA	√	
2013	Bates and Martin (2013)	√				EUA	√	
2013	Herro et al. (2013)	√				EUA	√	
2013	Ismail et al. (2013)			√		Malaysia		
2013	Şad and Göktaş (2014)			√	√	Turkey		
2014	Ciampa (2014)	√				Canada	√	

2014	O'Bannon and Thomas (2014)			√		EUA	√	
2014	Hashim (2014)	√				Malaysia		√
2014	Price, et al. (2014)			√		UK	√	
2014	Looi et al. (2014)			√		Singapore	√	
2014	Ekanayake and Wishart (2014)			√		Sri Lanka		√
2014	Kafyulilo (2014)			√		Tanzania		√
2015	Moreira and Ferreira (2015)	√		√	√	Portugal	√	

T – Tablets; **PDA** – Personal Data Assistant; **SP** – Smartphone; **DC** – Developed countries; **D1** – Developing countries

As can be seen through the analysis of Table 1, there is no study to present the evolution and trends of the use of mobile devices in various countries, much less in Portugal, with the exception of the initial study presented in (Ferreira et al., 2015).

4 Research methodology

The purpose of this section is to describe the procedures used to collect data that are the basis for this research. Initially, the state of the art focused on the period between 2009 and 2015 on the use of mobile devices in the TLP in HEIs. For this research, the following question has been selected to guide this research: What is the evolution and trends of the utilization of mobile devices in the TLP in higher education in Portugal?

According to Fortin (2003) "*the goal of a study indicates the why of the research. It is a declarative statement that needs the guidance of research according to the level of knowledge established in the field in question*". Therefore, we defined as the main goal of this study, the evaluation of the adoption and usage trends of mobile devices in the TLP in higher education in Portugal.

The main feature of the scientific method is an organized research, strict control of the use of observations and theoretical knowledge. In what concerns the research methodology, we adopted a quantitative approach with a fundamentally rationalist basis. Regarding data collection instruments, we used a closed questions survey questionnaire and the necessary statistical procedures to analyze its results (Baran, 2014). This questionnaire entailed a set of closed questions, aiming to assess developments and trends of the mobile devices utilization between 2009/10 and 2014/2015 in higher education in Portugal. According to Fortin (2003) "*The quantitative research method is a systematic process of collection of observable and quantifiable data. Objectivity, prediction, control and generalization are characteristics inherent in this approach*".

In this approach, data is collected through structured questionnaires and clear goals, in order to ensure uniform understanding of the respondents and a consequent standardization of results.

The method of the questionnaire, according to (Baran, 2014), is recommended when one wants to know a population, to analyze social phenomena and, in cases where it is necessary, to inquire a great number of people about a certain subject. The questionnaire was subjected to the evaluation of four experts in the field before being delivered. The objective of this study was to obtain answers that will measure the influence of the utilization of mobile devices in HEI. The quantitative study was based on a questionnaire with 16 questions (Q1-Q16), see Annex I. As a matter of space we will just present the analysis of some questions. The data were collected and treated with the use of IBM SPSS Statistics 20.0 software.

5 Analysis and discussion of results

The surveys presented to the students had a few changes depending on the academic year (2009/10 and 2014/15), since there are some equipment and technologies that were important in 2009/10 and today are no longer used, such as PDA, or technologies that are now part of the daily lives of students.

In the survey conducted in the academic year 2014/15 were included questions related to Tablets and new technological solutions. In this context, the section will be divided into six subsections, the first one with the sample characterization information (Ferreira et al., 2015), the second dedicated to the use of discussion forums (Q14), the third to the use of mobile devices to support learning (Q15) through the analysis and discussion of the comparative study of the common questions of the academic years 2009/10 and 2014/15, as well as the intersection of these issues with the course (Q1), age (Q2) and gender (Q3). Also in this subsection, were analyzed the evolution of the use of mobile phone and smartphone in the three courses for both academic years (Q4). The fourth subsection is dedicated to the use of mobile devices supporting collaborative learning (Q16). The fifth section is relative to the use of social networks and Google Apps in devices in learning environments (Q11 and Q12). In the last section, with the aim of identifying which devices (mobile phone, smartphone, tablets) and technological applications (social networks and Google Apps), and trends that most contribute to learning in the technological environment was held, given the nature of the variables involved in the study, one Exploratory Factor Analysis (EFA) was used to know how these variables are associated.

