# Digital competence of higher education professors: analysis of academic and institutional factors

***Competencia digital de profesores de educación superior: análisis de factores académicos e institucionales***

***Competência digital de professores de ensino superior: análise de fatores acadêmicos e institucionais***

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### *Abstract*

This article aims to analyse the differences associated with the variables of teaching and institutional nature in the level of proficiency of teachers in digital competences, using the DigCompEdu framework as theoretical reference. A quantitative approach was used and the data collection strategy was based on an online survey. The sample was composed of 846 Portuguese higher education professors linked to 37 universities and 76 polytechnic institutes. The results indicate that characteristics such as working at PhD program level, teaching online and being linked to polytechnic institutes are associated with higher levels of digital competence.

### *KEYWORDS*

Digital competence, Higher education, DigCompEdu.

### Resumen

El objetivo de este artículo es analizar las diferencias asociadas a las variables de carácter docente e institucional en el nivel de competencias digitales en los docentes, tomando como referencia teórica el marco DigCompEdu. Se adoptó un enfoque cuantitativo y la estrategia de recopilación de datos se basó en una encuesta en línea. La muestra estuvo compuesta por 846 profesores portugueses de educación superior vinculados a 37 universidades y 76 institutos politécnicos. Los resultados indican que características como trabajar a nivel de programa de doctorado, impartir e-learning y estar vinculado a institutos politécnicos se asocian a mayores niveles de competencia digital.

### PALABRAS CLAVE

Competencia digital, Educación superior, DigCompEdu.

### *Resumo*

O objetivo deste artigo é analisar as diferenças associadas às variáveis de caráter docente e institucional no nível de competências digitais em professores, tomando como referencial teórico o marco DigCompEdu. Adotou-se abordagem quantitativa e a estratégia de coleta de dados baseou-se em questionário online. A amostra foi constituída por 846 professores portugueses do ensino superior vinculados a 37 universidades e 76 institutos politécnicos. Os resultados indicam que características

como trabalhar em nível de doutorado, lecionar e-learning e estar vinculado a institutos politécnicos estão associadas a níveis mais elevados de competência digital.

***PALAVRAS-CHAVE***

Competência digital, Ensino superior, DigCompEdu.

# 1. INTRODUCTION

The inclusion of Information and Communications Technology (ICT) in higher education settings has led to important advances which has affected university teachers. It has resulted in a marked change in their instructional method, moving from transmissive teaching based on traditional methodologies to enriched learning environments, and promoting the use of more activities that foster autonomy and collaboration (Guillén-Gámez & Mayorga-Fernández, 2019).

According to Maderick et al. (2016) and Guillén-Gámez and Mayorga-Fernández (2019), there is a notable scarcity of studies examining the assessment of teachers' digital competence. The studies available are mostly on personal variables such as gender, age and length of experience (Amhag et al., 2019; Ashrafzadeh & Sayadian, 2015; Guillén-Gámez & Mayorga-Fernández, 2019; Noori, 2019; Pedro et al., 2021; Tena et al., 2016). These studies are, however, important considering that the development of students' basic competences, digital competences being one of them, requires teachers with a level of digital competences that allow them to use technology effectively in their activities, enabling construction and adaptation to the new challenges inherent to the 21st century competences (Cantabrana & Cervera, 2015; Díaz, 2019). This article seeks to contribute to the study of professors' digital competences in higher education.

## 1.1. DIGITAL COMPETENCE

Knowing how to use technology is not the same as knowing how to teach with technology. Mishra and Koehleer (2006) deeply explored this idea when they proposed the Technological Pedagogical Content Knowledge (TPCK) model:

> The relationships between content (the actual subject matter that is to be learned and taught), pedagogy (the process and practice or methods of teaching and learning), and technology (both common as blackboards and advanced as digital computers) are complex and nuanced. (Mishra & Koehler, 2006, p. 9)

The European Parliament and the Council of the European Union, recognizing that education contributes to the preservation and renewal of the common cultural base of society, recommended eight key competences for lifelong learning, among them, digital competences (European Parliament & Council of the European Union, 2006).

UNESCO (2008) was one of the forerunners in the development of frameworks that promoted the use of ICTs in education, recognizing the significant potential of ICTs to accelerate economic progress, reduce the digital divide, and support the development of inclusive knowledge societies, based on human rights, achieving gender equality and empowerment.

In 2010, the European Commission launched "Europe 2020 – a strategy for smart, sustainable and inclusive growth", proposing seven initiatives, including a Digital Agenda. The Digital Agenda was at the beginning of the Digital Economy & Society Index (DESI), which demonstrates the digital performance of each European Union (EU) Member State (European Commission, 2010a, 2010b, 2014, 2016) and stimulates development in this field.

Digital competences involving cognitive, behavioural, and technical competences help mitigate the numerous problems and challenges of the knowledge society. The importance of digital competences in education is at the centre of discussions of major global organizations such as the United Nations Educational Scientific and Cultural Organization (UNESCO) (2018), the United Nations (2020) and the Council of the European Union (2018), as well as the European Commission (2020a), and globally prestigious institutions such as the International Society for Technology in Education (ISTE) (2020) and the Education and Training Foundation (ETF) (2018).

UNESCO's ICT Competency Framework for Teachers Version 3.0 (UNESCO, 2018) presents specific guidelines for the planning of educational and professional development programs for teachers to fulfill their role in training students with the integration of technologies.

> The effective integration of ICTs in the schools and classrooms can transform pedagogy and empower students. In this context, it is essential that teachers have the competencies to integrate ICTs in their professional practice to ensure the equity and quality of learning. Teachers also need to be able to harness ICTs to guide learners in developing Knowledge Society skills such as critical and innovative thinking, complex problem solving, the ability to collaborate, and socio-emotional skills. (UNESCO, 2018, p. 6)

The 2030 Agenda for Sustainable Development, was adopted by the UN General Assembly with 17 Sustainable Development Goals (SDGs). ICTs related targets are addressed in: Quality education (Goal 4), Gender equality (Goal 5), Infrastructure (Goal 9), Reduced inequalities within and across countries (Goal 10), Peace, justice and strong institutions (Goal 16) and Partnerships for the goals (Goal 17) (Unesco, 2018).

