redie
Revista Electrónica de Investigación Educativa

ISSN: 1607-4041 | redie.uabc.mx

Digital Competence, Device Access, and Classroom Practices in Higher Education[1]

Competencia digital, acceso a dispositivos y prácticas de aula en educación superior

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How to cite: Santos, C., & Mattar, J. (2026). Digital competence, device access, and classroom practices in higher education. *Revista Electrónica de Investigación Educativa.* Publicación anticipada en línea https://doi.org/10.24320/redie.2026.of.6730

Abstract

This article explores the relationships between digital competence, access to digital devices, and digital practices among Portuguese higher education professors, emphasizing the need for digital proficiency in today's educational landscape. Using a quantitative approach, data from 846 professors were collected through a questionnaire and analyzed using inferential statistics, including t-tests, Cohen's d for effect size, and Pearson correlation coefficients. Results highlighted statistically significant differences in digital competences associated with the use of mobile devices (excluding mobile phones), with medium effect sizes. In terms of digital practices, all examined practices showed statistically significant

[1] ***Online First:*** Author's version Accepted for publication.

(Received: April 22, 2024; Accepted: September 4, 2024)

differences, with effect sizes ranging from medium to high-level. Notably, the correlation between digital competence proficiency and the number of digital practices in the classroom was stronger than that with the number of digital devices, underscoring that active engagement in digital practices is more crucial to developing digital competences than mere access to digital devices. These findings suggest that educational policies should focus not only on providing access to digital tools but also on integrating these tools effectively into pedagogical practices to enhance educational outcomes and prepare educators and students for a digital future.

Keywords: Higher Education, Digital Competence, Professors, DigCompEdu

Resumen

Este articulo explora las relaciones entre la competencia digital, el acceso a dispositivos digitales y las prácticas digitales entre los profesores de educación superior en Portugal, enfatizando la necesidad de competencia digital en el panorama educativo actual. Mediante un enfoque cuantitativo, se recogieron datos de 846 profesores a través de un cuestionario y se analizaron utilizando estadísticas inferenciales, incluidos tests t, la d de Cohen para el tamaño del efecto y los coeficientes de correlación de Pearson. Los resultados destacaron diferencias estadísticamente significativas en las competencias digitales asociadas al uso de dispositivos

móviles (excluyendo los teléfonos móviles), con tamaños de efecto medios. En términos de prácticas digitales, todas las prácticas examinadas mostraron diferencias estadísticamente significativas, con tamaños de efecto que variaron de medios a altos. Es notable que la correlación entre la competencia en competencia digital y el número de prácticas digitales en el aula fue más fuerte que la correlación con el número de dispositivos digitales, subrayando que la participación activa en prácticas digitales es más crucial para desarrollar competencias digitales que el simple acceso a dispositivos digitales. Estos hallazgos sugieren que las políticas educativas deberían centrarse no solo en proporcionar acceso a herramientas digitales, sino también en integrar estas herramientas de manera efectiva en las prácticas pedagógicas para mejorar los resultados educativos y preparar a educadores y estudiantes para un futuro digital.

Palabras clave: Educación Superior, competencia digital, Profesores, DigCompEdu

I. Introduction

Digital technologies have profoundly changed almost every aspect of our lives: the way we communicate (Redecker, 2017), how we play, how we work, how we organize our lives, our cities, and our mobility; how we participate in civic, social, and political dimensions; how we acquire knowledge and information; the way we think; and how we behave in isolation or collectively, among other factors (Boulianne, 2020; Redecker, 2017; Trencher & Karvonen, 2020; Zagorskas & Burinskienė, 2019). For Benali et al. (2018), “The proliferation of mobile technologies such as smartphones and tablets has changed the way people live, communicate, interact, learn, and generate new knowledge” (p. 99).

Consequently, more “children and young adults are growing up in a world where digital technologies are ubiquitous” (Redecker, 2017, p.12). These children and young adults must be competent to use digital technologies effectively, consciously, productively, and civilly. However, not all new professors are comfortable interacting with technologies at the expected level (Pedro, 2016).

With the increased digitalization in society and education, innovative technologies and pedagogies have substantially impacted higher education. Teaching is increasingly centred on digital resources due to the abundance of information available on the internet and the promotion of a massive and open education approach (Lebrún et al., 2021).

Information and Communication Technologies (ICT) are essential tools in academic practice, both in teaching and research. However, its use in the teaching-learning process has often been limited to digitizing educational content without taking full advantage of the benefits of collaborative environments, Web 2.0, and emerging technologies. The improvement of the digital competences of professors can be an essential bridge to move from the instrumental use of technologies to a conscious and consistent use, incorporating pedagogical and didactic practices to integrate these technologies into the teaching-learning process effectively. Thus, it is essential to explore the potential of technology to improve students' learning experience and promote more efficient and innovative teaching (Durán et al., 2017).

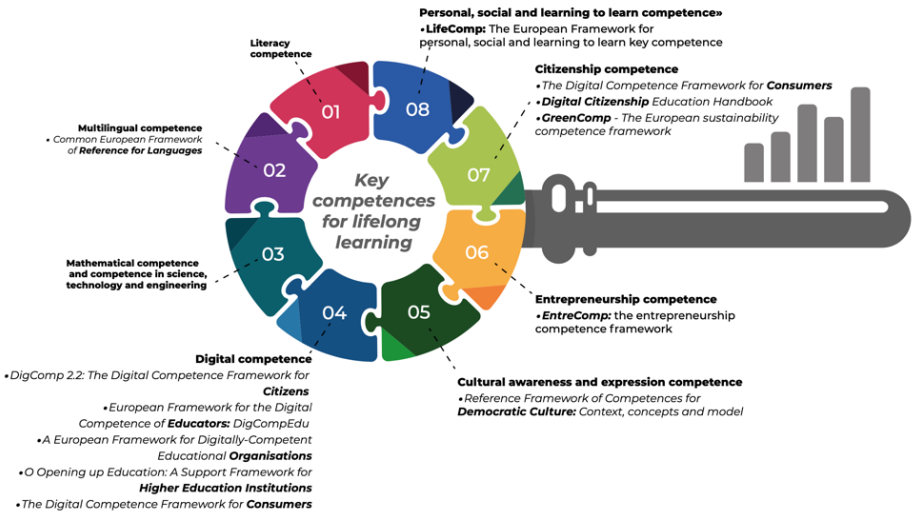
The use of technologies in education is a central theme in the discussion in institutions such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) with the UNESCO ICT Competency Framework for Teachers (UNESCO, 2018) and the United Nations (UN), through the 2030 Agenda for Sustainable Development in which several goals related to ICT (4, 5, 9, 10, 17 and 17).