5.1 General characterization

The study sample consists of 151 students in the 2009/10 academic year and 273 students in the academic year of 2014/15, distributed among the courses of Electrical and Computer Engineering (from now on will be referred to throughout the text as Engineering), Economics/Management and Law in HEI in the north of Portugal. The age-related question (Q2) revealed some differences between the two academic years of study (20109/10 and 2014/15). For example, while in 2009/10, the percentage of students aged 18 years was 4.6% in 2014/15, the percentage passing to 25.3%. In contrast, the trend in higher class (> 20 years) has a reversal of the proportions, i.e., 45.7% and 28.9%, respectively. In both academic years the percentage of female students is approximately 60% (Q3).

The distribution of students attending the courses (Q1) is as follows: in the academic year 2009/10 responded to the survey 21.85% of law students, 40.40% of students of Economics/Management and 37.75% of students engineering; while in the academic year 2014/15 responded to the survey 28.94% of law students, 34.80% of students in courses Economics/Management and 36.26% of engineering students, with a clear trend of using mobile devices in TLP.

5.2 Discussion forums and usefulness of discussion forums

When it comes to the matter of “Do you use discussion forums in collaborative learning environments?” (Q14) in the academic year 2009/10 we obtained 55,3% on students who did not use the forums, whereas during the academic year of 2014/15 that percentage appears to be more relevant (68,6% answered that they don’t use).

If we analyze in detail this question segmented by Courses (Tables 2-3), it is worth noting that, between the 2 academic years, it is possible to observe a change of behavior when it comes to the Engineering Course (meaning, while in the academic year of 2009/10 the answer that prevailed was “Yes” (75%), in the academic year of 2014/15 what prevailed was “No” (80,9%)). Additionally, when it comes to Economics/Management, it is relevant to stand out that during the academic year of 2009/10 the biggest percentage is “No” (77%). Nevertheless, in 2014/15 the opinion of the students in this area is almost equitably distributed between the answers “Yes” and “No”. Law students show the same type of behavior during the two academic years (prevails the answer of “No”).

Table 2 – Use of discussion forums by course (year 2009/2010)

		Course			
		Economics / Management	Engineering	Law	Total
Use of discussion forums	**No**	47	14	22	83
	% within "Use of discussion forums"	56,6%	16,9%	26,5%	100,0%
	% within "Course"	77,0%	25,0%	66,7%	55,3%
	Yes	14	42	11	67
	% within "Use of discussion forums"	20,9%	62,7%	16,4%	100,0%
	% within "Course"	23,0%	75,0%	33,3%	44,7%
Total		61	56	33	150
		40,7%	37,3%	22,0%	100,0%
		100,0%	100,0%	100,0%	100,0%

Table 3 – Use of discussion forums by course (year 20014/2015)

		Course			
		Economics / Management	Engineering	Law	Total
Use of discussion forums	**No**	52	76	58	186
	% within "Use of discussion forums"	28,0%	40,9%	31,2%	100,0%
	% within "Course"	52,5%	80,9%	74,4%	68,6%
	Yes	47	18	20	85
	% within "Use of discussion forums"	55,3%	21,2%	23,5%	100,0%
	% within "Course"	47,5%	19,1%	25,6%	31,4%
Total		99	94	78	271
		36,5%	34,7%	28,8%	100,0%
		100,0%	100,0%	100,0%	100,0%

Regarding these results, it seems interesting to analyze whether there was a difference in opinion on this issue, by the students according to their area of study. The courses of Engineering and Economics/Management were categorized as belonging to the Scientific area and Law course was regarded as a field of the Humanities.

Although the previous analysis leads us to think that there were differences in the opinion by areas of knowledge, the situation was not verified (conclusion reinforced by the values obtained for the Pearson Chi-Square test for independence with continuity correction – p-value = 0,199 > 0,05 and p-value= 0,252 > 0,05, respectively).

