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# Digital competence among university professors: analysis of the impact of the COVID crisis

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**ABSTRACT**
The digital revolution and the consequences of COVID-19 have had a significant impact on higher education. The need to develop digital competences, especially among educators and within the entire university system, has become a priority. Furthermore, due to the change of habits required by technology, digitization has entailed a great effort by professors. Until March 2020, the development of digital competence had been increasing gradually. However, its evolution has experienced a qualitative leap due to the impact of the COVID crisis, which forced all education to be delivered initially online, and later in hybrid form. Several theoretical models have been used to determine the digital competence of professors and its impact on student learning. The European Framework for Digital Competence of Educators (DigCompEdu) model is applied in this research. It defines the digital competence of professors in six areas comprising 22 competences, all categorized under three main headings. A survey with 271 university professors has provided the quantitative data analysis for the findings. The results will help to analyze professors' digital competence evolution showing that self-perception has improved by 51%, which is significant. Finally, some conclusions regarding training and investment in universities are considered from the study results.

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## 1. Introduction

The university system in Europe has undergone significant changes in recent decades. We can identify a recent evolution in different phases. The first one started with the Bologne Process in 1999. The objective of the educational change was to establish a standard qualification system in Europe to face the challenges posed by globalization and digitization (Del Pozo Andrés, 2008/2009; Marcelo & Yot-Domínguez, 2019). In addition, the change aimed to pursue a system that would facilitate work practices

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and be more closely linked to the professional world. Competences and learning outcomes have been developed as objectives of the teaching and learning process, whereas content is secondary or derived from the former. Consequently, achieving the objective involved making students responsible for their learning by putting into practice the constructivist-based educational philosophy known as student-centered learning (SCL) (O'Neill & McMahon, 2015), where the educator is a mediator or facilitator of the learning process. The second phase is due to the introduction of technology into all teaching-learning processes. As an innovative drive, both in terms of content (digital materials and resources) and mode (all versions of e-learning), technology has enhanced the paradigm shift of the entire educational environment. Over the years, all European Higher Education Area (EHEA) countries have tried to adapt to these new approaches to respond to the challenges of an uncertain, liquid context, a feature of the digital age (Bauman, 2005).

Since the global COVID crisis, we have started a new phase of the evolution of education, undergoing profound disruptions in which digitization has become essential and widespread. During the first part of the crisis, universities needed to react by implementing online distance learning as an emergency response. Therefore, in March 2020, all modes of teaching were converted into distance education through digital means in an attempt to put in-person and online education at the same level (Anormaliza et al., 2015; Udo et al., 2011). However, thanks to the innovative, adaptive capabilities of the entire educational community, teaching activity continued in most European universities (Benítez-Amado, 2020).

The pandemic and the resulting confinement of the population in their homes meant that education, conceived and designed for beinginperson, now had to be delivered by computers. Subsequently, the faculty was required to adapt to the use of technology, platforms, and telematic channels and the redefinition of methodologies, training activities, and evaluation systems.

Finally, once the restrictions were relaxed, it was possible to return to the classroom on a limited basis for the 20–21 academic year. To comply with health protocols (capacity constraints, the distance between people, etc.), most universities worldwide selected teaching models combining in-person classroom education with distance learning by the Internet, known as hybrid learning models (De Obesso & Nuñez-Canal, 2021).

The hybrid teaching model has entailed an unprecedented digital transformation of faculty members and universities (Bonfield et al., 2020). As a result, significant technology investments and digitization have become a permanent component rather than an overreaction to an emergency.

In this new scenario, the digital capabilities of professors have become an object of analysis and observation. This paper aims to respond to the research question: To what extent has the COVID crisis influenced the development of professors' digital competence in higher education? Following recent research on Educators' Digital Competence (EDC), we answer the question by comparing educators' perceptions of their digital capability before and after the pandemic. In addition, we collect data based on the European Framework for Digital Competence (Ferrari, 2013).

