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The state of mobile learning supported by gamification and augmented reality in higher education institutions across three continents

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O estado da aprendizagem móvel suportado pela gamificação e realidade aumentada em instituições de ensino superior em três continentes

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El estado del aprendizaje móvil respaldado por la gamificación y la realidad aumentada en las instituciones de educación superior en tres continentes.

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Resumo: A digitalização generalizada é atualmente uma realidade das organizações e da sociedade em geral. Na última década, por exemplo, os smartphones foram gradualmente transformando o seu âmbito passando de apenas fornecedores de comunicação de voz para poderosos dispositivos de media e computação. Essa transformação deu origem a um crescimento de iniciativas empresariais, nomeadamente o fornecimento de serviços por meio de aplicações móveis. Neste contexto, o ensino superior enquanto organização e parte da sociedade está "obrigado" a alterar o seu modo operante em geral e em particular no processo de ensino-aprendizagem, tornando-o mais digital e ao mesmo tempo mais motivador para os alunos. O objetivo deste estudo é investigar a perceção de professores de ensino superior na área de tecnologia, na Europa do Sul, América do Sul e Ásia sobre o uso de tecnologias móveis, como gamificação e realidade aumentada, e como elas podem ser usadas para promover envolvimento do aluno dentro e fora da sala de aula. (pode ir até 200 palavras)

Palavras-chave: Aprendizagem móvel. Educação superior. Gamificação. Professores. Realidade aumentada.

Abstract: *The pervasive digitization is now a reality for organizations and society at large. In the last decade, for example, smartphones have been gradually transforming their scope from just voice communications providers to powerful media and computing devices. This transformation has led to a growth in business initiatives, namely in the services provision throughmobile applications. In this context, higher education asanorganizationandpartofsociety is compelled to change its operant mode in general and in particular in the teaching-learning process making it more*

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digital and at the same time more motivating for students. The aim of this study is to investigate the perception that higher education professors in the area of technology, across Southern Europe, South America, and Asia have about the use of mobile technologies such as gamification and augmented reality and how they can be used to promote student'sengagementinsideandoutsideoftheclassroom.

***Keywords**: Augmentedreality. Gamification. Highereducation. Mobile learning. Professors.*

***Resumen**: La digitalización generalizada es ahora una realidad para las organizaciones y la sociedad en general. En la última década, por ejemplo, los teléfonos inteligentes han ido transformando gradualmente su alcance de proveedores de comunicaciones de voz a medios poderosos y dispositivos informáticos. Esta transformación ha llevado a un crecimiento en las iniciativas comerciales, es decir, en la provisión de servicios a través de aplicaciones móviles. En este contexto, la educación superior como organización y parte de la sociedad se ve obligada a cambiar su modo operante en general y en particular en el proceso de enseñanza-aprendizaje, haciéndolo más digital y al mismo tiempo más motivador para los estudiantes. El objetivo de este estudio es investigar la percepción que los profesores de educación superior en el área de tecnología, en el sur de Europa, América del Sur y Asia tienen sobre el uso de tecnologías móviles como la gamificación y la realidad aumentada y cómo se pueden utilizar para promover participación delalumnodentroyfueradelaula.*

***Palabrasclave**: Aprendizaje móvil. Educación universitaria. Gamificación. Profesores. Realidadaumentada.*

INTRODUÇÃO

Digitization, also known as digital transformation, began in the industry. However, nowadays, this digital transformation is transversal to the whole society, being part of any organization or even individual. In this context, the literature demonstrates that the presence of digital technologies in education is also a reality and contributes to an increase in the overall performance of higher education institutions and in particular of students (Moreira et al., 2019; Flórez et al., 2019; Durão et al., 2019).

Before the advent of technologies, the design of higher education remained almost unchanged. College students made notes of teachers' lectures (i.e. master classes) and carried books back and forth in class. However, with the proliferation of mobile devices (smartphones, tablets, etc.) and the Internet, educational institutions in general and higher education institutions have been / are essentially challenged (Brown et al., 2019) having to change their modus operandi, both at management level and at the level of the teaching-learning process (TPL). Thus, higher education institutions (HEIs) in providing new teaching-learning methodologies have to address the need to adapt new learning environments (González, 2015) to students who currently have different characteristics, i.e. highly digital students (Ma et al., 2016).

According to (National Research Council, 2011), for the actual generation, education evolves towards integrating knowledge with practice, which occurs in contexts and communities that are important to students, and provides connections with their own experiences. This assertion is supported in (Strnberg and Pretz, 2005), since learning is seen as included within a physical and psychosocial context and distributed between a person and the tools he or she is using. To complement in (Dede, 2008) it is shown that knowing, doing and the context must be seen as compliments of each other.

The proliferation and use of mobile devices in society in general and in particular the new generation of students, highly experienced in technology and interested in social media, mobile technologies and strategy games, contributes to changes in society where education is included as stated (Friedrich et al., 2008). In this context,

according to (Rice, 2012) the correct use of most technologies stimulates learning environments and promotes student motivation, being these determining factors in learning.

Removing time and location limits is an important factor in providing lifelong learning. Thus, (Jamali et al., 2015) considers mobile learning technology as an alternative teaching resource because users have easy real-time access to information. Likewise, (Roffmann and Friese, 2012) considers that mobile learning is a type of eLearning without time and space restrictions and this technology improves the quality of classic learning environments, but does not replace them. Due to the increasing popularity of mobile devices, mobile learning (m-learning) (Georgieva, 2007) is used as a promising teaching innovationapproach.