Another analysis has been conducted in order to evaluate the possibility of existing significant differences of opinion of the students using their gender as criterion. We concluded that those differences were meaningful for the academic year of 2009/10 (p-value = 0,014 < 0,05) on which prevailed, positively, the opinion of the masculine gender. On the academic year

of 2014/15, there were no more differences in the opinion based on gender (p-value = 0,348 > 0,05), which shows that the differences between the two genders are progressively disappearing, even when it comes to technology use. After this analysis, we thought it might be relevant to evaluate whether the age (group 1- 18/19 years and group 2- 20 or more years) had any influence on the opinion of the students when it comes to using the forums. In both academic years, we concluded that there were significant differences (p-value = 0,014 e p-value = 0,002, respectively). To enhance that, in the academic year of 2009/10 younger respondents have predominance on the positive opinion (63,9%), while in the academic year of 2014/15, this age group has an opinion predominantly negative (78,7%). For the older respondents, in both academic years we can verify the predominance of the answer "No" (above 60%).

Although the predominance is the lack of using the discussion forums for learning, it is interesting to refer that, for those who answered "Yes" to using the forums on the academic year of 2009/10, almost all of them (94,2%) considered the forums useful for learning. On the other hand, on the academic year of 2014/15 that percentage, even though relevant, decreased meaningfully to 74,7% (Tables 4-5). In the academic year of 2009/10 the percentage is similar to all courses (p-value = 0,178 > 0,05). Nevertheless, in the academic year of 2014/15 results show some differences between the ones who consider the forums useful, those differences appear as a strong influence from the Engineering Course (89,1%), which leads to an association between the opinion about the usefulness of the forums and the Course the students is taking (p-value = 0,002 < 0,05).

Table 4 – Usefulness of discussion forums (year 2009/2010)

		Course			
		Economics / Management	Engineering	Law	Total
Usefulness of discussion forums	**No**	1	1	2	4
	% within "Usefulness of discussion forums"	25,0%	25,0%	50,0%	100,0%
	% within "Course"	6,3%	2,4%	16,7%	5,8%
	Yes	15	40	10	65
	% within "Usefulness of discussion forums"	23,1%	61,5%	15,4%	100,0%
	% within "Course"	93,8%	97,6%	83,3%	94,2%
Total		16	41	12	69
		23,2%	59,4%	17,4%	100,0%
		100,0%	100,0%	100,0%	100,0%

Table 5 – Usefulness of discussion forums (year 2014/2015)

		Course			
		Economics / Management	Engineering	Law	Total
Usefulness of discussion forums	**No**	10	5	7	22
	% within "Usefulness of discussion forums"	45,5%	22,7%	31,8%	100,0%
	% within "Course"	50,0%	10,9%	33,3%	25,3%
	Yes	10	41	14	65
	% within "Usefulness of discussion forums"	15,4%	63,1%	21,5%	100,0%
	% within "Usefulness of discussion forums"	50,0%	89,1%	66,7%	74,7%
Total		20	46	21	87
		23,0%	52,9%	24,1%	100,0%
		100,0%	100,0%	100,0%	100,0%

5.3 Mobile devices to support learning

Evaluating the answers to the question "Would you consider using mobile devices to support learning?" (Q15), the percentage of students who responded positively is prevalent in both academic periods. It should be highlighted that it is even more apparent the percentage of positive responses in the period 2014/15, 93.4% of "Yes", against 87.3% in the previous period (2009/10).

The positive prevalence is relevant whatever the attended course (with particular regard to the period 2014/15). Therefore, when we perform Chi-Square test to assess whether there is association between the questions and the course we conclude that there is no significant association (p-value=0.343 and p-value=0.912, respectively). It seemed interesting to analyze whether there are differences of opinion on this question by students' course areas. Considering the areas – Science and Humanities Courses, the results are in Tables 6-7.

Table 6. Frequency of use of mobile device by Course area (year 2009/2010).

		Science courses	Humanities courses	Total
Frequency of use of mobile device	No	13	6	19
	% within "Frequency of use of mobile device"	68,4%	31,6%	100,0%
	% within "Course area"	11,1%	18,2%	12,7%
	Yes	104	27	131
	% within "Frequency of use of mobile device"	79,4%	20,6%	100,0%
	% within "Course area"	88,9%	81,8%	87,3%
Total		117	33	150
		78,0%	22,0%	100,0%
		100,0%	100,0%	100,0%

Table 7. Frequency of use of mobile device by Course area (year 2014/2015).