The Council of the European Union (2018) redefines digital competence as:

> Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking. (p. 9)

According to Cabero-Almenara et al. (2020), the digital revolution has transformed, in various aspects, the university environment, requiring the promotion and development of digital teaching competence in Higher Education. The digital teaching competence is a requirement for a professional teacher profile that allows him to design, implement and evaluate training actions oriented so that the teacher can use the technology with his students in a didactic way (p. 364).

The Instituto Nacional de Tecnologías Educativas y Formación del Profesorado (INTEF) and the Ministerio de Educación, Cultura y Deporte

(MECD) of the Spanish government, have been making efforts in digital teaching competences since 2012 through the Marco Común de Competencia Digital Docente. The current version (October 2017) is an adaptation of DigComp 2.1 and DigCompEdu.

Digital competent teachers not only use technology but also significantly integrate them in the teaching and learning process, providing a practical meaning to education through digital resources, making it collaborative, interactive and dynamic (Sales et al., 2019).

The emergence of technical and digital innovation tools in the classroom has led to an increase in new teaching models in which teaching and assessment strategies are no longer exclusively based on face-to-face and individual interactions between teachers and students, making the teaching competence fundamental in the education process as well as an effective integration of the use of ICTs in the educational context (Caswell et al., 2008; Padilla-Hernández et al., 2020; Ramírez-Montoya et al., 2017; Rohatgi et al., 2016).

The most recent publication of the European Union on digital competence for citizens is DigComp 2.1: The Digital Competence Framework for Citizens (Carretero et al., 2017). As for digital competences of teachers, the most recent document was published by Redecker (2017) and is the European Framework for the Digital Competence of Educators: DigCompEdu, described in detail below.

## 1.2. AIM OF THE STUDY

This research aims to analyse the differences associated with teaching related factors (level of teaching cycle and course modality), institutional related factors (institutional category and institutional funding sector) and their relationship with the level of proficiency in digital competence of higher education teachers, considering the six areas of DigCompEdu. This study is based on the following research questions:

RQ1– What is the level of digital competence of Portuguese higher education professors?

RQ2– Are there statistically significant differences in the level of digital competences of Portuguese higher education professors arising from teaching-related factors (level of teaching cycle and course modality)?

RQ3– Are there statistically significant differences in the level of digital competences of Portuguese higher education professors arising from institutional related factors (institutional category and institutional funding sector)?

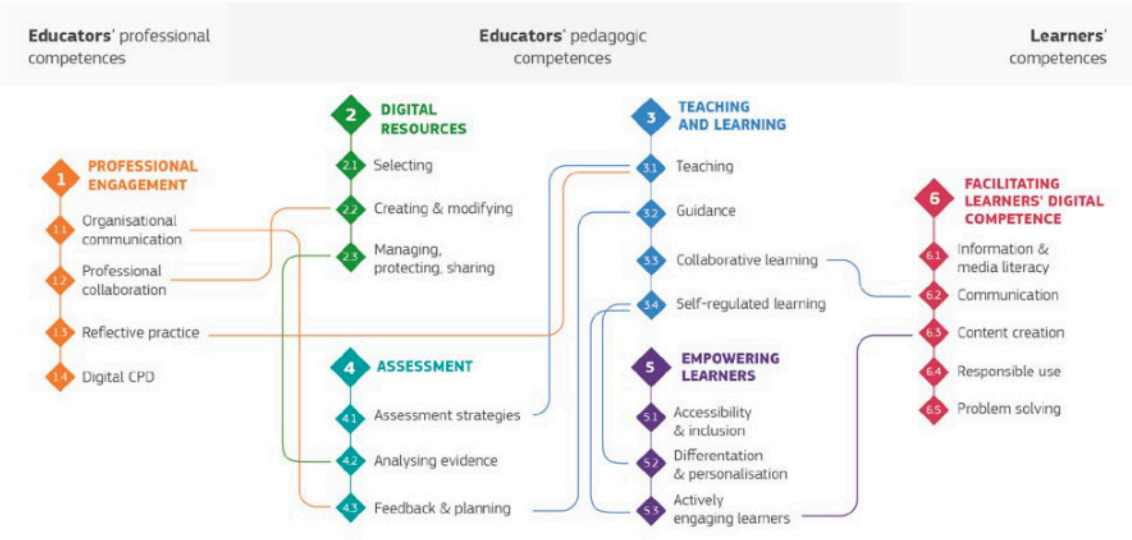
## 1.3. FRAMEWORK

For this study, DigCompEdu (Redecker, 2017) was adopted as conceptual background. This choice was based on: i) its consolidated use by the scientific community (Caena & Redecker, 2019; Dias-Trindade et al., 2020; Dias-Trindade & Moreira, 2018; Gilioli et al., 2019; Lucas et al., 2021; Pedro et al., 2021; Santos et al., 2021; ii) its superior evaluation results when compared to other frameworks (Cabero-Almenara et al., 2020); iii) the inclusion of a native data collection instrument (Redecker, 2019); and iv) the fact that it has a Portuguese language version (Lucas & Moreira, 2018).