The intensive use of mobile devices and mobile applications for a variety of activities (gamming, working, among others) led to the emergence of new mobile services and new opportunities to improve the TLPthrough ubiquitous wireless learning system. With this type of systems students can use the study materials through mobile devices (Ally, 2009), and they can use them easily whenever they want and where they want, maximizing the idea "always there always on".

The capabilities of mobile devices led to the emergence of new applications and technologies. In this myriad of solutions, the Augmented Reality (AR) and Gamification appear to have a high potential due to their characteristics to increase the engagement, effectiveness and the quality of student learning contents. However, studies (Cristia et al., 2017; Echeverría et al., 2012) show that the use of technology without an adequate pedagogical structure may not produce the desired result and may even have a negative impact on student learning.

Today, learning management systems, learning platforms, and other educational tools are widely used in classrooms. According to (Le Roux and Parry, 2017), students' motivation and engagement can be achieved through "always-on, socially interactive, technologically mediated communication artifacts".

The aim of this study is to investigate if higher education professors in the area of technology, in Southern Europe (SE), South America (SA), and Asia (AS) prepare their students for using mobile technologies, such as, for example gamification and augmented reality apps. The paper is organized as follows. In section 2 the background of mobile learning as well as augmented realty and gamification is presented and discussed. The research methodology is presented in section 3. In section 4 is presented the analysis and discussion of results. Finally, section 5 presents the final conclusions and some directions for future work.

2 BACKGROUND

2.1 MOBILE LEARNING

Educational institutions have shown great interest in incorporating mobile learning (m_learning) into their TLP (Moreira and Ferreira, 2017; Moreira et al., 2016; Delialioglu and Alioon, 2016). However, there must be increased concern on the part of decision-makers in the adoption of technology in the TLP, because it is not enough to apply and use the technology alone, but to develop methodologies that allow the proper integration of these technologies. Among the various definitions of m_learning, in (Cheng, 2015) it is defined as a form of e_learning that specifically uses mobile devices to provide learning and support content, anywhere, anytime (Chen and Huang, 2012). These

3 Know-how é uma expressão inglesa que designa literalmente "saber como". Logo, trata-se de um conjunto de conhecimentos práticosadquiridos por um profissional ou empresa, que promove para si vantagenscompetitivas.

technologies also allow students to benefit from a customized curriculum tailored to their learning needs (Hwang and Chang, 2011).

2.2 GAMIFICATION

The first documented use of gamification was in 2008. Gamification is defined as the use of game design elements in non-play contexts; gamification is a relatively new area, but with rapid growth (Deterding et al., 2011).

In the education sector the principles of gamification can help to improve some aspects of the TLP and are applied with "the intention to be more than entertainment" (Baxter et al., 2016). The main reason for this improvement is directly related to the mechanisms that allow to increase the involvement with the contents of learning and, essentially, to give feedback on the evolution of student learning through the use of tools. The application of gamification can, according to (Ritterfield et al., 2009), improve learning, overcoming some learning barriers, such as lack of attention, involvement and interest, by introducing the pleasure factor in the accomplishment of learning activities.

2.3 AUGMENTED REALITY

The Augmented Reality can be used in different devices (computers, tablets, smartphones, wearable components) (Swensen, 2016) and is defined as combining virtual and real objects in a real environment through mobile devices, working intuitively and in real time, that is there is a combination of virtual and real objects in the same environment (Azuma et al., 2001).

AR, according to Antonioli, et al.(2014), has great potential to be used as a new technology in education. The TLP benefits from the characteristics of AR, because professors realized that the incorporation of this technology enables students to learn effectively (Saidin et al., 2015). Some authors (Al-Azawi and Shakkah, 2018; Singhal et al., 2012) list a set of advantages in the use of AR in the TLP: (i) Provide easy communication between real and virtual environments; (ii) To give professors an approach to strengthen students' understanding in the classroom by increasing physical supports with virtual explanations and outlines; (iii) Connects to the formal class allowing students to learn outside of class time and outside the school boundaries; (iv) Allows visualization of interactions between 2D / 3D still images and 3D dynamic images.

In addition to the advantages listed above, AR offers another type of intuitiveness between the physical and virtual world and improves user's perception of the current world. AR empowers students to create essential practices and has become one of the key emerging technologies in education (Wu et al., 2013; Hsu et al., 2017).

3 RESEARCH METHODOLOGY

This section presents the procedures used in data collection which constitute the basis of the research / study presented. The research carried out used the quantitative methodology, which can be generically defined as a method of social research that uses statistical techniques for the collection and analysis of data. This approach aims essentially to find relationships between variables, to make descriptions using the statistical treatment of collected data, to test theories and to draw conclusions (Goertzen, 2017). The selection of the quantitative methodology is justified by the need to collect the opinions and attitudes of the respondents. Data collection was carried out with the use of a questionnaire.

The use of questionnaires requires special care, since it is not enough to collect the answers on the issues of interest, it is also important to perform a statistical analysis for the validation of the results. Aspects such as sample size, questionnaire formulation, data analysis, among others, are important and should be taken into account in research

(Campenhoudt, 2008). Before applied, the questionnaire was submitted to the evaluation of four experts in the area.