		Science courses	Humanities courses	Total
Frequency of use of mobile device	No	13	5	18
	% within “Frequency of use of mobile device”	72,2%	27,8%	100,0%
	% within “Course area”	6,8%	6,3%	6,6%
	Yes	179	74	253
	% within “Frequency of use of mobile device”	70,8%	29,2%	100,0%
	% within “Course area”	93,2%	93,7%	93,4%
Total		192	79	271
		70,8%	29,2%	100,0%
		100,0%	100,0%	100,0%

By observing the two tables above and performing Pearson Chi-Square test for independence with continuity correction (p-value=0.434> 0.05 and p-value=1.000> 0.05, respectively), it was possible to find that there are no differences of opinion by areas of knowledge.

We also performed an analysis to assess whether there were differences in the opinion of students according to their gender. In both periods, there are predominantly positive responses regardless of gender. Finally, we find it of interest to assess whether age (group 1 - 18/19, and group 2 - 20 years or more) had influence on the opinion of students on the use of mobile devices to support learning. We concluded that there are no significant differences in both periods with values obtained for the p-value exceeding 0.9, given the predominant "Yes" regardless of age group.

Among the mobile devices we also assessed, for the two periods, if there was an association between the frequency of use of each of them (PDA, Laptop, Mobile Phone, Smartphone and Tablet) and the Course, using for this Pearson Chi-Square test (Table 8).

It is worth noting that, regarding the PDA device, this was only assessed in 2009/10 because it was replaced with more modern technologies, such as the Tablet (only emerged for evaluating the period 2014/15).

Table 8. Values of the p-value for the crossing of the devices that are more used by Course.

	Academic year 2009/10	Academic year 2014/15
Laptop	**0,043**	0,000
Mobile phone	0,125	0,000
Smartphone	0,257	0,000
PDA	0,809	-----
Tablet	-----	0,082

For the school year 2009/10, the only significant association is between the use of the Laptop and the course, this is because we find that although predominate positive responses to any course, from among negative responses, is very relevant the value obtained for the Law degree (21.2% of "No" against the 8.2% and 5.3% for other courses).

As for the most recent period, we highlight some findings of interest only to the intersections that revealed the existence of a significant association. In the course of Engineering, nearly all students use the Notebook (97%) and the Smartphone (87.9%) and only 26.3% use the Mobile Phone. In the Economics/Management course, Laptop and Smartphone are also the most used devices though a lesser extent (about 65%). In Law course, the most widely used device is the Laptop (81%), and the Mobile Phone and Smartphone were used respectively by 57% and 55.7% of students.

Finally, comparing the evolution of the use of mobile devices in the two periods, the verified transition is evident, regardless of the course, for the use of a technologically more advanced device. While in the first period the Mobile Phone use was more frequent, in the most recent period, the Mobile Phone has been exceeded by the use of Smartphone (Fig. 3).

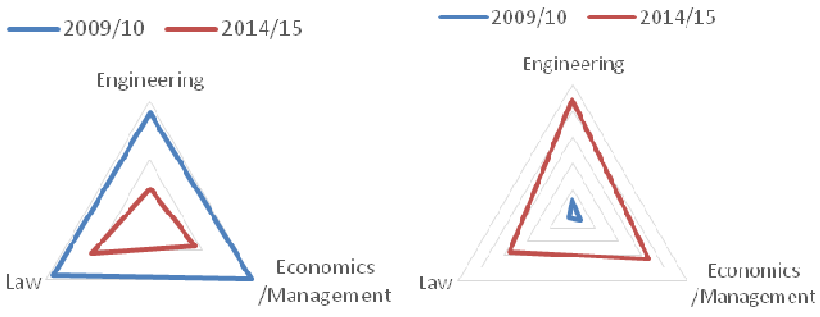

Figure. 3. (a) Evolution of the use of Mobile Phone in the three courses for both academic years and (b) Evolution of the use of Smartphone in the three courses for both academic years.