The literature on the field of education technology has, until now, studied the evolution and the need for faculty digital capacitation due to environmental changes

(Marcelo & Yot-Domínguez, 2019). This research contributes to the knowledge by offering a unique empirical study about the sharp increase in digital competencies of university professors derived from the necessity to adapt to the virtual teaching context during and after the pandemic. Moreover, this research tries to cover a literature gap in assessing COVID crisis implication on faculty technological skills due to the abrupt change suffered in education as in all aspects of normal life.

This paper is structured, describing first the theoretical framework regarding university transformation and faculty digital competence; afterward, the materials and methods of the empirical research are explained, followed by the results. Finally, we discuss our results regarding the research questions, proposing conclusions and suggestions, and further research and limitations.

## 2. Bibliographic review

### *2.1. The evolution of learning models in the digital age*

The so-called fourth industrial revolution (Schwab, 2016) has highlighted the importance of developing digital competence at all levels of society. Moreover, the need for future generations to be digitally literate has increased the importance of technology both as a means and an end to student learning (Fernández Márquez et al., 2019; Gisbert, et al. 2016). Thus, the definition of educators' digital competence has been a priority for international institutions, ranging from the European Union to the universities themselves, as well as a growing field of interest in the scientific literature (Perdomo et al., 2020; Rodríguez-García et al., 2019; Usart, et al. 2021). This research follows the latest trends that promote rigorous, evidence-based studies of contributions to the teaching and learning process, especially regarding the professors' impact on students (Higgins, 2020).

The main objective of universities is to contribute to student knowledge and ensure their successful transition to the working world (Allen & van der Velden, 2007). Nowadays, universities that follow the European Higher Education Area requirements are the institutions responsible for developing competences in students as pathways to employment. However, the organizational structures of universities are increasingly complex (Benítez-Amado, 2020) and suffer internal changes to adapt structures and resources to a more demanding external market. In this sense, some authors highlight that mission of universities nowadays goes beyond traditional academic activities such as the transference of technology and knowledge, including enhancement of regional economic development (Clauss et al., 2018). Moreover, Higher Education institutios are constrained by existing regulatory compliance that can hinder the responsiveness that the digital and global context demands to meet the needs of an ever-changing market (Road et al., 2017).

In the new millennium, the recent challenge for universities has been integrating technology (ICT) into teaching and learning (Al-Samarraie et al., 2018). In response to these changes and new educational needs, innovative formats have increased in university degree offerings. In this sense, online learning, also known as e-learning, is a method of receiving education by distance, which seeks to build the knowledge base of learners by offering an individualized learning experience in which electronic media specifically contribute to the learning process (Tavangarian et al., 2004). As a general concept, e-learning comprises other educational learning models such as web-based, computer-based, virtual, or blended, partially in-person (Skalka et al., 2012). There is no doubt that the e-learning model has been a great success in increasing the learning opportunities of the entire population, giving millions of people access to both degree qualifications (undergraduate and postgraduate) as well as a massive number of non-degree courses on a broad range of subjects (Means et al., 2014; Skalka et al., 2012). In this sense, having free access to education and widespread through massive open online courses (MOOCs) is an educational revolution enabled through technology. Moreover, this scenario has allowed essential conclusions about how humans learn through digital platforms and multimedia resources (Oakley & Sejnowski, 2019).

Nowadays, the pedagogical efficiency of e-learning has been confirmed by academic research (Cabero-Almenara, 2006), demonstrating the educational quality of this type of learning model when the requirements of rigor and initial course design based on learning outcomes are met (Huertas et al., 2018; Udo et al., 2011).

### *2.2. The emerging hybrid model*

The shift to online learning due to the COVID crisis has been defined as a 'remote educational emergency' (Bozkurt & Sharma, 2020). It is not comparable to what was hitherto known as e-learning, in which curricula and activities were designed to be permanently online (Huertas et al., 2018). However, due to a health crisis preventing in-person learning, an educational emergency was addressed using the Internet's advantages (Hodges et al., 2020). The outcome has been considered initially positive because the continuation of the learning process was made possible. However, more comprehensive preliminary studies have shown that long-term learning outcomes are considerable loss (Donnelly & Patrinos, 2021).