The quantitative study was based on an online questionnaire with 41 questions (Q1-Q41) relating to 6 sections (Demographic information, Prior knowledge, Participation/Engagement, Use of Mobile Devices (MD), Mobile use in the classroom and Self-efficacy). The first section consists of 6 questions, which include, for example, the age and gender. The second section consists of a question (Q7) with 11 items about professor's knowledge concerning MD (in particular, the items 10 and 11, with regard to whether they know how to download augmented reality and gamification apps on a MD). The third section contains 18 questions, 15 of which relate to professor 's opinions about students Participation/Engagement (inside and outside) class activity if they use their MD and 3 questions about the incorporation of MD, augmented reality and gamification in classes. The fourth section concerns a question with 15 items about how to use MD to perform educational tasks inside or outside the classroom (in particular the last 2 items regarding if students play an educational game on their MD or use their MD with augmented reality as a learning tool). In fifth section, we have 12 questions (Q27-Q38) about the use of the MD in the classroom (that is, what professors think about incorporating mobile learning in their classes and the ability of students to use them appropriately), two of these questions specifically refer to whether professors believe that students can be taught how to use MD with augmented reality apps and with gamification apps for learning. Finally, in the last section we have 3 questions (Q39-Q41) about self-efficacy. Almost all questions were close-ended type (Q38 and Q40 are the exceptions). Sections 2 and 4 use nominal scale (Yes (1)/ No (0)). Section 3 use five-point Likert scale ranging from "Strongly Disagree" (1) "Disagree" (2), "Neutral" (3), "Agree" (4) and "Strongly Agree" (5) and section 5 in the first 10 questions (Q27-Q36). Additionally, in question Q37 of section 5 we use a nominal scale (incorporate MD/ incorporate MD with training/ not incorporate).

The questionnaire has been online for 90 days and 212 valid responses were received. Data collected were treated by using the IBM SPSS Statistics 24.0 software. Statistical analyses used for the data analysis were Descriptive Analysis: frequency analysis, descriptive measures and graphical representations and Inferential Analysis: non-parametric (Kolmogorov-Smirnov test, Kruskal-Wallis test, multiple comparisons with Dunn´s test, Chi-square test and MANOVA one-way), correlation analysis and reliability analysis (Cronbach´s Alpha) (Campenhoudt, 2008; Maroco,2018).

4 ANALYSIS AND RESULTS DISCUSSION

The study sample consists of 212 professors from leading Universities, 80 from Southern Europe (SE), 61 from South America (SA) and 71 from Asia (AS). 55,2% of the professors in the sample are male and 44,8% female: in SE and SA the majority were male (70% in SE and 60,7% in SA) but in Asia 66,2% were female. Relatively to age, in SE professor´s majority were between 41-50 years (52,5%), in SA between 31-40 years and in AS between 31-40 although less prominent (36,1%). Only 6,6% of the professors have more than 60 years and only 6,6% of the professors have less than 30 years. Relatively to the levels of teaching degrees, we can conclude that in all continents professors teach in a high proportion in PhD, followed by Master and Degree.

To verify if the variability of the answers resulted from differences in professor's opinions, we performed a Reliability Analysis using Cronbach´s Alpha for the four dimensions (corresponding to sections 2 to 5), which are "Prior Knowledge" (Dimension 1), "Participation/Engagement" (Dimension 2), "Use of Mobile Devices" (Dimension 3) and "Mobile use in the classroom" (Dimension 4).

The values obtained were 0,844 (11 items), 0,939 (18 items), 0,860 (15 items) and 0,929 (10 items) respectively. Since this measure varies between 0 and 1 and higher values are more desirable, we can consider that all dimensions are reliable. According with these results it makes sense to present the descriptive results (percentages, mean and standard deviation (Sd), according to measurement scale) for each question/item. The results of the analysis can be found, resumed, in Table I (Dimension1), Table II (Dimension 2), Table III (Dimension 3), and Table IV (Dimension 4).

Table I presents the results of the percentages of "Yes" responses of the 11 items of "Prior Knowledge" (Dimension 1), by continent.

We note, for items 1 to 9, that the majority of these professors have excellent knowledge (with percentages at least 76%) on how to perform the most trivial tasks. Item 9 "Access college resources such as LMS, payroll, etc., on a MD" although large, there is a decrease (above 64%).

Moreover, despite being new mobile technologies, we denoted that although still high for SE and SA (>50%), we found a decrease when the prior knowledge is related to download Augmented Reality applications and Mobile App Gamification on a MD (items 10 and 11), for professors of all continents and in AS these percentages are below 50%. To confirm this perception obtained by exploratory analysis, we used independence Chi-square test (inferential analysis) and obtained p-value=0,007 and p-value=0,010 for item 10 and 11, respectively. So, professor´s opinions are not independent of the continents to which they belong. By comparing the results of exploratory analysis with those of inferential analysis, it seems that the difference of opinion is due to the Asian continent. Applying the Chi-square test with continuity correction only for the SE and SA continents, we conclude from the values obtained (p-value=0,239 and p-value =0,360) that in fact the professor´s opinion is independent of the continent to which they belong (SE or SA). For all of this Chi-square tests performed, all conditions of applicability were cheeked.

So we can conclude that in AS are significant differences in the percentages associated to items 10 and 11 compared to the other continents, in the sense that in AS these percentages are lower. These points to the fact that Asia is still lagging behind other continents in terms of knowledge about new technologies.