Digital competence is considered a core competence for citizens. It is transversal to the development of other essential competences needed for lifelong learning, including the ability to adopt and use digital technologies confidently, critically, and responsibly in different contexts. The Council of

the European Union has listed it as one of the eight critical lifelong learning competences (Council of Europe, 2018a).

The European Union has a long history in the development of frameworks, including key competences for lifelong learning (Council of Europe, 2018a), as Figure 1, including frameworks specifically focused on digital skills, whether for citizens (Vuorikari et al., 2022), Educators (Redecker, 2017), Educational Organizations (Kampylis et al., 2015), Open Education for Higher Education Institutions (Santos, 2019; Santos et al., 2017) and Consumers (Brečko & Ferrari, 2016), in addition to the ongoing process that seeks the certification of digital skills, the European Digital Skills Certificate (EDSC) as foreseen in action 9 of[2] the Action Plan for Digital Education 2021-2027 (European Commission, 2020).

Figure 1. Key competences for lifelong learning and Frameworks.



Source: Translated from Santos (2023)

[2] https://joint-research-centre.ec.europa.eu/digcomp/european-digital-competence-certificate-edsc_en

At the national level in Portugal, digital competences are strongly aligned with several policies, namely the National Digital Competence Initiative e.2030 (INCoDe.2030) (Council of Ministers, 2021), the “Certificate of Digital Competence” program (Government of Portugal, 2021), the Portugal 2030 Strategy (Council of Ministers, 2020a) and finally the Action Plan for the Digital Transition (PATD) (Council of Ministers, 2020b), in addition to national reference frameworks, such as the Digital Competence Reference Framework: Study for non-ICT employability in the future (INCoDE.2030, 2023).

The European framework for educators, DigCompEdu (Redecker, 2017), describes competences that focus on supporting and encouraging the adoption of digital tools to improve and innovate education aimed at educators from preschool to higher education. It is organized into six areas with 22 competences and six proficiency levels. The progression in the levels starts from the Newcomer (A1) to the Pioneer (C2) following the levels of the Common European Framework of Reference for Languages (Council of Europe, 2018a).

> At the first two stages, Newcomer (A1) and Explorer (A2), educators assimilate new information and develop basic digital practices; at the following two stages, Integrator (B1) and Expert (B2), they apply, further expand and structure on their digital practices; at the highest stages, Leader (C1) and Pioneer (C2), they pass on their knowledge,

critique existing practice and develop new practices. (Redecker, 2017, p.9)

The progression in proficiency levels is cumulative, as each top-level descriptor includes all lower-level descriptors with increasing complexity. Bloom's revised taxonomy inspires this progression. Moreover, it follows the levels of the Common European Framework of Reference for Languages (CEFR) (Council of Europe, 2018b). The use of these levels of progression, established and widely disseminated across Europe, has made it easier for educators to understand and value their level of digital competence and give coherence to European frameworks (Redecker, 2017).

Digital devices in the classroom should be treated as didactic material, and consequently, there is a need for planning and establishing pedagogical strategies. So, professors must use these devices to integrate digital technologies into pedagogical practices to support the teaching-learning process (Santos, 2023).

The recognition and validation of digital competences of higher education professors are crucial in the digital age. The proof of the applicability of the DigCompEdu framework in higher education underscores (Santos, 2023) its relevance in fostering innovative pedagogical practices. Through the recent DigCompEdu-FyA project (Castañeda et al., 2023), the DigCompEdu was adapted to create a Digital Competence Framework for University Educators, tailored to the specific context of higher education, aiming to establish a common standard for digital competence among professors and

promote the digital transformation of university teaching. Furthermore, the e-DigCompEdu, specifically designed for online higher education faculty, adds a new dimension to the foundational framework, acknowledging the need for distinct competencies for online education. This framework expands DigCompEdu by introducing specific competencies, such as Digital Curation and Online Assessment Processes, and areas focused on scientific digital literacy and digital management of online teaching and learning, thereby adding 12 new competences (Six distributed in existing areas and six grouped into two new areas).

Digital Competences of Higher Education Students

The digitization of society significantly impacts education, including higher education, where students are immersed in technologies and teaching practices based on research and teaching. Higher Education Institutions (HEIs) face a challenge: teaching and learning are increasingly mobile, ubiquitous, and technological. Professors are consequently invited to access various digital devices and adopt new digital practices in the classroom. In this sense, an adequate use of ICT might promote advances in the teaching process in higher education, building enriched learning environments. This use can lead to activities that generate autonomy and collaboration (Guillén-Gámez & Mayorga-Fernández, 2019; Santos, 2023).

The proper pedagogical use of ICT in classrooms (or online) might contribute to developing higher education students' informational,

technological, and digital competences. Educational institutions and professors must then adopt an appropriate approach to integrate ICT effectively into the teaching and learning process, aiming to prepare students to face future challenges. Therefore, the capacity of HEIs to meet the challenges arising from these technological changes involves quality professional development programs.

Objectives

The primary objective of this study is to investigate the relationships between digital competence, access to digital devices, and the adoption of digital practices in the classroom among higher education professors in Portugal. Specifically, this study seeks to explore four key Research Questions (RQ): (RQ1) whether there are significant differences in digital competence levels based on access to specific types of digital devices; (RQ2) whether there is a significant correlation between the level of digital competence and the number of digital devices to which professors have access; (RQ 3) whether there are significant differences in digital competence levels based on the types of digital practices implemented in the classroom; and (RQ 4) whether there is a significant correlation between the level of digital competence and the number of digital practices adopted by professors in the classroom.