5.4 Mobile devices in supporting collaborative learning

Through the evaluation of the answers to the question "Do you consider come to use mobile devices in collaborative learning environments?" (Q16), it was possible to find a predominance of positive responses ("Yes") in any of the periods and regardless of the course attended. However, whereas in the school year 2009/10 we concluded that there is a statistically significant association (p-value = 0.040 < 0.05) between the course and the responses to question Q16, this situation no longer holds for the period 2014/15 (p-value = 0.307 > 0.05). The existence of an association in the period 2009/10 was due to the fact that the percentage of positive responses in the course of Law, though high, (69.7%) was significantly lower than those obtained in the Engineering (83.6%) and Economics/Management (90.2%) courses.

Some conclusions were able to be determined regarding the combination of the usage of mobile devices in collaborative learning and students' gender. Concerning question Q15 (analyzed above), positive responses are prevalent, regardless of gender, for both periods. Similarly, we also evaluated whether age influences the opinion of students (Q16). Once again, we found similar behavior to that obtained through Q15 question, i.e., no significant differences in both periods (predominance of "Yes" in the two age groups).

So we think it would make sense to evaluate whether the answers to both Q15 and Q16 questions were related or not (Table 9). By carefully observing Table 9 and having regard to the values obtained for the respective p-value (p-value = 0.000 <0.05 in both periods), we conclude that these two questions are related in the sense that students, that consider the most, come to use mobile devices in learning are also the most likely to consider using these devices in collaborative learning (the same kind of behavior is found for those who do not consider come to use).

Table 9. Crossing of the questions Q15 and Q16 for both academic years.

		2009/10			**2014/15**		
		Q16			**Q16**		
		No	**Yes**	**Total**	**No**	**Yes**	**Total**
Q15	**No**	16	3	19	13	5	18
		84,2%	15,8%	100%	**72,2%**	27,8%	100%
		64%	2,4%	12,8%	52,%	2,0%	6,6%
	Yes	9	121	130	12	241	253
		6,9%	93,1%	100%	4,7%	**95,3%**	100%
		36%	97,6%	87,2%	48%	98%	93,4%
	Total	25	124	149	25	246	271
		16,8%	83,2%	100%	9,2%	90,8%	100%
		100%	100%	100%	100%	100%	100%

5.5 The use of social networks and Google apps

In the 2014/2015 academic year, it makes sense to analyze students' behavior regarding the use of new technologies (social networks and/or Google Apps), through questions such as "Do you use social networks / Google Apps in learning environments with mobile devices?" (Q11 and Q12).

By analyzing the Tables 10-11 and the results of the frequency of use of social networks (Yes – 64.94% and No – 35.06%) and Google Apps (Yes – 72.2% and No – 27.78 %), respectively, we find the prevalence of use of these technologies in learning environments.

Table 10 – Frequency of use of social network

		Frequency	Percent	Valid percent
Valid	No	95	34,8	35,1
	Yes	176	64,5	64,9
	Total	271	99,3	100,0
Missing	No response	2	0,7	
Total		273	100,0	

Table 11 – Frequency of use of Google Apps

		Frequency	Percent	Valid percent
Valid	No	75	27,5	27,8
	Yes	195	71,4	72,2
	Total	270	98,9	100,0
Missing	Invalid response	1	0,4	
	No response	2	0,7	
	Total	3	1,1	
Total		273	100,0	

We can also observe that there is an association between the use of social networks and Google Apps (p-value = 0,001 < 0,05). We concluded that those who use more social networks are also the ones who use Google Apps. For that reason, it makes sense to analyze in detail the use of social networks and Google Apps in learning environments, according to the Course the students are attending to.

Starting with the Course, we verified that it is statistically significant (p-value = 0,010 < 0,05, Table 12) the association with the use of social networks in learning environments.

Table 12 – Chi-Square test to the intersection of the use of social network with course

	Value	df	Assymp. Sig (2-sided)
Pearson Chi-Square	9,312	2	0,010
Likelihood Ratio	9,347	2	0,009
Linear-by-Linear Association	2,013	1	0,156
Nº of valid cases	271		

Curiously, we concluded that Engineering and Law courses are the ones who use social networks the most, in comparison with Economics/Management (for which the percentage of the ones who do not use is the same of those who use – Table 13).