Given these results, it seemed of interest to verify, for each continent, if the gender of the professors is independent of their knowledge on how to download Augmented Reality and Gamification apps on a mobile device. For item 10, we found a p-value of 0,023 for SE, 0,013 for SA and 1,000 for AS so we can conclude that gender has influence in prior knowledge for continents SE and SA. Note that when analyzing in detail the contingency tables constructed for the Chi-square test, we found that for female "No" predominates and for males the "Yes" predominates. With regard to item 11, in SE and AS the gender does not influence in prior knowledge (p-value=0,801 and p-value=1,000) because, in SE " Yes" predominates and in AS "No" predominates, whatever the gender.

Table 1 - Percentages of Yes responses of the 11 items of "Prior Knowledge" by continent

	I know how to...on a MD	(SE/SA/AS) (%)
1	Connect to and access the internet from	97,5%/96,7%/9
2	Download music and video files	85%/93,4%/83,1%
3	Find the definition of a word or concept	92,5%/93,4%/90,1%
4	Download a mobile application	92,5%/95,1%/91,5%
5	Interface or connect my calendar/alarm	85%/85,2%/81,7%
6	Translate a sentence into another language	90%/90,2%/76,1%
7	Access and participate in a social network site	87,5%/95,1%/87,3%
8	Send and receive emails/text messages	96,3%/96,7%/91,5%
9	**Access college resources such as LMS, payroll, etc.**	**72,5%/70,5%/64,8%**
10	**Download augmented reality applications**	**66,3%/55,7%/40,8%**
11	**Download Mobile App Gamification**	**62,5%/54,1%/38%**

Source: Authors (2019).

In terms of "Participation/-Engagement" -Dimension 2) the mean values for each continent, are close to the value 4 (agree position), which suggested that professors think that students will have greater involvement and participation in activities if they use their MD. The overall mean was 3.93, 4.17 and 3.9, respectively. These opinions are also consistent (variation coefficient <20%). It can also be seen in Table II that, in general, these values are higher in SA. More, in some questions it is interesting to verify that AS and SE has an identical behavior relatively to continent SA (for example Q16, Q17, and Q25).

Table 2 - **Mean and Standard Deviation (Sd) for questions of "Participation/Engagement" by continent**

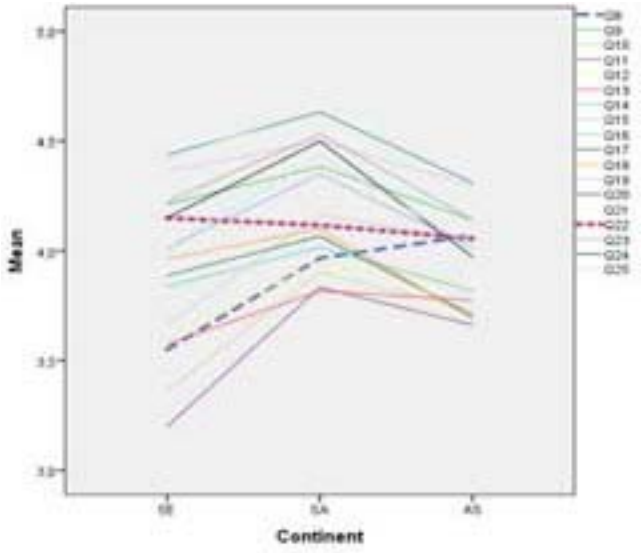
Questions	Mean (SE/SA/AS)	Sd (SE/SA/AS)
Q8 - My students would be more likely to participate in classes if they could use their MD	3,55/3,92/4,07	1,02/1,05/0,867
Q9 - Mobile learning opportunities would allow students to learn and study in places they normally couldn´t	4,21/4,33/4,14	0,76/0,93/0,87
Q10 - It would be easier for students to complete classwork and assignments if they could use MD	3,36/3,85/3,73	1,13/ 1,09/ 1,16
Q11 - My students would spend more time on classwork if they could access materials anytime, anywhere on their MD	3,20/3,79/ 3,66	1,06/ 1,1/ 1,1
Q12 - My students would be more likely to participate in class activities outside of the class time if they could do that through their MD	3,60/3,90/ 3,85	1,03/ 1,01/ 0,92
Q13 - My students would be more likely to engage in class discussions inside of class they could post their thoughts from their MD	3,58/3,77/ 3,77	1,12/1,06/ 1,05
Q14 - My students would be more likely to engage in class discussions outside of class they could post their thoughts from their MD	3,84/3,97/ 3,82	1,04/ 0,88/ 0,98
Q15 - My students would be more likely to ask for help if they could communicate through their MD	3,66/4,11/ 4,04	1,09/ 0,97/ 0,85

Q16 - Mobile learning could be incorporated into classes	4,01/4,30/ 4,01	0,92/ 0,92/ 0,85
Q17 - Augmented reality could be incorporated into ML classes	3,89/4,02/ 3,70	1,08/ 1,03/ 0,89
Q18 - Gamification could be incorporated into ML classes	3,96/4,11/ 3,69	0,99/ 0,97/ 0,92
Q19 - Students should be able to easily view course materials on their MD	4,36/4,44/ 4,30	0,77/ 0,87/ 0,85
Q20 - Students should be able to download mobile applications that could help them study	4,44/4,57/ 4,31	0,73/ 0,85/ 0,80
Q21 - Students should be able to access LMS (e.g. Moodle..) in a mobile format on their MD	4,45/4,56/ 4,24	0,75/ 0,83/ 0,89
Q22 - Students should be able to take quizzes on their MD	4,15/4,07/ 4,06	0,97/ 1,26/ 1,10
Q23 - Students should be able to participate in discussion forums from their MD	4,23/4,48/ 4,14	0,91/0,85/ 0,99
Q24 - It would not require a lot of effort for students to learn how to use a mobile application designed for my class	4,15/ 4,44/3,97	1,01/ 0,83/ 1,00
Q25 - It would be easy for students to engage in discussions using mobile application or website in mobile format	4,01/ 4,38/4,01	1,00/ 0,93/ 0,90

Source: Authors (2019).