In the academic year of 2020–2021 a new educational model different from previously existing e-learning or blended learning formats is emerging, thanks to significant technological advances. The new educational system, known as the hybrid model, has been defined by UNESCO as a 'learning approach that combines both remote and in-person learning in order to enhance the learner experience and ensure continuity' (UNESCO, 2020, p. 6).

During the 2020–21 academic year, most universities have opted for a hybrid learning model in which students are located in different places, either physically in the classroom or in other spaces connected to the classroom through telematic means. They simultaneously share the teaching and learning process with the professor and other students (Gnaur et al., 2020). This model comprises different formats: flipped classrooms, live synchronous teaching through video conferencing, asynchronous activities to be carried out autonomously by students, and other remote features through technology platforms that professors use to provide instruction and feedback. In this mixed format, educational institutions must make substantial technology investments in the classroom, providing cameras, screens, digital whiteboards, microphones, loudspeakers, computers, software, videoconferencing licenses, and surveillance systems for assessment, learning management systems, and more.

In addition to the investment in technological resources, all universities have had to provide professors with training to cope with this new model by scheduling courses related to virtual teaching, content generation, and new educational applications (De Obesso & Nuñez-Canal, 2021). Technology has caused tension and resistance in the university community due to the difficulties of simultaneously managing students in person and remotely.

In this line of study, professor Rama explains that there has been a shift from 'a unimodal teaching-learning dynamic focused on in-person lecturing to a diversity of complementary forms of multimodal learning' (Rama, 2021, p. 117). Although, at first glance, the hybrid format seems to have originated in response to a pandemic that paralyzed nearly 200 million students and thousands of professors is yet another format of education. Following this author, the hybrid model 'implies the construction of a new type of education managed with differentiated, more complex forms of management through the use of synchronous, asynchronous, automated, and manual types of teaching, and more flexible dynamics in order to respond to the growing demand for access, and to promote a diversity of learning environments adjusted to the distinct features of the various professional fields … ' (Rama, 2021, p. 121).

The simultaneous education that combines in-person and remote environments through technology had already been forecast in 2014 in the NMC Horizon Report: 2014 Higher Education Edition (The New Media Consortium, 2014), which studied trends in technology in higher education. The report focused on hybrid education as a future scenario of high growth.

The experience resulting from the hybrid model emphasizes the fact that students receiving instruction can be in different spaces simultaneously. Having students in a classroom connected by the Internet with others, guided by a professor, offers significant advantages, but it also creates uncertainties about the efficiency of educational outcomes, organizational transformations, and pedagogical consequences.

After a year of implementation, we now know that its strong point lies in enabling the teaching-learning cycle to continue, and its main limitations are linked to access to technology, a change in methodology, the digital skills of educators, and its impact on the learning and motivation of students. As a result, several initiatives are currently investigating the pedagogical outcomes of this model as a line of research.

As educators' adaptation to technology has not been easy, COVID circumstances created a state of necessity that boosted the capacity of all faculty. Therefore, this study aims to prove to what extent that capacitation took place and how the professors perceived it.

### *2.3. The digital competence of educators*

The DeSeCo Competences Project (OECD, 2005; Salganik et al., 1999) pointed out that competences are more than just knowledge and skills, as they include the ability to cope with complex demands by putting those skills into action in specific situations, as well as the use of psychological resources, abilities, and attitudes. There are many competences, and those considered essential have been identified. The main objective is to foster a link between education and the needs of today's new society (Valle & Manso, 2013). In this context, digital competence is considered one of the key skills for accessing lifelong learning (Europea Unión, 2006; Morselli, 2019).

The changes resulting from the introduction at the beginning of the 21st century of the concept of competences as an educational goal (Rychen & Salganik, 2003) have led the university to assume pedagogical criteria of student-centered learning. Therefore, interactive methodologies, project-based learning, experiential learning, etc. are encouraged.

Blair's learning pyramid (Blair, 2008) explains how the levels of learning evolve from the master class, where the only responsibility of the student is to listen and therefore assume a passive position, to more active methodologies, for example, the flipped classroom where the student assumes educators position, empowering the students in their learning process and educators acting as tutors. (Sánchez et al., 2021).