Through addressing these questions, the study aims to provide a deeper understanding of how access to digital technologies and the integration of

digital practices influence the development of digital competence among higher education faculty.

II. Methodology

Data on digital competences were collected using the digital tool <<omitted for anonymous review>> in which the questionnaire DigCompEdu Check-In was incorporated (Redecker, 2019), considering the Portuguese version (Lucas, 2019). The instrument also included sociodemographic questions related to personal, teaching, and institutional profiles and questions regarding access to digital devices and digital practices in the classroom.

Data collection occurred between the second semester of 2019/2020 and the first semester of 2020/2021.

Professors indicated which digital devices (seven options) they had access to answer multiple-choice questions, with the option to choose more than one alternative. Data were collected on mobile (mobile phone, tablet, e-book reader, and Notebook) and non-mobile devices (desktop, printer, and iTV). I was pointed out by professors that digital practices (seven options) were adopted in the classroom, answering multiple-choice questions with the option for choosing more than one alternative. Data were collected on data sharing practices (files, collaborative document production, virtual learning environment, and calendar) and communication practices (instant messaging, personal social networks, and classes with synchronous videos).

Parametric t-tests were conducted to identify statistically significant differences. The access to digital devices and the adoption of digital practices in the classroom were treated as independent variables, while the digital competence proficiency level, measured through a self-perception instrument, was treated as a continuous dependent variable (Field, 2024).

To assess the effect size of the observed differences between groups, we will use Cohen's d. Cohen proposed widely accepted guidelines for interpreting effect sizes. A Cohen's d value equal to or lower than 0.20 suggests a small effect size, while a value ranging from 0.20 to 0.80 signifies a medium effect size, and a value equal to or >0.80 points to a high-level effect size (Field, 2024; Toksoz & Acikgoz, 2024). Based on these criteria, we will classify the magnitude of the differences found in our singing data.

To investigate the relationship between the average proficiency level in digital competencies concerning the number of devices (mobile and non-mobile) and also in relation to digital practices (sharing and communication), we will use the Pearson correlation. According to Field (2024), the Pearson correlation measures the strength of a relationship between two continuous variables or between one continuous variable and a categorical variable containing two categories. It can vary from –1 (a perfect negative relationship) through 0 (no relationship) to +1 (a perfect positive relationship). It is also an effect size measure, where values of ±0.1 represent a small effect, ±0.3 a medium effect, and ±0.5 a large effect.

The data was exported from the data collection tool and then encoded, processed, and analyzed anonymously with IBM® SPSS® Statistics version 29.0.2.0 (20).

III. Results

Based on the results obtained with the self-perception instrument, the digital competence proficiency level was calculated (Ghomi & Redecker, 2019), and access to digital devices and digital practices in the classroom were investigated.

Characterization of the Respondents

Data had 846 respondents, 53.8% (n=455) male and 46.2% (n= 391) female; 74.8% (n=633) PhDs, 15.7% (n=133) Masters and 9.5% (n=80) graduates. Regarding the type of education, 61.5% (n=529) comes from institutions integrated into the university system, and 38.5% (n=326) from polytechnic education. Professionally, 91.7% (n=776) work in a public institution and 8.3% (n=70) private, 52.7% (n=446) work at the undergraduate level, 32.4% (n=274) at the master's level and 14.9% (n=126) at the PhD level, as shown in Table 1.

Table 1. Characterization of the Respondents

Gender	**Male**	**Female**	
% (n=)	53.8 (455)	46.2 (391)	
Degree level	**Graduates**	**Masters**	**PhD**
% (n=)	9.5 (80)	15.7 (133)	74.8 (633)
Institutional category	**Universities**	**Polytechnic**	
% (n=)	61.5 (529)	38.5 (326)	
Institutional funding sector	**Public**	**Private**	**Military and political public**
% (n=)	91.7 (776)	8.3 (70)	0 (0)

Level of the teaching cycle	Graduates	Masters	PhD
% (n=)	52.7 (446)	32.4 (274)	14.9 (126)

The sample comprised professors linked to 37 universities and 76 polytechnic institutes.

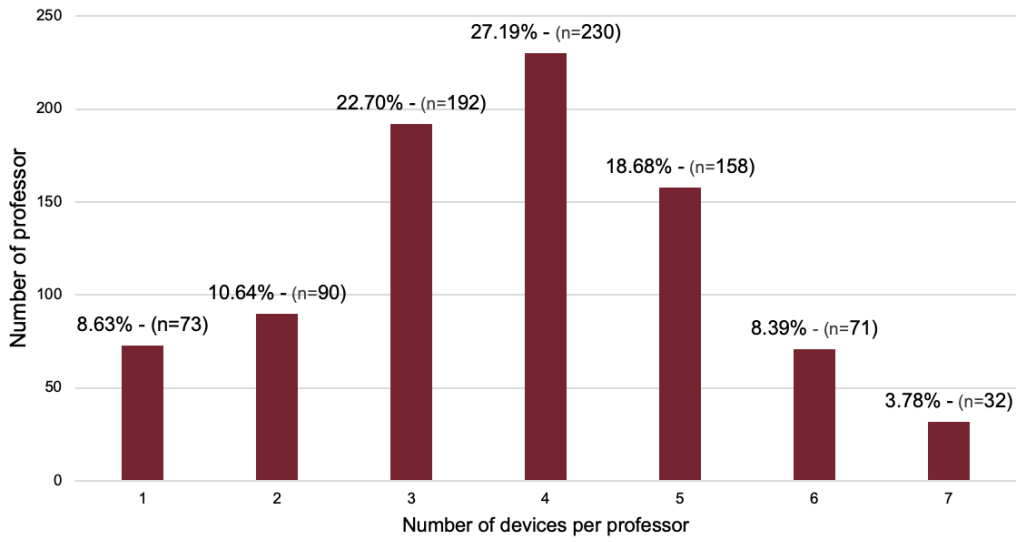
Digital Competence Proficiency Level

The general results regarding the digital competence proficiency level indicate an overall average of 47.88 points (scale 0 – 88 points), corresponding to B1 – Integrator. When analyzed in a stratified way, it indicates that 3.07% of the sample presented the proficiency level A1 – Beginner, 16.67% A2 – Explorer, 36.29% B1 – Integrator, 28.37% B2 – Specialist, 13.12% C1 – Leader, and 2.48% C2 – Pioneer <omitted for anonymous review>.