DigCompEdu was designed to align with institutional and contextual requirements in different countries, connecting the development of digital competences of teachers and students. and linking them to institutional capacity development (Caena & Redecker, 2019). It describes the competences to support the use of digital tools to improve and innovate education and is organized into six areas with 22 interlocking competences: Professional engagement (PE);

**Figure 1**

*DigCompEdu competence areas*



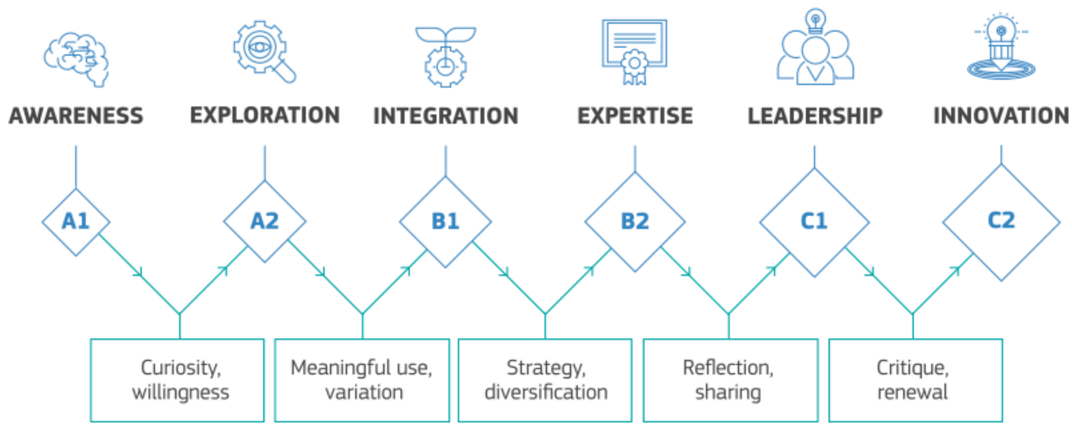

*Source. Redecker (2017)*

digital resources (DR); teaching and learning (TL); assessment (AS); empowering learners (EL) and facilitating learners' digital competence (FL). This is presented on Figure 1.

The progression in proficiency levels is cumulative in the sense that each higher-level descriptor includes all the lower-level descriptors, that is, they assume an increasing degree of complexity, as shown in Figure 2.

**Figure 2**

*DigCompEdu competence areas*




*Source. Redecker (2017)*

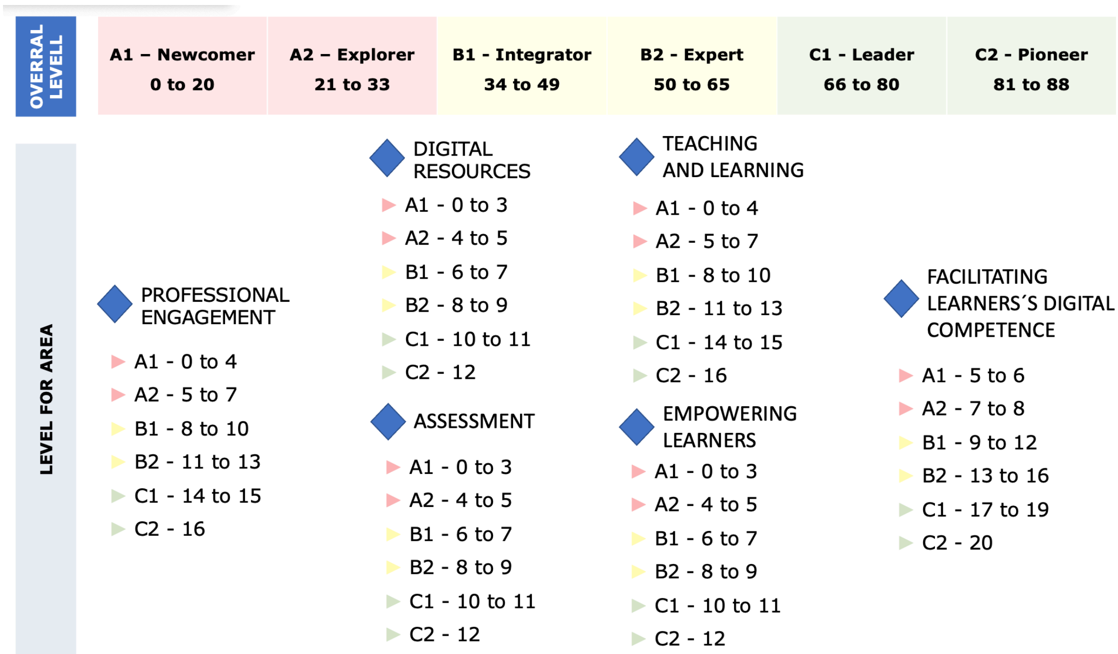
## 1.3.1. DATA COLLECTION INSTRUMENT

The DigCompEdu Check-In, native to DigCompEdu, has been statistically validated by several researchers in order to gauge the level of proficiency of teachers, both in elementary and secondary school levels (Benali et al., 2018; Dias-Trindade et al., 2019; Dias-Trindade & Moreira, 2018; Ghomi & Redecker, 2019; Silva et al., 2019) as well as in higher education (Dias-Trindade et al., 2020; Pedro et al., 2021; Santos et al., 2021), including in the Portuguese context (Dias-Trindade et al., 2019, 2020; Dias-Trindade & Moreira, 2018; Lucas et al., 2021).

The instrument is composed of 22 questions, one question per competency, with five alternative responses. This allows a score of 0 to 4 points per question, which enables a maximum score of 88 points for the overall assessment and by area, varying according to the number of questions-competence (Caena & Redecker, 2019; Lucas et al., 2021; Redecker, 2019), as explained in Figure 3.

**Figure 3**

*General proficiency by levels and areas*




## 1.4. BACKGROUND IN PORTUGAL

The Portuguese higher education system is composed of universities and polytechnics. University education is oriented towards the provision of solid scientific training, combining the efforts and competences of teaching and research units. Polytechnic education is professionally oriented and intervenes in advanced technical training (Assembleia da República Portuguesa, 2007). Both can be offered by public and private institutions. According to current data (Direção-Geral do Ensino Superior, 2021), Portugal has 37 universities and 76 polytechnics, 36.3% private and 63.7% public.