Active methodologies such as flipped classrooms or the learning by doing approach have changed the role of educators. Instead of reinforcing the cognitive function, the educator becomes a facilitator and an active part of the teaching and learning process (Ladeveze & Núñez-Canal, 2018). Technology has contributed to this change in perspective and the new professors' role.(Marcelo & Yot-Domínguez, 2019).

Consequently, the university transition to the digital world has highlighted the relevance of digital competences for all agents. Understood broadly, digital competence encompasses a multidimensional ability to use technology in different domains (Ferrari, 2013). Previous research has found that the educator's digital skills are related to a better learning experience in the use of active methodologies by students (Fuentes et al., 2019). Other research has found a link of the quality of the learning process in higher education with the faculty's use of technology. Regarding communication tools, assessment, and feedback, it is accepted that professors' digital interaction is a relevant factor (Liesa-Orús et al., 2020).

The relationship between a developed and innovative society and the use of technological resources has implied that learning such technologies is one of the main goals of educational policy in many countries. In this sense, the European Union has developed under the DIGCOMP project a tool for assessing and enhancing the digital competence of all citizens (Carretero et al., 2017). Furthermore, because of education's relevance in building digital citizenship (Ferrari, 2013), other specific models have been introduced in education, such as DigCompEdu (Redecker, 2017). These projects confirm the growing interest in measuring the effectiveness of educational technology in promoting enhanced learning (Rodríguez-García et al., 2019).

In Spain, the Ministry of Education has developed a national framework for educators' digital competence (INTEF – Instituto Nacional de Tecnologías Educativas y Formación del Profesorado, 2017). Some scholars have used the INTEF model as a validated instrument with some modifications (Durán Cuartero et al., 2019; Touron et al., 2018). Along the same line, other authors have developed different self-assessment tools for measuring digital competence among faculty members as the first step toward improved use of technology (Cantabrana et al., 2019; Usart, et al., 2021).

In the research herein, after having studied the different frameworks, the choice was to apply the European model (DigCompEdu) for being the more accurate to measure the evolution that occurred during the COVID pandemic (Redecker, 2017) as some comparative studies have shown it (Cabero-Almenara et al., 2020). Moreover, the DigCompEdu model provides a comprehensive view of how students' digital skills and educators' pedagogical criteria are interconnected and integrated into the learning process.

The effectiveness of this instrument has been demonstrated in several research studies showing the reliability and validity of the tool with interesting results. For instance, experienced ICT professors achieve significantly higher student scores, demonstrating the crucial value of educators' digital competence in the learning process (Ghomi & Redecker, 2019). The model has also been confirmed in more extensive studies in Spain that focused on university professors with a sample of 2,262 lecturers from Andalusian universities (Cabero-Almenara et al., 2020). Other research involving doctoral students as future professors has also produced satisfactory results from applying this instrument to measure educators' competence (Demeshkant, 2020).

The DigCompEdu tool describes the digital competence of an educator in six areas, showing 22 specific competences (Redecker & Punie, 2017) that are categorized under three main domains. The first refers to professional competence, educators' commitment, attitude, and ICT use in the teaching process. The second refers to the educators' pedagogical competence, which includes the following: digital resources, their teaching and learning procedures, the empowerment of learners, and an evaluation system. Finally, the third domain deals with students' competence and how educators facilitate digital skills development among learners.

The use of self-assessment methods to evaluate the possibility of fulfilling the desired behavior (in this case, the better use of educator digital skills) has its theoretical roots in the concept of self-efficacy developed by Bandura (Bandura,1986). These intentional models -the intention to do something is the best predictor of the possibility of this intention happening in the future- have been broadly used since some decades ago to measure entrepreneurship competence in education (Krueger and Casrud 1993; Liñán, 2004). Moreover, some education studies are based on educators' self-evaluation to introduce an active reflection that encourages enhancing and improving self-performance (Ruskovaara et al., 2015). Following previous studies, this research uses a self-assessment method through a validated tool.