Digital Devices

The results showed that, regarding mobile devices, 93.74% of the professors have a mobile phone, 58.98% a notebook, 51.89% a tablet, and 14.07% an e-book reader. Regarding non-mobile devices, 78.13% of the professors have a desktop, 66.55% a printer, and 13.59% an iTV. The mode was four devices, as shown in Figure 2.

Figure 2. Number of devices (mobile and non-mobile)



Overall, on average, professors have 3.77 devices (out of 7.00 possible), 2.19 mobile (out of 4.00 possible), and 1.58 non-mobile (out of 3 possible).

To address Research Question 1 (RQ1), which investigates whether there are significant differences in digital competence levels based on access to specific types of digital devices, t-tests (Field, 2024) were conducted. Additionally, Cohen's d (Field, 2024; Toksoz & Acikgoz, 2024) was calculated to assess the effect size of the observed differences between the groups. The groups compared consisted of professors who had access to a specific device versus those who did not.

The results showed a statistically significant difference in the digital competence means considering whether the professors can access the mobile devices Tablet, E-book reader, and Notebook, and the non-mobile device iTV, as shown in Table 2. Table 2 also shows that the effect size ranged from small to medium, as measured by Cohen's d.

Table 2. Average t-test of digital competence and device access

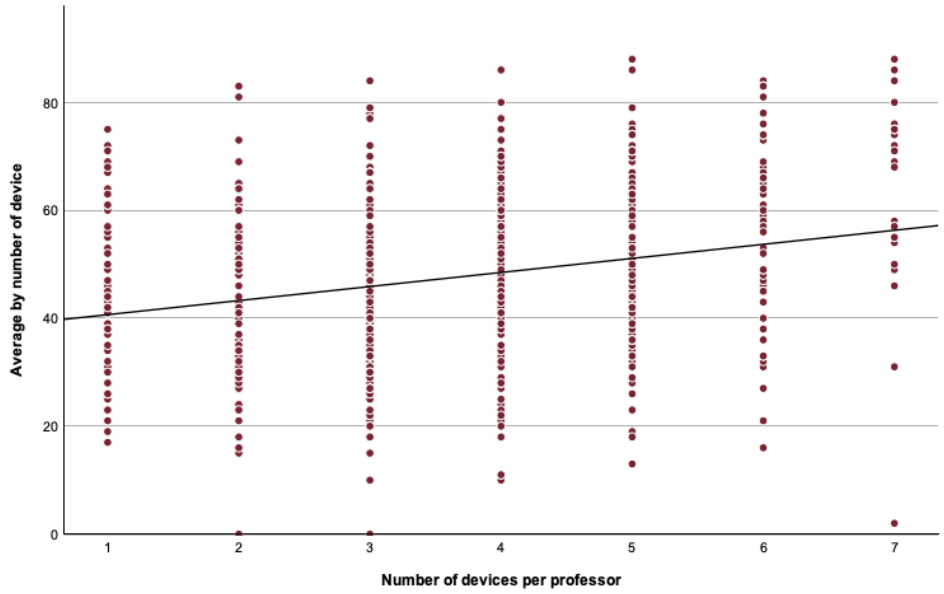
Digital Devices	t (844)[a]	*p-value*	Average DC[b] with access	Average DC[b] without access	Effect Size (Cohen's d)
Mobile					
Mobile phone	1.436	p=0.151	48.08	44.81	Medium (.204)
Tablet	5.264	p<0.05[c]	50.64	44.90	Medium (.362)
E-book reader	6.367	p<0.05 [c]	56.38	46.48	Medium (.630)
Notebook	4.471	p<005 [c]	49.91	44.94	Medium (.313)
Non-mobile					
Desktop	1.848	p=0.065	48.42	45.95	Small (.154)
Printer	0.635	p=0.526	48.13	47.48	Small (.004)
iTV	6.615	p<0.05 [c]	56.88	46.47	Medium (.664)

Note. [a]Degree of Freedom; [b]Digital Competence; [c]Statistically significant difference

To address Research Question 2 (RQ2), which examines whether there is a significant correlation between the level of digital competence and the number of digital devices to which professors have access, a Pearson Correlation to (Field, 2024) analysis was performed. This analysis was used to determine the strength and direction of the relationship between the two variables, providing insight into how the number of devices is associated with the level of digital competence.

The data analysis revealed a moderate positive correlation ($r = 0.243$; $p < 0.001$) between the number of digital devices a professor owns and their proficiency level in digital competencies, as shown in Figure 3. The same graph also shows a linear trend line indicating a gradual increase in average proficiency as the number of devices increases.

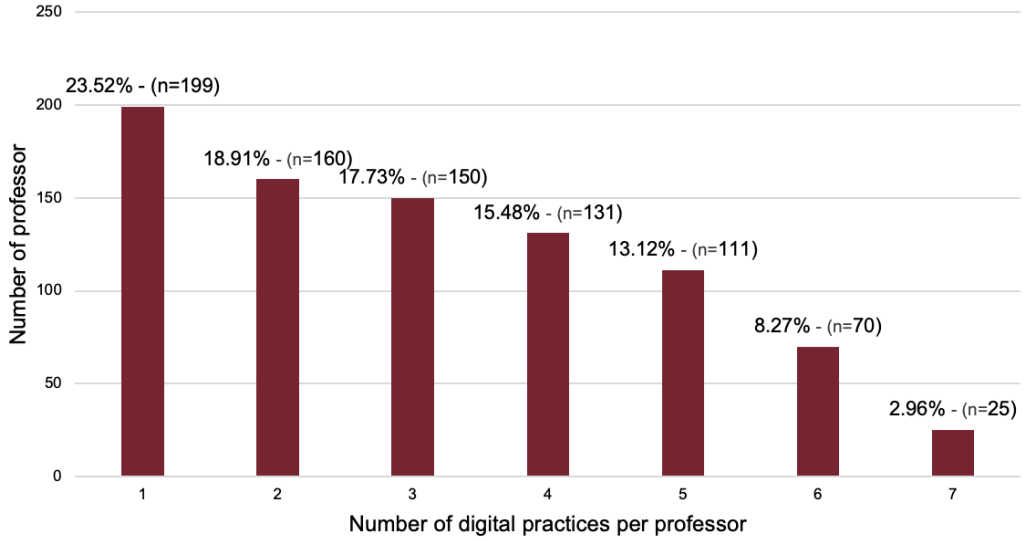
Figure 3. Correlation between average and number of devices (mobile and non-mobile)