Summarizing , the opinion of professors of SA is always more positive except for questions Q8 and Q22 as is clearly visible in Figure 1. Focusing the study on the new mobile technologies (Q17 and Q18) in order to assess whether there are differences in professors' opinions to incorporate in their classroom, according continent, we opt by non-parametric tests since the hypothesis of Normal distribution was not verified. So we performed the Kruskall-Wallis test which is the most adequate in this case. The results obtained for p-value were 0,046 and 0,021 for questions Q17 and Q18 lead us to conclude that are statistically significant differences in regard on the continent. Moreover, the same tests applicate to the other questions lead us also to conclude that there are only no differences in questions Q9, Q12, Q13, Q14 and Q19.

Figure 1 - Behavior of the mean of "Participation/Engagement" by continents.



Source: Authors (2019).

In regard to "Use of MD" (Dimension 3), in the sense, of what educational tasks professors ask students to do (inside or outside the classroom), opinions about the use of MD´s are identical (Table III) in all the continents. Chi-square test confirm there are no significant differences in the percentages associated with each continent (all p-values>0,05). For items 3 and 15 there is a reversal in the opinions. For item 3, "No" is predominant (60%) in SE and for SA professors and AS professors no. Perhaps SE professors do not view social networks as a suitable study tool in the context of digital transformation. For item 15 "Yes" is predominant in AS (53,5%) but "No" is predominant in SE and SA although, as already mentioned, there are no significant differences. It is interesting to note that all items that refer to "Text a classmate…" (items 6 to 9) predominate the "No" response in all continents, perhaps because it is considered, by the professors, a disturb element, in the contextofclassroom.

Table 3 - **Percentages of Yes responses of the 15 items of "Use of MD" (Q26) by continent**

I would ask students to…		**(%) (SE/SA/AS)**
1	Download applications that help them learn new subjects	68,8%/77%/83,1%
2	Use MD to look up something that they didn´t know or understanding during class	70%/67,2%/83,1%
3	Engage in social networking on their MD	**40%/52,5%/52,1%**
4	Write notes on their MD to remind themselves of an assignment	67,5%/63,9%/57,7%
5	Set alarms or reminders on their MD to help them remember an assignment or a test	65%/63,9%/62%
6	Text a classmate during class	21,3%/34,4%/23,9%
7	Text a classmate about the contents of the class	40%/42,6%/33,8%
8	Text a classmate about the professor´s ability	17,5%/24,6%/18,3%
9	Text a classmate about the level of engagement in the class	18,8%/29,5%/16,9%
10	Take a picture or video with their MD that they could be used for an assignment	65%/67,2%/64,8%
11	Access an LMS (e.g. Moodle) on their MD	77,5%/83,6%/70,4%
12	Read a paper or assignment on their MD	62,5%/72,1%/73,2%
13	Use their MD as a study tool	60,8%/70,5%/76,1%
14	Play an educational game on their MD	51,3%/57,4%/62%
15	Use their MD with augmented reality as a learning tool	**48,8%/47,5%/53,5%**

Font: Own elaboration.

Table 4 shows the results some of the 10 questions of "Mobile use in the classroom" (Dimension 4).

Table 4 - Mean and Standard Deviation (Sd) for questions of "Mobile use in the classroom" by continent

Questions	mean (SE/SA/AS)	Sd (SE/SA/AS)
Q27 - I believe students can be taught how to appropriately use MD for learning	4,00/4,30/4,24	0,90/0,99/0,82
Q28 - I believe students can be taught how to appropriately use MD for collaborative learning	4,08/4,39/4,25	0,87/0,88/ 0,81
Q29 - I believe students can be taught how to appropriately use MD with augmented reality apps for learning	3,86/4,16/4,04	0,92/1,00/0,84
Q30 - I believe students can be taught how to appropriately use MD with gamification apps for learning		

Q31 - I believe using mobile applications for learning in my classroom would benefit students	3,61/4,33/4,07	1,10/ 0,91/0,91
Q32 - I think students would be more motivated to learn if they could use MD	3,65/4,18/3,97	1,13/1,03/0,93
Q33 - Students would think is fun to use an interactive MD in my classroom	3,95/4,02/4,07	1,01/1,12/0,87
Q34 - I would like my students to be able to use MD to access course contents and practical skills	3,94/4,34/4,24	0,93/ 0,93/0,77
Q35 - I would like to learn more about m-learning, so that I can incorporate it in my classroom	3,79/4,33/4,10	1,21/0,98/0,86
Q36 - I would like to learn how to create mobile applications, so that I can incorporate them into my lessons	3,73/4,15/3,93	1,22/1,11/1,07

Source: Authors (2019).

All the mean values are close to the value 4 (agree position) and opinions are consistent for professors in all continents (variation coefficient<20%). As can be seen in Table 4 and Figure 2, these values seem higher in SA and AS although professors of all the continents agree about students using MD in classroom. The overall mean was 3.85, 4.24 and 4.09 respectively.