The most recent data available for the population surveyed in this article indicated a total of 35,283 faculty members. Regarding the institutional category, 61.2% (n=21,595) of the professors worked in university education and 38.5% (n=13,688) in polytechnic education. Regarding the institutional funding sector, 77.3% (n=27,279) worked on public establishments and 22.7% (n=8,004) on private institutions. As for gender, 54.9% (n=19,368) were male and 45.1% were female (n=15,915) (Fundação Francisco Manuel dos Santos, 2021).

Several studies conducted in the Portuguese context have adopted the same theoretical references as this article (framework and instrument), which have marked the B1 integrator level of proficiency as an overall result, either with elementary school teachers (Dias-Trindade & Moreira, 2018; Lucas et al., 2021) or in higher education teachers (Dias-Trindade et al., 2020; Pedro et al., 2021; Santos et al., 2021).

Focusing on elementary and secondary education, Lucas et al. (2021) identified that factors such as gender, age, and experience exerted effects on the averages obtained in the levels of digital competence of teachers. Dias-Trindade and Moreira (2018) point out contrary results regarding age and disciplinary department by identifying no significant differences.

In higher education, Dias-Trindade et al. (2020) indicate that faculty staff aged 40-49 years tend to have higher proficiency levels than other age groups (30-39 years, 50-59 years, and 60-69 years). Regarding the scientific area, professors of arts and humanities presented higher results than the others (science and technology, economics, psychology and education).

In their study, Santos et al. (2021) indicate that professors with a master's degree obtained higher scores (B2) than graduates and PhDs. Regarding age and length of career, they did not identify significant differences between the groups. Faculty teaching on PhD programs scored higher (B2) than faculty teaching only undergraduate and master's courses (B1). Faculty teaching in courses with some percentage of online learning scored higher (B2) than faculty teaching exclusively on-campus courses (B1). Finally, professors working in polytechnic education obtained higher scores (B2) than those working in university education (B1). No differences were identified in relation to the institutional funding sector (B1).

Pedro et al. (2021), whose study focuses on the six areas of DigCompEdu and considers variables of a personal nature, identified no differences regarding gender. Regarding the level of education, differences were identified in the areas 'teaching and learning' (TL) and 'empowering learners' (EL); teachers with a lower academic degree (undergraduate) showed lower results (A2) when compared to those with a master's or doctorate (B1). Regarding age and career time, the results were very similar, with a difference only in the EL area in the intermediate ranges (age groups 45-54 years and 55-64 years and in career time of 11-20 years, 31-30 years, and 31-40 years), showing higher results (B1) when compared to the other ranges (A2).

## 2. METHODOLOGY

The aim was to analyse the differences associated with teaching related factors (level of teaching cycle and course modality) and institutional related factors (institutional category and institutional funding sector) on the level of digital competences in higher education professors considering the six areas of DigCompEdu. Thus, a quantitative approach was adopted, using an online survey as data collection strategy, following the procedures recommended by Rea and Parker (2014). This follows the trend of most research on digital competence that focuses on the use of measurement instruments based on self-assessment of the perceptions of professors, supported by webtools that analyse, describe and/or measure the level of proficiency in digital competence based on the opinions of respondents (Durán et al., 2019).

The DigCompEdu Check-in tool (Redecker, 2019), translated into Portuguese (Lucas, 2019), was incorporated into a webtool available at http://www.digcomptest.eu/ (Santos et al., 2020). The development of this tool allowed quick access to the data and gave the respondents access to a self-diagnosis report of the digital competences of professors, which was automatically sent to their email.

The teaching related factors considered the level of teaching cycle where the professors mostly taught (bachelor's, master's and doctorate, with only one option for the respondent to choose) and course modality (100% on-campus courses, 70% on-campus and 30% e-learning courses, 30% on-campus and 70% e-learning courses or 100% e-learning). The institutional factors considered the institutional category (universities vs. polytechnic) and institutional funding sector (public vs. private).

## 2.1. RELIABILITY

Based on Cronbach's alpha (Cronbach, 1951), an internal consistency analysis was performed and a score of .936 was obtained. The corrected item-total correlation and the squared multiple correlation tests (Table 1) allowed us to understand that the instrument has a high internal consistency. The values were similar to those found by other researchers (Benali et al., 2018; Ghomi & Redecker, 2019; Lucas et al., 2021), even when applied to the same population as in this article (Dias-Trindade & Moreira, 2020).

**Table 1**

*Reliability*

| AREA/COMPETENCE | CORRECTED ITEM-TOTAL CORRELATION | SQUARED MULTIPLE CORRELATION |
|---|---|---|
| Area 1 – Professional engagement | | |
| 1.1 | .5750 | .3930 |
| 1.2 | .5090 | .3200 |
| 1.3 | .6030 | .4750 |
| 1.4 | .5190 | .3190 |
| Area 2 – Digital resources | | |
| 2.1 | .5300 | .3680 |
| 2.2 | .5640 | .4000 |
| 2.3 | .4270 | .2400 |
| Area 3 – Teaching and learning | | |
| 3.1 | .7090 | .5630 |
| 3.2 | .6880 | .5350 |
| 3.3 | .5650 | .3830 |
| 3.4 | .7120 | .6030 |
| Area 4 – Assessment | | |
| 4.1 | .6920 | .5960 |
| 4.2 | .5570 | .4000 |
| 4.3 | .7040 | .5620 |
| Area 5 – Empowering learners | | |
| 5.1 | .6720 | .4760 |
| 5.2 | .6250 | .4470 |
| 5.3 | .6770 | .5070 |
| Area 6 – Facilitating learners' digital competence | | |
| 6.1 | .5330 | .3830 |
| 6.2 | .6780 | .5240 |
| 6.3 | .5760 | .4100 |
| 6.4 | .6320 | .4800 |
| 6.5 | .6620 | .4760 |

## 2.2. DATA ANALYSIS

In the first stage of data extraction, only the respondents who stated that they were higher education professors and worked in the Portuguese context were considered. This procedure was essential because the data collection tool is open and is available to fill out on the web.