Digital Practices in the Classroom

The results showed that, regarding sharing practices, 88.53% of professors use sharing files, 45.04% develop documents collaboratively, and 22.34% use calendars. Regarding communication practices, 47.04% of professors use synchronous classes with videos, 45.86% use instant messaging, 36.17% use Virtual Learning Environments (VLE), and 27.42% personal social networks. The mode was one digital practice in the classroom, as seen in Figure 4.

Figure 4. Indication of the digital practices adopted in the classroom



On average, professors adopt 3.12 digital practices in the classroom (out of 7 possible practices), of which 1.92 are sharing (out of 3 possible practices) and communication 1.2 (out of 4 possible practices).

To address (RQ 3), whether there is a significant correlation between the level of digital competence and the number of digital practices adopted by professors in the classroom, t-tests (Field, 2024) were conducted. Additionally, Cohen's d (Field, 2024; Toksoz & Acikgoz, 2024) was calculated to assess the effect size of the observed differences between the groups. The groups compared consisted of professors who adopted a specific digital practice in the classroom and those who did not.

The results showed a statistically significant difference in the means of the professors considering adopting any of the practices indicated in the classroom, as shown in Table 3. Table 2 also shows that the effect size ranged from Medium to High-level, as measured by Cohen's d.

Table 3. Average t-test of digital competence and digital practices

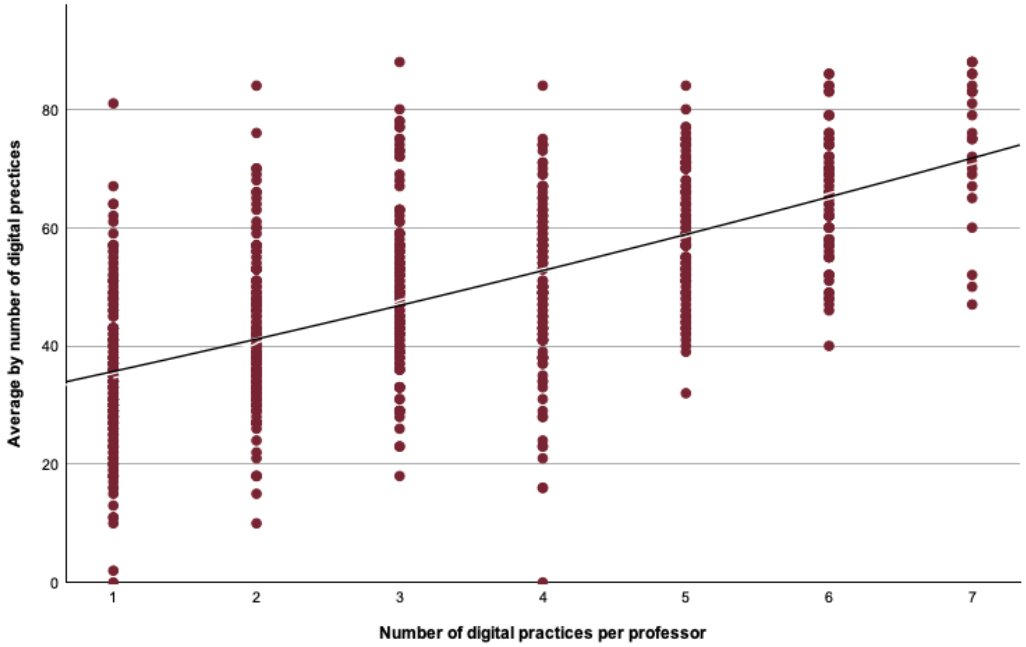
Digital Classroom Practices	t (844)[a]	*p-value*	Average DC[b] practice	Average DC[b] does not practice	Cohen's d (Effect Size)
Sharing					
Cloud Files	5.024	p<0.05 [c]	48.87	40.26	Medium (.542)
Production of collaborative documents	16.168	p<0.05 [c]	56.51	40.80	High-level (1.120)
Virtual Learning Environment (VLE)	14.378	p<0.05 [c]	57.35	42.51	High-level (1.030)
Calendar	9.902	p<0.05 [c]	57.55	45.10	High-level (.817)
Communication					
Instant Messaging	8.507	p<0.05 [c]	50.39	43.44	Medium (.587)
Personal Social Networks	8.294	p<0.05 [c]	55.06	45.17	Medium (.639)
Synchronous videos	12.550	p<0.05 [c]	54.64	41.89	High-level (.865)

Note. [a]Degree of Freedom; [b]Digital Competence; [c]Statistically significant difference

To address Research Question 4 (RQ4), which examines whether there is a significant correlation between the level of digital competence and the number of digital practices adopted in the classroom, a Pearson correlation analysis (Field, 2024) was performed. This analysis was used to determine the strength and direction of the relationship between the two variables, providing insight into how the number of digital practices is associated with the level of digital competence.

The data analysis revealed a large effect positive correlation ($r = 0.636$; $p < 0.001$) between the number of digital practices a professor owns and their proficiency level in digital competencies, as shown in Figure 5. The same graph also shows a linear trend line indicating a gradual increase in average proficiency as the number of digital practices.

Figure 5. Correlation between average and number of digital practices (sharing and communication)



IV. Discussion

The general assessment of the digital competence proficiency level of higher education Portuguese professors was B1 – Integrator <<blind review>>. These results will now be discussed regarding the access to digital devices and digital practices in the classroom.