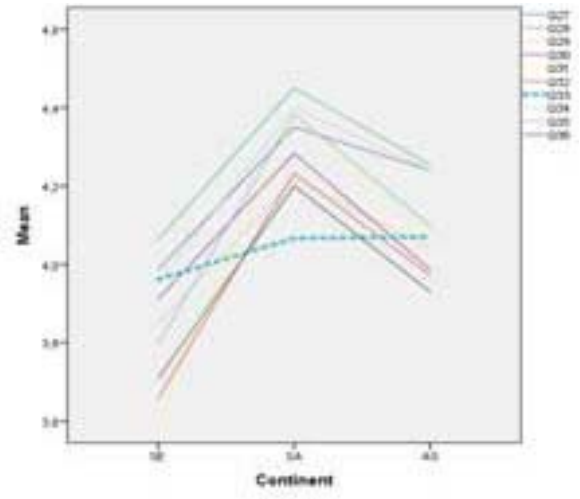
SA and AS have more confidence in their students than SE in the sense that professors believe that students can be taught and that students are motivated to appropriately use MD in their classes.

Looking at Figure 2, we can easily see that all mean values turned out to be positively higher on continent SA except for Question 33. However, when performing the Kruskal-Wallis test to verify that they are statistically significant, we obtained p-value = 0.598 which led us to conclude that, for this question, there are no significant differences regarding professor´s opinion, whatever the continent.

It is also important to highlight the lower availability of SE professors in learning m-learning and mobile applications in order to incorporate into their lessons (Q35 and Q36).

Despite this, it should be noted that the dispersion of the responses in AS is less than the dispersion of the responses in the other continents, which reveals greater consistency in the responses in the AS continent.

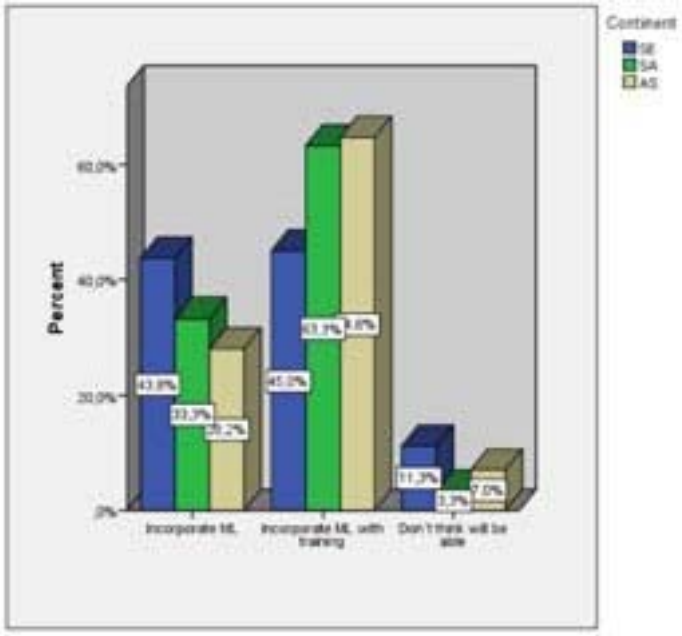
Figure 2 - Behavior of the mean of “Mobile use in the classroom” by continents.



Source: Authors (2019).

Concerning "Incorporation of mobile learning in the classroom" (Q37), we found that the majority (62,3%) of SA and (64,8%) of AS professors said will be able to effectively incorporate this with training against 45% of SE professors. It should also be noted that the low percentage of professors from all continents (11,3% in SE, 4,9% in SA and 7% in AS) not think will be able to effectively incorporate mobile learning (see Figure 3).

Figure 3- Percentages of question Q37, by continen.



Source: Authors (2019).

In order to assess professor´s global opinion about the questions in Dimensions 2 and 4 ("Participation/Engagement" and "Mobile use in the classroom") we constructed 2 indices, Index_D2 and Index_D4, calculating the arithmetic mean of the variables that integrate each dimensions. To identify if these 2 indices were associated we calculate Pearson correlation coefficient, by continent.

Correlation analysis confirms the significant relation at the 0,01 level (see Table V). The results show that exists strong positive correlation (r > 0,8), whatever the continent, that is, the professors that most agree in Dimension 2 ("Participation/Engagement") are those who most agree in Dimension 4 ("Mobile use in the classroom").

Table 5 - Pearson correlation between Index_D2 and Index_D4, by continent

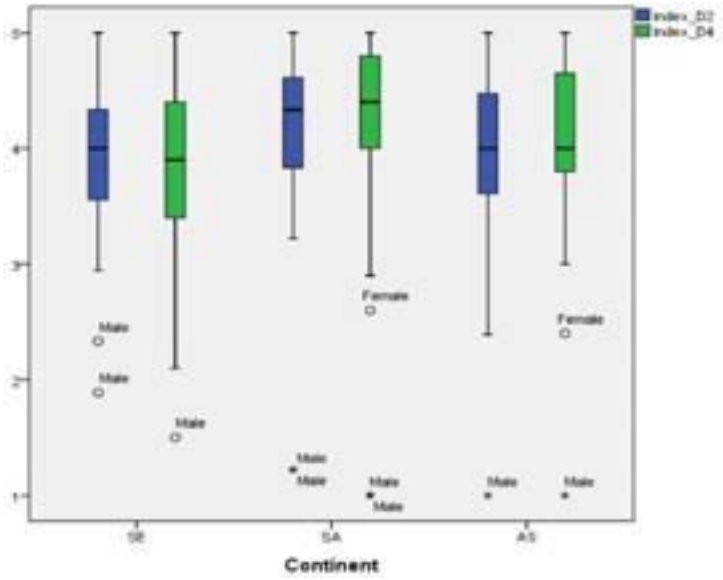
	Continent								
	SE			SA			AS		
	Index_D2			Index_D2			Index_D2		
	P	S		P	S		P	S	
Index_D4	,848	,000	79	,884	,000	61	,832	,000	71

S – Sig. (2-tailed); P – Pearson

Source: Authors (2019).