The process of data treatment and analysis was based on the application of descriptive and inferential statistical techniques, such as multivariate analysis of variance (MANOVA) and Tukey post-hoc, using IBM® SPSS® Statistics (version 26.0.0.0). The use of MANOVA was intended to analyse the effect of the factors selected for this study (Cohen et al., 2018; Larson & Betsy, 2014).

## 2.3. SUBJECTS

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

The dissemination and invitation to participate in this study were carried out via: i) email invitation sent to the leaders of all higher education institutions, 37 universities and 76 polytechnic institutes (Direção-Geral do Ensino Superior, 2021), ii) directly to the faculty members when the email address was publicly available on the internet; and iii) dissemination of the research through the https://www.incode2030.gov.pt/acoes-com-selo-incode2030 website.

Considering the population data, the minimum sample size was determined using the multinominal proportions technique (Thompson, 1987) for a confidence level of 95% resulting in a minimum number of 510 faculty members.

The sample consists of 846 Portuguese higher education professors, as described in Table 2. It was possible to identify that at least 45 institutions were represented in the sample (39,82% of high education institutions of Portugal), although the information on which institution the respondent worked was not required.

**Table 2**

*Demographic characteristics of the participants*

| Gender | Male | Female | | |
|---|---|---|---|---|
| N (%) | 455(53%) | 391(46.2%) | | |
| Level of teaching cycle | Doctorate | Master's | Bachelor's | |
| N (%) | 126(14.9%) | 274(32.4%) | 446(52.7%) | |
| Course modality | 100% On-c | 70% On-c and 30% e-L | 30% On-c and 70% e-L | 100% e-L |
| N (%) | 515(60.9%) | 247(29.2%) | 43(5.1%) | 41(4.8%) |
| Institutional category | Universities | Polytechnic | | |
| N (%) | 520(61.5%) | 326(38.5%) | | |
| Institutional funding sector | Public | Private | Military and political public | |
| N (%) | 776(91.7%) | 70(8.3%) | 0(0%) | |

*Note: On-c= on-campus courses; e-L= e-Learning courses*

# 3. RESULTS

Based on the results obtained after the surveys were filled out by the respondents, the overall and per area scores were calculated and related to the proficiency levels shown in Figure 4.

## 3.1. OVERALL RESULTS

The overall result of the proficiency level in digital competence pointed to an overall mean of 47.88 points, with a standard deviation of 16.08, indicating a B1 (integrator) proficiency level.

The analysis by area showed that the professors in the AS area presented an A2 – explorer level, lower than all other areas in which they presented a B1 – integrator level, according to Table 3.

**Table 3**

*Results by area*

| Areas | Level (mean±sd) |
|---|---|
| PE | B1 (9.7±3.07) |
| DR | B1 (7.18±2.44) |
| TL | B1 (9.03±3.63) |
| AS | A2 (5.55±2.59) |
| EL | B1 (6.03±3.06) |
| FL | B1 (10.35±4.30) |

*Note: SD= Standard Deviation*

## 3.2. TEACHING RELATED FACTORS

In this section, we present the results considering the level of teaching cycle and course modality where professors conducted their teaching activities.

### 3.2.1. LEVEL OF TEACHING CYCLE

The professors showed a difference in proficiency level in the AS and EL areas, starting at A2 in bachelor's to B1 in doctorate. In the other areas, (PE, DR, TL, and FL) no differences in levels were identified, as can be seen in Table 4.

**Table 4**

*Proficiency level by area and level of teaching cycle*

| Area | Bachelor's (n=446) (Mean±SD) | Master's (n=274) (Mean±SD) | Doctorate (n=126) (Mean±SD) |
|---|---|---|---|
| PE | B1 (9.46±3.03) | B1 (9.89±2.92) | B1 (10.62±3.33) |
| DR | B1 (7.00±2.23) | B1 (7.28±2.43) | B1 (7.59±2.63) |
| TL | B1 (8.60±3.52) | B1 (9.21±3.49) | B1 (10.15±4.03) |
| AS | A2 (5.39±2.49) | A2 (5.53±2.60) | B1 (6.12±2.85) |
| EL | A2 (5.78±3.00) | B1 (6.15±3.02) | B1 (6.67±3.27) |
| FL | B1 (9.74±4.27) | B1 (10.59±4.07) | B1 (11.96±4.46) |

*Note: SD= Standard Deviation*

MANOVA demonstrated the existence of a statistically significant effect, as shown in Table 5.

**Table 5**

*MANOVA level of teaching cycle*

| Significance test | Value | F | Hypothesis(DF) | Error(DF) | P Value |
|---|---|---|---|---|---|
| Pillai's trace | .044 | 3.114 | 12 | 1,678 | < .0001 |

The subsequent univariate ANOVAs showed an effect on the teaching level at which the professor worked on the means of all areas, as shown in Table 6.

**Table 6**

*Subsequent ANOVAs level of teaching cycle by area*

| AREA | F (2,843) | P VALUE |
|---|---|---|
| PE | 7.398 | .001 |
| DR | 3.276 | .038 |
| TL | 9.714 | <.0001 |
| AS | 3.873 | .021 |
| EL | 4.454 | .012 |
| FL | 14.167 | <.0001 |

Tukey's post-hoc identified that the differences ($p<.05$) found in the PE, DR, AS, and EL areas are found between faculty members teaching at the doctoral and undergraduate levels. In the TL area, a difference was found between faculty members teaching at the doctoral level compared to the master's level, as well as at the undergraduate level. Finally, in the FL area, a difference was found between all groups, based on the levels at which the professors teach.