The increasing use of ICT in education, particularly in higher education, requires professors to have an increasingly high proficiency level in digital competences. This need is due to the emergence of new digital tools for pedagogical and administrative purposes, which becomes even more challenging when professors start working with e-learning activities.

Competences derive from Knowledge, Skills, and Abilities (KSA), and they manifest themselves through specific actions in the classroom, from

planning to execution, evaluation, and overall administration of educational work (Paz-Saavedra et al., 2022; Vuorikari et al., 2022), in addition to the adoption of digital practices.

The European Union considered digital competence one of the key competences for lifelong learning. Frameworks and instruments were then produced to assess and develop the digital competences of citizens, educational organizations, and educators. The literature presented to support this article points to the influences technology has in our everyday lives, and specifically in education, and the need for professional development to better prepare professors to contribute to the improvement of their students' digital competences.

Regarding access to digital devices, mobile and non-mobile (93.74%) and desktop (78.13%) were the most frequent, while e-book readers (14.07%) and iTV (13.59%) were the least frequent. It is essential to highlight the percentage of 93.74% of professors who report having a mobile phone; however, according to the National Communications Authority (ANACOM, 2020) in the report of the first quarter of 2020, in Portugal the mobile service (condition for the operation of the mobile phone) has penetration in 114.3 per 100 inhabitants, data that continue to increase, reaching 121.8 in the first quarter of 2023 (ANACOM, 2023) excluding Machine-to-Machine (M2M) connections and access points exclusively to data services (cards associated with PC/tablet/pen/router), that is, access to mobile service is

virtually universal in Portugal. Although the sample has high values (93.74%), it was not possible to identify this universalization.

To address RQ1, which investigates whether there are significant differences in digital competence levels based on access to specific types of digital devices, considering mobile devices, excluding mobile phones, the t-test showed statistically significant higher average in digital competences proficiency when comparing professors with and without access to Tablets, E-book Readers, and Notebook devices. Importantly, the effect size was uniformly medium across all these devices. The difference was not statistically significant between professors who have or do not have access to mobile phones, which may be related to the theory of universalization of this device since it was absorbed in such a way by society that its use and adoption occurs intuitively, with or without adequate levels of digital competence.

Considering the non-mobile devices, an inverse movement was observed. Only one of the three devices, the iTV, was found to have a statistically significant higher average of professors who have or do not have access to it. The effect size for the iTV was medium. There was no statistically significant difference between the professors who had access to the desktop and printer.

It seems that there is no difference between the averages when we consider the classic devices (regardless of whether being mobile or non-mobile), such as mobile, printer, and desktop, which may be related to their

absorption in society as everyday devices, besides the fact that these devices do not have a dependence on the internet for operation.

To address RQ2, which examines whether there is a significant correlation between the level of digital competence and the number of digital devices to which professors have access, the moderate positive Pearson correlation was identified. This trend was visually represented in Figure 3, where a linear trend line showed a gradual increase in average as the number of devices increased. Although the correlation is moderate positive, it suggests that owning multiple digital devices may be associated with higher-level digital competencies. However, it is important to consider that other factors besides the number of devices also significantly influence professors' digital competence proficiency.

Regarding the digital practices in the classroom (sharing and communication), the most common are cloud file sharing (88.5%) and synchronous video (47.04%), and the least common are shared calendars (22.34%) and personal social networks (27.42%). The Foundation for Science and Technology (FCT) (2023) (Government of Portugal) makes available to the entire academic community, professors, and students the Colibri service, a collaboration service that allows remote meetings through synchronous videos via Zoom Video Communications. A considerable number of higher education institutions also offer packages of productivity tools such as Microsoft 365 and/or Google Workspace. The high percentage (47.04%) of professors who adopt synchronous classes by

video may have been driven by this platform, which does not occur with the VLE (36.17%), as institutions and even each organic unit are responsible for their VLE, with a range of suppliers, versions, quality and extension of support to professors.

To address RQ3, whether there is a significant correlation between the level of digital competence and the number of digital practices adopted by professors in the classroom, the t-test showed a statistically significant higher average in all digital practices (sharing and communication) when comparing the professors who adopt them or not. The adoption of digital practices among professors reveals significant variation in effect sizes, indicating different degrees of impact on their professors' digital competences. In sharing practices, only cloud files showed a medium effect size, while the production of collaborative documents, the use of VLE, and calendar practices exhibited high-level effect sizes. These latter practices reflect a more substantial impact on the professors' digital competences. On the other hand, among communication practices, only synchronous videos reached a high-level effect size, with Instant messaging and personal social networks showing medium effect sizes. These results underscore the differentiated importance of certain digital practices in enhancing professors' digital competences, suggesting that activities related to sharing and collaboration in classes have a greater potential to develop these competencies compared to activities focused solely on communication.

To address RQ4, which examines whether there is a significant correlation between the level of digital competence and the number of digital practices adopted in the classroom, a large effect positive Pearson correlation was identified, similar to the correlation between the number of digital devices and the average professor's digital competences. However, this time, we observe a large positive effect. This trend was visually represented in Figure 5, where a linear trend line showed a gradual increase in average professor's digital competences as the number of digital practices increased. Although the correlation is a large effect, it suggests that engaging in more digital practices may be associated with better professor's digital competences. However, again, it is important to consider that other factors, besides the number of digital practices also significantly influence professors' digital proficiency.

In their study Paz-Saavedra et al. (2022), with higher education professors, indicated a positive attitude toward the use of Digital Technologies (DT) in education (on a scale of 0-5 Likert), that the use of DTs helps improve teaching activities (4.22), helpful for the dissemination of educational projects (4.12), and facilitate the generation of innovative educational strategies (4.06), also found a positive relationship between attitudes and digital competence: "Our results indicate a positive correlation between TDC and the lecturer" (p. 126). This positive attitude corroborates the data identified in this article regarding adopting digital practices in the classroom.