We build boxplot clusters (Figure 4) to verify if there exist some differences in Index_D2 or/and in Index_D4 by continent. We can conclude immediately that, professor's opinion relatively to variables that compose Index_D2 and Index_D4 is more favorable for SA continent. In a preliminary analysis it also seems quite similar the professor's opinion of SE and AS, regarding the variables that compose Index_D2 and that compose Index_D4. So, we verified that are more SA professors who think that students will have a higher involvement and participation in the activities if they use their MD just as there are more SA professors that believe that students can be taught to appropriately use MD, compared with the professors of other continents. Also noteworthy is the existence of some moderate and severe outliers, predominantly male (very unfavorable opinion´s).

Figure 4 - Distribution of Index_D2 and Index_D4 for each continent



Source: Authors (2019).

To verify if we can perform tests of parametric hypotheses, we start by evaluating whether the two Indices (Index_D2 and Index_D4) follow a Normal distribution (Kolmogorov-Smirnov test with Lilliefors correction) with a significance of 5% (Table VI). This hypothesis was not verified in both cases, for at least one continent. The assumption of normality was not verified.

Table 6 - Results of Kolmogorov-Smirnov by continent

One-Sample Kolmogorov-Smirnov Test			
Continent		Index_D2	Index_D4
SE	N	80	79
	Asymp. Sig. (2-tailed)	,200[c]	,200[c]
SA	N	60	60
	Asymp. Sig. (2-tailed)	,046[c]	,000[c]
AS	N	71	71
	Asymp. Sig. (2-tailed)	,200[c]	,025[c]
c. Lilliefors Significance Correction.			

Source: Authors (2019).

Simultaneously we proceed to the M-Box test for the homogeneity of covariance matrices that provide a p-value of 0,266>0, 0. As the assumption of normality does not occur, we will choose to use non-parametric alternatives (MANOVA one-way) to know if the continent (factor) to which the professor belongs influences his opinion about the two indices above (dependent variables). As nonparametric methods for multivariate designs are based on the orders of the observations we have to work with "Rank_Index_D2" and "Rank_Index_D4" (as there were ties, to these cases was attributed the average of the orders they would have if they are not tied). We can proceed to the analysis of the results of Multivariate tests (Table 7).

Table 7 - Multivariate tests (factor-CONTINENT)

Multivariate Tests[a]						
Effect		Value	F	Df	Error df	Sig.
Intercept	Pillai's Trace	,787	380,434[b]	2	206	,000
	Wilks' Lambda	,213	380,434[b]	2	206	,000
	Hotelling's Trace	3,694	380,434[b]	2	206	,000
	Roy's Largest Root	3,694	380,434[b]	2	206	,000
Continent	Pillai's Trace	**,098**	5,319	4	414	,000
	Wilks' Lambda	,903	5,380[b]	4	412	,000
	Hotelling's Trace	,106	5,439	4	410	,000
	Roy's Largest Root	,095	9,832[c]	2	207	,000
a. Design: Intercept + Continent						
b. Exact statistic						
c. The statistic is an upper bound on F that yields a lower bound on the significance level.						

Source: Authors (2019).

The most robust adequate statistic is based on the Pillai Trace (PT), calculated from the orders "Rank_Index_D2" and "Rank_Index_D4" and follows a Chi-Square distribution with $p * (m-1)=2 * (3-1)=4$ degrees of freedom, where p is the number of dependent variables and m is the number of continents. So, the observed value $X2=(N-1)PT=211*0,098=20,678$. As p-value=0 < α=0,05 we reject the hypotheses that the continent has no influence on the professor s opinion in Dimension 2 and Dimension 4. In order to identify in which of the two dimensions (Index_D2 and Index_D4) and continents we observe the significant differences, we use the Kruskal- Wallis test for each of the dimensions follow by the multiple comparisons of the order means.

As we can see in Table VIII the p-values (Sig.) < 0,05 (p-value = 7% and p-value = 0%) so we can conclude that there are at least two continents that differ significantly from each other regarding professors' opinions about Participation/Engagement (Dimension 2) and Mobile use in the classroom (Dimension 4).

Table 8 - Results of Kruskal-Wallis test

	Null Hypothesis	Sig.	Decision
1	The distribution of Index_D2 is the same across categories of Continent	7,000	Reject the null hypothesis
2	The distribution of Index_D4 is the same across categories of Continent	,000	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is ,05.

Source: Authors (2019).

However, the Kruskal-Wallis test does not indicate which continents for which professors' opinions are significantly different. Therefore, to perform this identification we will proceed to the multiple comparison of the order means using the Dunn test statistic for Index_D2 and Index_D4 (Tables 9 and 10).

Table 9 - Results of Dunn´s multiple comparisons for Index_D2

Samples 1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
SE-AS	-7,698	9,949	-,774	,439	1,000
SE-SA	-32,102	10,421	-3,080	,002	,006
AS-SA	24,404	10,701	2,281	,023	,060

Source: Authors (2019).