### 3.2.2. COURSE MODALITY

The professors showed a difference in proficiency level in the PE, DR, TL, AS and EL areas. The FL area showed no differences, as shown in Table 7.

**Table 7**

*Proficiency level by area and course modality*

| AREA | 100% On-c (n=515) (MEAN±SD) | 70% On-c 30% e-L (n=247) (MEAN±SD) | 30% On-c 70% e-L (n=43) (MEAN±SD) | 100% e-L (n=41) (MEAN±SD) |
|---|---|---|---|---|
| PE | B1 (9.02±3.06) | B1 (10.82±2.64) | B2 (11.40±3.02) | B2 (11.20±2.49) |
| DR | B1 (6.65±2.38) | B2 (8.10±2.11) | B2 (8.14±2.68) | B1 (7.17±2.87) |
| TL | A2 (7.99±3.50) | B1 (10.48±3.15) | B2 (11.51±3.74) | B1 (10.71±2.90) |
| AS | A2 (4.91±2.40) | B1 (6.47±2.60) | B1 (7.07±2.83) | B1 (6.32±1.97) |
| EL | A2 (5.24±2.93) | B1 (7.21±2.78) | B1 (7.74±3.74) | B1 (7.07±2.56) |
| FL | B1 (9.39±4.28) | B1 (11.72±3.82) | B1 (12.30±4.72) | B1 (12.12±3.22) |

*Note: On-c= On-campus courses; e-L= e-learning courses; SD= Standard*

In the PE area, the results were higher (B2) in the 70% and 100% e-learning professors compared to the others (B1). In general, the DR and TL areas presented higher results when the professors worked in both modalities, when compared to the group of professors who work exclusively in one of the modalities. In the AS and EL areas, the group of professors who work only in on-campus courses scored lower (A2) than the e-learning modality (B1), regardless of the proportion, as shown in Table 7.

MANOVA demonstrated a statistically significant effect, as shown in Table 8.

**Table 8**

*MANOVA course modality*

| SIGNIFICANCE TEST | VALUE | F | HYPOTHESIS(DF) | ERROR(DF) | P VALUE |
|---|---|---|---|---|---|
| Pillai's trace | .165 | 8.118 | 18 | 2,517 | < .0001 |

The subsequent univariate ANOVAs showed an effect on course modality on the means of all areas, as shown in Table 9.

**Table 9**

*Subsequent ANOVAs course modality by area*

| AREA | F (3,842) | P VALUE |
|---|---|---|
| PE | 29.613 | < .0001 |
| DR | 23.712 | < .0001 |
| TL | 42.415 | < .0001 |
| AS | 29.716 | < .0001 |
| EL | 32.962 | < .0001 |
| FL | 24.093 | < .0001 |

Tukey's post-hoc identified that the differences ($p<.05$) found in the PE, TL, AS, EL, and FL areas were identified among faculty members working exclusively in on-campus courses compared to faculty members working in e-learning, regardless of the proportion. In the DR area, the difference was found only among faculty members who worked exclusively in on-campus courses compared to those who worked in the e-learning modality in the proportions of 30% and 70%.

## 3.3. INSTITUTIONAL RELATED FACTORS

In this section we present the results considering two institutional related factors: the type of institution and its funding model.

### 3.3.1. INSTITUTIONAL CATEGORY

The professors showed a difference in proficiency level in the EL area, in which polytechnic professors showed a higher result (B1) than university professors (A2). In the other areas, no differences were found, with PE, DR, TL and FL having B1 proficiency level and AS A2, according to Table 10.

**Table 10**

*Proficiency level by area and institutional category*

| Area | Universities (n=520) (Mean±SD) | Polytechnic (n=326) (Mean±SD) |
|---|---|---|
| PE | B1 (9.57±3.13) | B1 (10.10±2.93) |
| DR | B1 (7.18±2.52) | B1 (7.17±2.30) |
| TL | B1 (8.79±3.66) | B1 (9.40±3.54) |
| AS | A2 (5.49±2.60) | A2 (5.63±2.57) |
| EL | A2 (5.87±3.03) | B1 (6.29±3.09) |
| FL | B1 (10.19±4.39) | B1 (10.60±4.14) |

*Note: SD= Standard deviation*

MANOVA demonstrated a statistically significant effect, as shown in Table 11.

**Table 11**

*MANOVA institutional category*

| SIGNIFICANCE TEST | VALUE | F | HYPOTHESIS(DF) | ERROR(DF) | P VALUE |
|---|---|---|---|---|---|
| Pillai's trace | .018 | 2.502 | 6 | 839 | .021 |

The subsequent univariate ANOVAs showed that there is an effect on the institutional category on the means of the PE and TL areas, as shown in Table 12.

**Table 12**

*Subsequent ANOVAs institutional category by area*

| AREA | F (1,844) | P VALUE |
|---|---|---|
| PE | 5.993 | .015 |
| DR | .002 | .967 |
| TL | 5.531 | .019 |
| AS | .623 | .430 |
| EL | 3.662 | .056 |
| FL | 1.876 | .171 |

### 3.3.2. INSTITUTIONAL FUNDING SECTOR

The professors showed no difference in proficiency level, as shown in Table 13.

**Table 13**

*Proficiency level by area and institutional funding sector*

| Area | Public (n=776) (MEAN±SD) | Private (n=70) (MEAN±SD) |
|---|---|---|
| PE | B1 (9.74±3.09) | B1 (10.19±2.76) |
| DR | B1 (7.20±2.45) | B1 (6.86±2.33) |
| TL | B1 (8.96±3.65) | B1 (9.80±3.32) |
| AS | A2 (5.52±2.55) | A2 (5.86±2.98) |
| EL | B1 (6.03±3.04) | B1 (6.04±3.22) |
| FL | B1 (10.34±4.29) | B1 (10.41±4.41) |

*Note: SD= Standard deviation*

MANOVA demonstrated the existence of a statistically significant effect, as presented in Table 14, although the subsequent univariate ANOVAs show no effect on any of the areas (Table 15).