Table 13 – Intersection of the use of social network with course

		Course			
		Engineering	Economics / Management	Law	Total
Use of social network	No	25	43	27	95
	% within "Use of social network"	26,3%	45,3%	28,4%	100,0%
	% within "Course"	25,3%	46,2%	34,2%	35,1%
	Yes	74	50	52	176
	% within "Use of social network"	42,0%	28,4%	29,5%	100,0%
	% within "Course"	74,7%	53,8%	65,8%	64,9%
Total		99	93	79	271
		36,5%	34,3%	29,2%	100,0%
		100,0%	100,0%	100,0%	100,0%

When it comes to the use of Google Apps, we no longer prove the existence of an association (p-value=0,236 >0,05, Table 15). We can only refer that there is a tendency for students from all courses to a frequent use of Google Apps (Table 14).

Table 14 – Intersection course with use of Google Apps

		Course			
		Engineering	Economics / Management	Law	Total
Use of Google apps	No	24	24	27	75
	% within "Use of Google apps"	32,0%	32,0%	36,0%	100,0%
	% within "Course"	24,2%	25,5%	35,1%	27,8%
	Yes	75	70	50	195
	% within "Use of Google apps"	38,5%	35,9%	25,6%	100,0%
	% within "Course"	75,8%	74,5%	64,9%	72,2%
Total		99	94	77	270
		36,7%	34,8%	28,5%	100,0%
		100,0%	100,0%	100,0%	100,0%

Table 15 – Chi-Square test to the intersection of the course with use of Google Apps

	Value	df	Assymp. Sig. (2-sided)
Pearson Chi-Square	2,891[a]	2	,236
Likelihood ratio	2,819	2	,244
Linear-by-linear Association	2,366	1	,124
Nº of Valid Cases	270		

a. 0 células (0,0%) esperavam uma contagem menor que 5. A contagem mínima esperada é 21,39.

5.6 Exploratory Factorial Analysis

The relational structure (in the academic year 2014/15) of the variables Mobile Phone and Smartphone (associated to question Q4 “Which mobile devices do you use on your daily life?”), forums (associated to question Q14 “Do you use of discussion forums in collaborative learning environments?”), social networks and Google Apps (associated to questions Q11 and Q12 “Do you use social networks/Google tools in learning environments using mobile devices?”) and support and collaborative (associated to questions Q15 e Q16 "Do you consider come to use mobile devices to support learning?" and "Do you consider come to use mobile devices in collaborative learning environments?") were assessed by Exploratory Factorial Analysis (EFA) based on a correlation matrix, with the extraction of the factors by Principal Component Analysis with orthogonal Varimax rotation.

The retained common factors were those with the eigenvalue greater than 1, in line with the screeplot and the percentage of variance explained (Marôco, 2011). The first three factors together account for 66.73% of the total variance.

To evaluate the validity of the usage of EFA, we used KMO criterion (Kaiser-Meyer-Olkin measure of sampling adequancy) with the criterions of classification defined in (Marôco, 2011). Having seen a KMO = 0.510 proceeded to the AFE because this value indicates that it is acceptable to use this factor model. In addition, the Bartlett's test of sphericity has associated with a significance level of 0.000 that conducted to the rejection of the hypothesis that the correlation matrix is an identity matrix showing therefore that there is a correlation between some variables. In case of not verifying, we should reconsider the use of this factor model (Pestana and Gageiro, 2003).

Thus, on Table 16 are synthetized the factorial weights of each variable in each of the three factors, their eigenvalues, the communalities of each variable and the percentage of variance explained by retained factors.

Table 16 – EFA results

Component Matrix[a]

	Component			
	1	**2**	**3**	**Communalities**
Mobile	**-,923**	-,015	-,001	,852
Smartphone	**,910**	,035	,146	,851
Socialnet	,105	-,063	**,551**	,318
Google	,031	-,065	**,785**	,622
Forums	-,009	,174	**,654**	,458
Support	-,050	**,891**	,021	,797
Collaborative	,098	**,874**	,000	,774
Eigenvalues	1,840	1,564	1,268	
% of Variance	26,280	22,343	18,109	
Cumulative %	26,280	48,623	**66,732**	

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

The first factor (component 1) shows very high factorial weights (near to 1) on the variables Mobile and Smartphone and explains 26,28% of total variance. The second factor (component 2) shows high factorial weights on the variables support and collaborative and explains 22,34% of total variance. The third factor (component 3) shows high factorial weights on the variables Google, forums and socialnet (less predominant) and explains 18,11% of total variance. On total, the 3 factors explain 66,73% of total variance.