Table 10 - Results of Dunn´s multiple comparisons for Index_D4

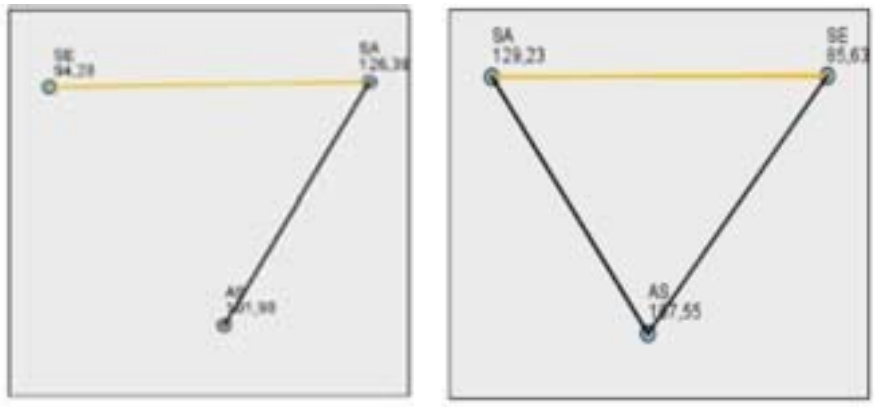
Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
SE-AS	-21,916	9,911	-2,211	,027	,081
SE-SA	-43,600	10,379	-4,201	,000	,000
AS-SA	21,684	10,628	2,040	,041	,124

Source: Authors (2019).

Using the unadjusted asymptotic p-value (Sig.), we can conclude that the significant differences occur between continents SE-SA and AS-SA for Index_D2 and between all continents with respect to Index_D4. If we use Adj. Sig. the differences between some continents become marginally significant. Since we have only three continents (groups) we chose the results provided by test Sig.

These conclusions confirm our preliminary analysis (using the box-plot) and can also be validated by the graphical representations of the continents with sample average rank of each continent (see Figure 5). In these representations the continents that differ significantly are identified, with a yellow line. Note that relatively to Index_D2 there isn´t a line connecting SE and AS.

Figure 5 - Pairwise comparisons of Index_D2 and Index_D4 for each continent



Source: Authors (2019).

5 CONCLUSIONS

The new digital age requires new models of teaching and learning. They respond, on the one hand, to the needs of a constantly changing high-tech world and, on the other, to the presence of actors with new profiles, i.e. highly digital students. Therefore, the referred leads to the need for teachers in general, and higher education teachers in particular, to explore and experiment their educational efforts in the sense of develop activities, methodologies and technologies far beyond the traditional blackboard and textbook, namely mobile learning with gamification and augmented reality.

So, as general conclusions we can say that the majority of professors have excellent knowledge on how to perform the most trivial tasks. Exceptions to "Download augmented reality applications" and "Download Mobile App Gamification on a MD" in continent Asia. At the same time, by assessing professor´s opinion by continent, the results obtained suggest that their opinions are independent of the continent with exception to continent AS. More specifically, in AS continent, there are significant differences in percentages associates to items 10 and 11 ("Download augmented reality applications" and "Download mobile app gamification") compared to the other continents, in the sense that in AS the percentages are lower. Moreover, regarding gender, we have found differences in knowledge about to "Download augmented reality applications" (item 10) for continents SE and SA ("No" predominates for female and "Yes" predominates for male). With regard to "Download mobile appgamification" (item 11) gender only influences prior knowledge in SA.

In terms of "Participation/Engagement" the mean values are identical for all continents and are close to the value 4 (agree position), which suggested that professors think that students will have greater involvement and participation in activities if they use their MD. However, although similar, professor's opinions of SA are always more positive except with respect to "The students would be more likely to participate in classes if they could use their MD" (Q8) and "Students should be able to take quizzes on their MD" (Q22). Finally, we can also have concluded that there are significantly differences in professor's opinions, by continent, in most of the questions.

In regard to "Use of MD" in the sense of what educational tasks professors ask students to do, opinions about the use of MD´s are identical in all the continents. Although these similar opinions, it is interesting to note that for all items that refer to "text a classmate…" (items 6 to 9), predominate the "No" response in allcontinents.

Relatively to, "Mobile use in the classroom", all the mean values are close to the value 4 and opinions are homogeneous for professors in all continents. These values seem higher in SA and AS, although, the professors of three continents agree about students using MD inclassroom.

Also relevant is the large percentage of professors from the continents SA and AS who think that they are able to effectively incorporate ML in their classes, with training. In Asia, this percentage is no longer predominant although it can be considered moderately high (45%).

In order to conclude whether or not these higher education professors, in the area of technology, prepare and/or are committed to having their students use mobiles technologies for better and more effective performance in their classes, we consider that professors' opinions about "Students Participation/Engagement if they use their MD" and "Incorporating ML in their classroom" are relevant. Thus, when carrying out a detailed study of these two aspects we find that: on the three continents under review, professors that most agree that their students will be more participatory and engaged in/out of the classroom if they use their MDs are those professors who most agree on that it is possible to incorporate

successfully into their classes with/without training ML (strong positive correlation). So, the results of the study point to a similar situation in the different countries with small differences, particularly with regard to students' participation, engagements and mobile use in the classroom.

Unfortunately, the small sample size did not allow to definitively understand how professors prepare their students for using mobile technologies with gamification and augmented reality and how they can be used to promote student engagement within and outside the classroom. As future work will be explored by collecting data with a larger sample in order to obtain greater statistical significance. The research also intends, on the one hand to accompany the evolution of teachers towards digital higher education and on the other hand to have the perception of the students' needs of a more digital teaching.

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