**Table 14**

*MANOVA institutional funding sector*

| Significance Test | Value | F | Hypothesis (DF) | Error(DF) | P Value |
|---|---|---|---|---|---|
| Pillai's trace | .019 | 2.682 | 6 | 839 | .014 |

**Table 15**

*Subsequent ANOVAs institutional funding sector by area*

| AREA | F (1,844) | P VALUE |
|---|---|---|
| PE | 1.382 | .240 |
| DR | 1.303 | .254 |
| TL | 3.480 | .062 |
| AS | 1.099 | .295 |
| EL | 0.001 | .980 |
| FL | 0.018 | .894 |

# 4. DISCUSSION

This paper aimed to analyse the differences in teaching-related factors (level of teaching cycle and course modality) and institutional related factors (institutional category and institutional funding sector) and their relationship with the level of proficiency in digital competence of professors.

Although Guillén-Gámez and Mayorga-Fernández (2019) identified in the literature that personal factors, such as gender and age, may result in differences in the level of university professors' digital competence, Lucas et al. (2021) point out that several works in this regard are contradictory, thus, there is no consensus in the academic community on the effect of such factors.

Few works have focused on analysing whether variables of an academic nature can influence the level of digital competence of university professors (Guillén-Gámez & Mayorga-Fernández, 2020; Santos et al., 2021), a gap that this article seeks to reduce.

In relation to factors that affect the proficiency level of professors, Guillén-Gámez and Mayorga-Fernández (2020) identified the number of national and international research stays, number of research projects, teaching innovation, number of master's studied and number of years of university teaching experience, with the last one having a negative weighting.

The results collected to answer the first research question indicate that the general level of proficiency in digital competences of professors is B1 – integrator. Other studies in the Portuguese context showed similar results (B1), either in basic and secondary education (Dias-Trindade & Moreira, 2018; Lucas et al., 2021) or in higher education (Dias-Trindade et al., 2020; Santos et al., 2021).

The overall results by area indicated lower results (A2) in the AS area compared to the others (B1). This fact is worrisome, since assessment is essential for monitoring students' progress, facilitating feedback, and to allow educators to evaluate and adapt their teaching strategies. As well, it is highly relevant for the evaluation of programs success and the prestige of institutions. At the same time, assessment can be a facilitator or bottleneck for innovation in education (Redecker, 2017).

Guillén-Gámez and Mayorga-Fernández (2020) also identified the deficiencies in assessment practices of higher education professors. They claim that professors make little use of the potential that today's resources may have for assessment, and few studies focus on this issue.

In general, it was possible to identify differences in the level of proficiency in digital competences in relation to five out of six areas in DigCompEdu. The teaching-related factors showed the highest number of differences (7), especially in course modality (5), while the institutional-related factors showed few differences (1), according to the summary presented in Table 16.

**Table 16**

*Difference between the level of proficiency in digital competence and factors*

| Area | TRF | | IRF | | Total by area |
|---|---|---|---|---|---|
| | CL | CM | IC | IFS | |
| PE | = | ≠ | = | = | 1 |
| DR | = | ≠ | = | = | 1 |
| TL | = | ≠ | = | = | 1 |
| AS | ≠ | ≠ | = | = | 2 |
| EL | ≠ | ≠ | ≠ | = | 3 |
| FL | = | = | = | = | 0 |
| Total by factor | 2 | 5 | 1 | 0 | |

*Note: TRF= Teaching-related factors, CL= Level of teaching cycle; CM= Course modality; IRF= Institutional-related factors; IC= Institutional category; IFS= Institutional funding sector*

It is important to note that the institutional funding sector showed no difference in any of the areas. The FL area was the least affected, with no difference in any of the factors.

Bearing in mind the second research question and focusing on the differences in the level of digital competences of Portuguese higher education professors arising from teaching related factors (level of teaching cycle and course modality), differences were identified in the proficiency level of professors in the AS and EL areas. In the AS area, professors working at the bachelor's and master's levels showed lower levels (A2) than those teaching at the doctorate level (B1). In the EL area, bachelor's professors showed lower levels (A2) than those teaching in master's and doctorate courses (B1), making the difference between PhDs and graduates evident in these two areas.

Other studies point to important evidence that correlates with this article. Durán et al. (2017) and Santos et al. (2021) pointed out the positive relationship of the academic degrees of the faculty staff with their level of digital competence, which suggests that obtaining these degrees may be a process that promotes the development of the digital competences of the faculty (Pedro et al., 2021).

Factors directly related to research such as innovation in research projects/teaching (Guillén-Gámez & Mayorga-Fernández, 2019), number of national and international research stays, and number of research projects (Guillén-Gámez & Mayorga-Fernández, 2020) were identified as factors that show positive relationships with the level of proficiency in digital competences.

Teaching-related factors, such as the level of teaching cycle factor, shown statistically significant effects on the means in the tests. Tukey's post-hoc test identified that a difference is found in professors who teach at the doctoral level, whether this difference is only in relation to professors who teach at the undergraduate level (PE, DR, AS and EL), at the master's level (TL), or in relation to both (FL).

Also, in teaching-related factors, specifically the course modality, differences were identified in the level of proficiency of professors in the PE, DR, TL, AS and EL areas. In the PE area, higher results were found with the groups formed based on the two highest proportions of e-learning (B2) compared to the other groups (B1). In the DR area, the highest performance occurred when professors worked in both modalities simultaneously (B2) in relation to working in only one modality (B1). The TL area showed the highest level when professors worked in the proportion of 30 on-campus courses and 70% e-learning. The AS and EL areas presented the same behaviour: professors who worked exclusively in on-campus courses presented lower results (A2) when compared with professors who worked in e-learning (B1), regardless of the proportion.