IV. Conclusion

This article examined the relationships between digital competence, access to digital devices, and digital practices in the classroom among higher education professors in Portugal.

In response to RQ1, which investigates whether there are significant differences in digital competence levels based on access to specific types of digital devices, the findings of this study indicate statistically significant differences in professors' digital competence depending on the type of device (mobile and non-mobile). It was observed that the use of tablets, e-book readers, notebooks, and iTVs is associated with higher digital competence, all showing medium Cohen's effect sizes, suggesting a considerable impact of access to these digital technologies on the digital competences of educators. Notably, there were differences between mobile and non-mobile devices; in mobile devices, only mobile phones showed no significant difference, while among non-mobile devices, only iTVs showed a difference, indicating that mobile devices are more correlated with higher-levels of proficiency in digital competences.

In response to RQ2, which examines whether there is a significant correlation between the level of digital competence and the number of digital devices to which professors have access, the findings of this study identified a medium effect size. This relationship suggests that broader access to

various digital devices can facilitate better integration and utilization of digital tools in educational contexts.

In response to RQ3, whether there is a significant correlation between the level of digital competence and the number of digital practices adopted by professors in the classroom, the findings of this study indicate statistically significant differences in all practices, both sharing and communication. However, the effect size varied, being medium for cloud file sharing practices and high-level for other sharing practices, suggesting that these latter are more strongly associated with high-level of digital competence. On the other hand, in communication practices, only the practice of synchronous videos had a high-effect while the other two practices had a medium effect.

In response to RQ4, which examines whether there is a significant correlation between the level of digital competence and the number of digital practices adopted by professors in the classroom, the findings of this study identified large effect positive correlation. This suggests that the more digital practices professors integrate into their teaching, the higher their level of digital competence tends to be. These results highlight the critical role that adopting diverse digital practices plays in enhancing digital proficiency, reinforcing the notion that active engagement with digital tools in educational settings is a key factor in developing digital competence.

The findings of this study reveal an important contrast between the associations observed with access to digital devices and the adoption of

digital practices in relation to the digital competence of higher education professors. While access to certain devices, such as tablets, e-book readers, and notebooks, showed a moderate association with digital competence, not all devices resulted in significant differences. In contrast, all of the digital practices investigated showed significant associations, with some, such as collaborative document sharing and the use of synchronous videos, demonstrating a stronger effect. These findings suggest that while access to devices is relevant, it is the adoption of digital practices in the classroom that is more strongly associated with higher levels of digital competence among professors. Therefore, educational policies should not only ensure access to digital devices, but also promote their effective use through the integration of digital pedagogical practices to better support the development of digital competences in educational settings.

Despite the contributions of this study to the understanding of the relationships between digital competence, access to devices, and digital practices in the classroom among higher education teachers in Portugal, certain limitations must be acknowledged. Firstly, the sample being confined to the Portuguese context limits the generalisability of the findings to other international settings, as cultural, technological, and political factors may shape the dynamics observed. Furthermore, the exclusive focus on higher education does not allow for comparative analysis across other educational levels, such as primary and secondary education, which possess distinct pedagogical and technological characteristics.

Future research could replicate the methodological design of this study in different educational contexts, including primary and secondary education, to examine whether the relationships between the variables studied exhibit similar patterns. Additionally, applying the same methodology in other countries would enable a comparative and cross-cultural analysis.

Authorship contribution:

Cassio Cabral Santos: Investigation, Methodology, Formal Analysis, Funding acquisition, Writing –original draft.

João Augusto Mattar Filho: Conceptualization, Investigation, Methodology, Funding acquisition, Writing –review & editing.

Declaration of no conflict of interest:

The authors declare no conflict of interest.

Supporting Agencies: Source of funding

- This work was supported by National Funds through FCT-Portuguese Foundation for Science and Technology, I.P., under the scope of UIDEF - Unidade de Investigação e Desenvolvimento em Educação e Formação, UIDB/04107/2020.
- The National Council for Scientific and Technological Development (CNPq) (408676/2021-3) and The Coordination for the Improvement of Higher Education Personnel (Capes) (88881.657911/2021-01) (João Mattar).

References

Autoridade Nacional de Comunicações. [ANACOM]. (2020). *Serviços Móveis: Primeiro trimestre de 2020*. https://www.anacom.pt/streaming/STM1T20.pdf?contentId=1533717&field=ATTACHED_FILE

Autoridade Nacional de Comunicações. [ANACOM]. (2023). *Serviços Móveis: Primeiro trimestre de 2023*. https://www.anacom.pt/streaming/ServicosMoveis1T2023.pdf?contentId=1745043&field=ATTACHED_FILE

Benali, M., Kaddouri, M., & Azzimani, T. (2018). Digital competence of Moroccan teachers of English. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, *14*(2), 99–120. https://www.learntechlib.org/p/184691/

Boulianne, S. (2020). Twenty years of digital media effects on civic and political participation. *Communication Research*, *47*(7), 947-966. https://doi.org/10.1177/0093650218808186

Brečko, B., & Ferrari, A. (2016). *The Digital Competence Framework for Consumers.* Joint Research Centre Science for Policy Report. https://doi.org/10.2791/838886

Castañeda, L., Vanaclocha, N., Velasco, J. R., Ruiz, P., Hartillo, M. I., Pereira, E., & Ruiz, A. (2023). Marco de Competencia Digital Docente Universitario. Creación y validación DIGCOMPEDU-FyA. https://hdl.handle.net/10201/136836

Council of Ministers. (2020a). Resolução do Conselho de Ministros 98/2020 - Aprova a Estratégia Portugal 2030. *Diário Da República*, *1.ª série*(222), 12–61. https://data.dre.pt/eli/resolconsmin/98/2020/11/13/p/dre

Council of Ministers. (2020b). Resolução do Conselho de Ministros 30/2020 - Aprova o Plano de Ação para a Transição Digital. *Diário Da República*, *1.ª série*(78), 6–32. https://data.dre.pt/eli/resolconsmin/30/2020/04/21/p/dre