Note that the communalities (proportion of each variable's variance that can be explained by the factors), with the exception of SocialNet variable, are all high, which shows that three factors retained are appropriate to describe the latent correlational structure among all EFA variables.

It should be noted that for the 1st factor there is a clear opposition between variables Mobile and Smartphone. This happens because students who use more, on a daily basis, one of the mobile devices, use less the other (see Table 16 and Fig. 4). Regarding the use of mobile devices in the TLP, and collaborative learning environments, the corresponding variables support and collaborative appear together on the 2nd factor and, as mentioned, have a very high weight, which reinforces the conclusion reached in section 5.4. Finally, the factor 3 is defined by Google, SocialNet and forums variables that have positive weights, which justifies its position on the same side of the axis.

In a nutshell, observing Fig. 4, the 1st factor (component 1) is clearly defined by the "Devices", the 2nd factor (component 2) defines the "Trends" in learning with mobile devices and the 3rd factor the "Applications" (component 3).

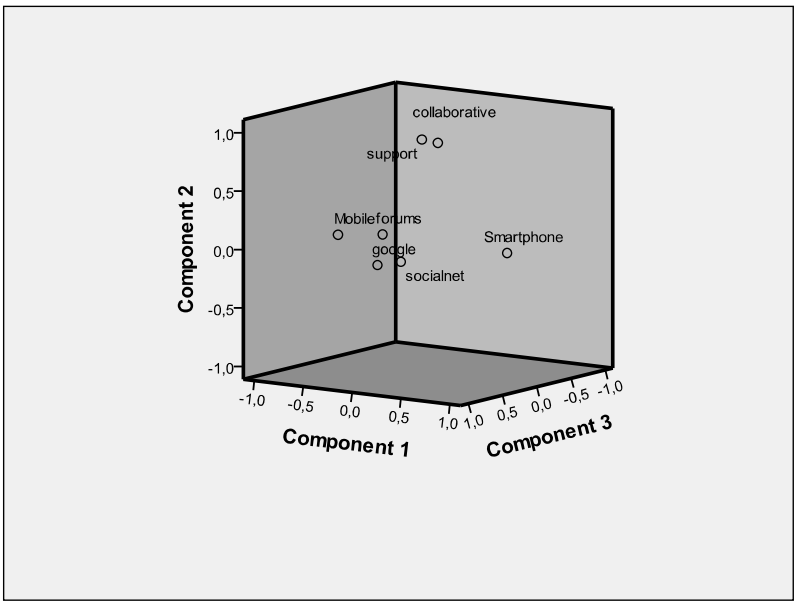

Figure 4. Component plot in rotated space.

6 Study limitations

The study has two limitations. The first is related to the sample size, ie the number of institutions chosen to conduct investigations was limited to higher education institutions in the north of Portugal. However, the institutions of the selection process have taken into account its importance in number of students and scientific and pedagogical quality in Portugal, so their representativeness is significant. The second limitation relates to the perception of students concerning the utilization – past, present and future – of mobile devices in higher education in the context of teaching and learning, not assessing whether the use of such technologies actually contributes to stimulate interest in learning content.

The study does not reflect the most recent developments in the existing institutions of higher education. For instance, the impact of the use of such technologies in the actual performance of students, specifically within the collaborative learning model. Future research should expand the number of institutions considered, including major institutions of the center and south of Portugal to be able to perform a more accurate assessment of utilization trends of mobile devices in higher education, particularly in the implementation of collaborative learning model.

7 Conclusions

Nowadays, it is impossible to ignore the wide and increased mobile technology use. This is sustained by the need of an individual to be "always on". Mobile devices allow that the number of individuals who use the internet anywhere increases daily. This technology has a set of features which enable an unprecedented versatility, that has led to their large-scale proliferation, and thus contributing to sweeping changes worldwide in several areas namely education and way of people work.