In general, this article showed that professors who worked in the e-learning modality showed higher levels of digital competence than those who worked exclusively in the on-campus courses modality, with emphasis on the group of professors who worked 30% on-campus courses and 70% e-learning. Ramírez-Montoya et al. (2017) had already identified a difference in the level of digital competence between professors in traditional teaching (professors whose classes were fully on-campus) and online teaching (professors whose classes were developed in virtual environments).

Teaching in the e-learning modality demands comfortable levels of mastery from professors in several virtual environments and web tools, technical knowledge combined with pedagogical strategies for content production, regular use of communication tools (synchronous and asynchronous), systems and platforms such as repositories and virtual learning environments, as well as copyright and online conduct rules. Various evidences converge around a positive relationship of these fields and digital competence, as reported by researchers such as Durán et al. (2017) on the use of systems and programs in Web 1.0 and 2.0 environments, Ramírez-Montoya et al. (2017) in relation to the knowledge, production and use of Open Education Resources (OER), and Krumsvik et al. (2016) in relation to the time professors are in front of the screens (screen time).

Vieira and Pedro (2021) state:

> As far as professor training is concerned, it is important to emphasize that, according to the answers of a considerable part of the respondents, the search for professional development in this area has been at the initiative of the professors, pointing to a lack of institutional valorisation of qualifications for and/or online education, especially in the Portuguese context. (p. 28)

The course modality showed statistically significant effects on the means. Tukey's post-hoc test identified that in the PE, TL, AS, EL and FL areas, the difference was between professors who worked 100% on-campus courses in relation to professors who worked in e-learning, regardless of the proportion. In the DR area, the difference was found only between professors who worked exclusively in on-campus courses in relation to those who worked in e-learning, in the proportions of 30% and 70%.

Finally, regarding the third research question (Are there statistically significant differences in the level of digital competences of Portuguese higher education professors arising from institutional related factors (Institutional category and Institutional funding sector)?) it was possible to see, in the institutional category, that the differences in the proficiency level of professors were identified only in the EL area, with the MANOVA showing a statistically significant effect on the PE and TL areas. Several other pieces of evidence in this regard indicate that faculty in polytechnic education were more digitally competent. Vicente et al. (2020) indicate that polytechnic faculty were more digitally innovative (80.9%) than university faculty (73.80%), and Pedro et al. (2021) highlight higher proficiency levels in polytechnic faculty (B2) when compared to university faculty (B1).

Regarding the institutional funding sector, no differences in the level of proficiency in the areas were identified, although the MANOVA indicated a statistically significant effect.

## 5. CONCLUSION

The general level of proficiency in digital competences of Portuguese higher education professors was B1 – integrator, which indicates that there is plenty of room for improvement, especially concerning investment in professional development and stimulating self-exploration of pedagogically and scientifically valid digital environments and tools. This effort to increase the level of proficiency must be assumed by institutions and professors, and is relevant for the promotion of the digital competences of graduate and postgraduate students. The ability to facilitate learners' digital competence is an integral part of the digital competences of educators (Dias-trindade & Santo, 2021; Redecker, 2017).

One deficiency noted was in the AS area with an A2 – explorer level, compared to the others that scored a B1 – expert level, with the negative results of this deficiency magnified in the context of the COVID-19 pandemic. These deficiencies may have led faculty members to carry out the transfer of content taught in face-to-face classes to virtual learning platforms, thus promoting Emergency Remote Teaching (ERT) practices rather than e-learning (Hodges et al., 2020; Pérez López et al., 2020). The COVID-19 pandemic only made explicit the urgent need for professors to possess digital competences capable of grounding their pedagogical practice in virtual learning environments in line with a digital society and with the daily practices of their students.

As for the level of proficiency considering the teaching-related factors, differences were identified in both factors studied. In course modality, differences occurred in the AS and EL areas, both in the pedagogic competence dimension of DigCompEdu. It is important to highlight that although the difference was found only in these two areas (following the scale of the instrument), professors who teach at the doctoral level obtained higher means than the others in all of them, reinforcing the thesis that obtaining academic degrees and experience in research promotes digital competences, to the extent that today it is quite difficult to develop scientific research without a substantial knowledge of digital technologies (Pedro et al., 2021).

Specifically regarding course modality, differences were found in five of the six areas, demonstrating the strong impact of the modality on the level of proficiency. The professors who worked in the 30% on-campus courses and 70% e-learning proportion obtained the highest means, even higher than the 100% e-learning modality. This superiority of professors who worked in two modalities can be related, at least partially, to the framework adopted as a theoretical reference and that guides the instrument used in this article; DigCompEdu did not specifically consider the universe of e-learning or even *blended learning* (Mattar et al., 2020), thus it does not have specific digital teaching competences related to this teaching modality. The lack of difference in the facilitating learners' digital competence (FL) area can be explained in part because it does not reflect intrinsic professor competences (e.g., ability to perform a certain task). This area is about the capacity to enable learners to use digital technologies creatively and responsibly for information, communication, content creation, well-being and problem-solving.

Finally, some reports (Santos et al., 2021; Vicente et al., 2020) had already indicated the superior performance of professors linked to polytechnic institutes, either in terms of digital innovation or in terms of digital proficiency, which indicates the need for special attention to digital competences from universities, and even more for the traditional ones. With the results obtained in this article, it was possible to identify that this superiority was in the area of empowerment of learners, which deals with using digital technologies to enhance inclusion, personalization and the active engagement of learners, which showed higher results (B1) when compared to universities (A2). No difference was found in the level of proficiency when compared by institutional funding sector, indicating the need for investment in both technological infrastructure and the professional development of professors.

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