Council of Ministers. (2021). Resolução do Conselho de Ministros 59/2021 - Revê e aprova os princípios orientadores do programa «Iniciativa Nacional Competências Digitais e.2030 - INCoDe.2030». *Diário Da República*, *1.ª série*(94), 23–30. https://data.dre.pt/eli/resolconsmin/59/2021/05/14/p/dre

Council of Europe. (2018a). *Recommendation of Council of Europe on critical competences for lifelong learning (2018/C 189/01)*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2018.189.01.0001.01.ENG

Council of Europe. (2018b). *Common European Framework of Reference for Languages: Learning, Teaching, Assessment: Companion Volume with New Descriptors*. https://rm.coe.int/cefr-companion-volume-with-new-descriptors-2018/1680787989

Durán, B., López, J., Martínez, J., & Flores, T. (2017). Formación en TIC y competencia digital en la docencia en instituciones públicas de educación superior. *Apertura*, *9*(1), 80–96. https://doi.org/10.18381/Ap.v9n1.922

European Commission. (2020). *Digital Education Action Plan 2021-2027: Resetting education and training for the digital age*.

https://ec.europa.eu/education/sites/default/files/document-library-docs/deap-communication-sept2020_en.pdf

Field, A. (2024). *Discovering Statistics Using IBM SPSS Statistics: North American Edition* (6th ed.). SAGE Publications.

Foundation for Science and Technology (FCT). (2023). *Colibri V3 - Videoconf - A web collaboration environment that provides tools for conducting classes, meetings, or work groups*. https://videoconf-colibri.zoom.us/

Ghomi, M., & Redecker, C. (2019). Digital competence of educators (DigCompedu): Development and evaluation of a self-assessment instrument for teachers' digital competence. *CSEDU 2019-Proceedings of the 11th International Conference on Computer Supported Education*, *1*(June 2020), 541–548. https://doi.org/10.5220/0007679005410548

Government of Portugal. (2021). Portaria n.º 179/2021: Procede à criação do Programa «Certificado de Competências Digitais». *Diário Da República*, *1ª série*(167), 27–34. https://data.dre.pt/eli/port/179/2021/08/27/p/dre

Guillén-Gámez, F. D., & Mayorga-Fernández, M. J. (2019). Prediction and Explanation of Factors that Affect the Digital Competence of Lecturers: A Case Study at Spanish University. *The International Journal of Learning in Higher Education*, *26*(2), 107–117. https://doi.org/10.18848/2327-7955/CGP/v26i02/107-117

Kampylis, P., Punie, Y., & Devine, J. (2015). *Promoting Effective Digital-Age Learning: A European Framework for Digitally-Competent Educational Organisations*. Publications Office of the European Union. https://doi.org/10.2791/54070

Lebrún, C., Cievas, M., Ortega, G., & Amador, P. (2021). Competencias docentes, una innovación en ambientes virtuales de aprendizaje en educación superior. *A Pertura*, *13*(2), 6–21. https://doi.org/10.32870/Ap.v13n2.2061

Lucas, M. (2019, February 15). *DigCompEdu Check-In (Portuguese version)*.

National Digital Competence Initiative e.2030 [INCoDE.2030]. (2023). *Quadro de Referência de Competências Digitais: Estudo para a empregabilidade não TIC no futuro*. https://www.incode2030.gov.pt/wp-content/uploads/2022/12/Doc-3-1-Quadro-de-Referencia-e-Competencias.pdf

Paz-Saavedra, L. E., Cervera, M. G., & Usart-Rodríguez, M. (2022). Competencia digital docente, actitud y uso de tecnologías digitales por parte de profesores universitarios. *Pixel-Bit, Revista de Medios y Educación*, *63*, 91–130. https://doi.org/10.12795/pixelbit.91652

Pedro, N. (2016). Infraestrutura, redes, tecnologias e ambientes online: Em que salas de aula? In CNE - Conselho Nacional de Educação (Ed.), *Aprendizagem, TIC e Redes Digitais* (pp. 100–111). CNE - Conselho Nacional de Educação.

http://www.cnedu.pt/content/edicoes/seminarios_e_coloquios/LIVRO_TIC_RedesDigitais.pdf

Redecker, C. (2017). *European Framework for the Digital Competence of Educators: DigCompEdu* (Y. Punie, ed.). Publications Office of the European Union. https://doi.org/10.2760/159770

Redecker, C. (2019, January 18). *DigCompEdu Check-In (English version)*.

Santos, A. (2019). *Practical guidelines for academics: modernizing higher education via open educational practices (based on the OpenEdu Framework).* Publications Office of the European. https://doi.org/10.2760/55923

Santos, A., Nascimbeni, F., Bacsich, P., Atenas, J., Aceto, S., Burgos, D., & Punie, Y. (2017). Policy Approaches to Open Education - Case Studies from 28 EU Member States (OpenEdu Policies). https://doi.org/10.2760/283135

Santos, C. (2023). *Desenvolvimento do e-DigCompEdu: Quadro de referência das competências digitais docentes do ensino superior online* [Tese de doutoramento, Universidade de Lisboa]. Repositório da Universidade de Lisboa. http://hdl.handle.net/10451/58016

Toksoz, F., & Acikgoz, A. (2024). Randomized controlled study: The effect of video-based distance education for approaching children with fever on parents' knowledge levels and fever management. Journal of Pediatric Nursing, 76, e42–e49. https://doi.org/https://doi.org/10.1016/j.pedn.2024.01.017

Trencher, G., & Karvonen, A. (2020). Stretching “smart: Advancing health and well-being through the smart city agenda. In *Smart and Sustainable Cities?* (pp. 54-71). https://doi.org/10.1080/13549839.2017.1360264

United Nations Educational Scientific and Cultural Organization (UNESCO). (2018). *ICT Competency Framework for Teachers. Version 3.0* (N. Butcher (ed.); 3rd ed.). UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000265721

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens* (1st ed.). Publications Office of the European Union. https://doi.org/10.2760/115376

Zagorskas, J., & Burinskienė, M. (2019). Challenges caused by increased use of e-powered personal mobility vehicles in European cities. *Sustainability*, *12*(1), 273. https://doi.org/10.3390/su12010273