Mobile technology is used more as a tool than as a teaching methodology. From the research carried out, there is a consensus that this technology does not ensure by itself success in learning. However, when used as part of an effort to support the involvement of an active learning, there is evidence that they can lead to increase students' motivation and satisfaction. The introduction of BYOD in the classroom aims, from the students' perspective, to involve them in learning, leading them to participate more actively as well as ensuring that the learning is more effective; on the teacher's perspective it allows to "personalize" and motivate students in the teaching/learning process taking into consideration that this process can and should be considered beyond the classroom. In this way, mobile devices are an important base to mLearning and collaborative learning.

Collaborative learning with mobile devices trends seems to be a learning innovation whose time has come. It will make a student actively engage in building his/her own knowledge. Mainly, collaborative learning supported by mobile technology allows students to have on their hand access and to share materials, as well as to acquire skills that promote working in group and sharing ideas and knowledge. In a collaborative learning environment, there is a shift in the learning approach, i.e. in a traditional approach the focus is on the teacher and in static and repetitive contents. Oppositely, with collaborative learning, the learning process is centered in the students where they have a critical apprehension of contents that goes beyond the classroom. Students can learn anywhere and anytime.

In order to understand the developments in the use of mobile devices in higher education in Portugal, a research was carried out in two separate academic years, separated by five years (2009/2010 and 2014/2015), and in very heterogeneous courses (Law, Management/Economics and Engineering). As previously discussed, the result clearly shows a high growth rate of the use of mobile technology in higher education institutions in Portugal just like other countries already studied.

The goal of future work within the same target (higher education institutions in Portugal) is to identify and analyze how much mobile technologies, mLearning and collaborative learning, in the TLP, are introduced and their advantages and disadvantages. Furthermore, it will evaluate the continuous support and targeted training resources at the HEI have produced positive, or negative, changes in students' mobile learning practices. This task will be achieved through a set of new questionnaires to the students and teachers.

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Annex I

Use of ICTs/ mobile devices in higher education

Thanks for answering to this survey about the use of mobile devices.

The questionnaire is part of a study on the use of mobile devices and intend to evaluate their impact on the teaching-learning process.

*** Mandatory response**.

1. Course*

☐ Economics ☐ Engineering ☐ Management ☐ Law

2. Age *****

☐ 18 ☐ 19 ☐ 20 ☐ > 20

3. Gender *****

☐ M ☐ F

4. Which mobile devices do you use on your daily life? ***** You can choose more than one option

☐ Laptops ☐ Tablet ☐ Mobile phone ☐ Smartphone ☐ Other: _____

5. From those mobile devices indicated, which do you spend more time? *****

☐ Laptops ☐ Tablet ☐ Mobile phone ☐ Smartphone ☐ Other: _____

6. Do you agree with the use of e-mail applications on mobile devices? *****

Strongly disagree ☐1 ☐2 ☐3 ☐4 ☐5 Strongly agree

7. Do you access to Web pages on mobile devices? *****

Not at all ☐1 ☐2 ☐3 ☐4 ☐5 Very much

8. Do you consider useful to access the Internet on mobile devices? *****

Nothing useful ☐1 ☐2 ☐3 Very useful

9. Do you use file transport on mobile devices? *****

Never ☐1 ☐2 ☐3 ☐4 ☐5 Always

10. Do you consider useful the file transport on mobile devices? *****

Strongly disagree ☐1 ☐2 ☐3 ☐4 ☐5 Strongly agree

11. Do you use social networks (e.g. Facebook, Twiter) in learning environments with mobile devices? *****

☐ Yes ☐ No

12. "Do you use Google Apps in learning environments with mobile devices?"*

☐ Yes ☐ No

13. How many SMS do you send daily?*

☐ 0 ☐ 1 a 10 ☐ 11 a 20 ☐ 21 a 30 ☐ > 30

14. Do you use discussion forums in collaborative learning environments?*

☐ Yes ☐ No

15. Would you consider using mobile devices to support learning?*

☐ Yes ☐ No

16. Do you consider come to use mobile devices in collaborative learning environments?*

☐ Yes ☐ No

Thanks for the collaboration!