## 3. Empirical analysis

### *3.1. Hypothesis*

Based on a literature review and observation of the context of educational change, a hypothesis for our study's development was established following research question: To what extent has the health crisis impacted the development of university professors' digital competence?

> Hypothesis: The COVID crisis has had a massive, exponential impact on educators' digital competence development in higher education.

**Table 1.** University Faculty in Spain in Business Administration and Law, academic year 2017–2018.

| | Total | | Public University | | Private University | |
|---|---|---|---|---|---|---|
| | **total** | % | **total** | % | **total** | % |
| Total | 122,910 | 100.0% | 103,876 | 84.5% | 19,034 | 15.5% |
| University centres | 115,987 | 94.4% | 98,173 | 79.9% | 17,814 | 14.5% |
| Affiliated centres | 6,923 | 5.6% | 5,703 | 4.6% | 1,220 | 1.0% |

*Source*: Prepared by the authors based on data obtained from the Ministry of Universities (2020).

To verify or not the hypothesis, empirical research was carried out using the DigCompEdu measuring tool. T respondents were asked about their performance in each competence 'before' and 'after' the COVID health crisis. The sample design, data collection, and analysis are described below.

### 3.2. Population and sample

This research study analyzed 251 observations from a Madrid university professors' in business studies. In this case, the scope of the sample includes professors between 31 and 60 years of age from different types of higher education institutions (state universities 40.2%, and private 40.2%), as well as both genders (39.4% female and 60.2% male). Thus, the diversity of the population is reflected in the sample analysed. Regarding the respondents' background, 53.4% of the sample are academic professionals, and 46.6% are non-academic professionals who combine their work-life with university teaching. In terms of years of teaching experience, the respondents have been categorized into six groups, ranging from 1-5 years to more than 25 years.

To confirm the validity of the sample, we have used as a reference the data published in a 2020 report by the Ministry of Universities (Ministerio de Universidades. Gobierno de España, 2020). The report includes information on educators in public universities (98,173), representing 79.9% of the total (see Table 1). From this reference regarding the distribution of professors by their field of knowledge, we observed that 13,155 belong to Business Administration and Law, consisting of 13.4% (see Table 2).

In order to calculate a percentage that would be representative, we took the Ministry's data, which refers only to public universities. Then, we applied the same percentage of 13.4% (see Table 2) to the universe of data for all professors belonging to the fields of study of Business Administration and Law in all public and private universities (see Table 3).

In terms of geographical dispersion (see Table 4), the Autonomous Region of Madrid has a total of 25,042 professors, which represents 20.37% of the total (25,042/122,910).

### 3.3. Data collection

Based on these data, a non-probabilistic sample was created. The study is aimed at a particular group of professors from Business Administration and Law faculties and

**Table 2.** Distribution of professors at public universities according to their field of knowledge. Academic year 2017–2018.

| Field of knowledge | % | Number of centers |
|---|---|---|
| Education | 6.4 | 6,283 |
| Arts & Humanities | 11.5 | 11,290 |
| Social sciences, journalism, and documentation | 11.9 | 11,683 |
| Business Administration and Law | **13.4** | **13,155** |
| Science | 16.1 | 15,806 |
| Computer Science (IT) | 3.8 | 3,731 |
| Industrial engineering and construction | 15.1 | 14,824 |
| Agriculture, livestock, forestry, fisheries, and veterinary science | 1.8 | 1,767 |
| Health and social services | 19.0 | 18,653 |
| Services | 1.0 | 982 |
| | **100.0** | **98,173** |

*Source*: Prepared by the authors based on data obtained from the Ministry of Universities (2020).

**Table 3.** Professors in Spain in the fields of Business Administration and Law, academic year 2017–2018.

| Faculty. Academic year 2017–2018 | | | | | Business Administration and Law |
|---|---|---|---|---|---|
| 122,910 | Public University | 103,876 | University centers | 98,173 | 13,155 |
| | | | Affiliated centres | 5,703 | 764 |
| | Private University | 19,034 | University centers | 17,814 | 2,387 |
| | | | Affiliated centers | 1,220 | 163 |
| | | | | | 16,470 |

*Source*: Prepared by the authors based on data from the Ministry of Universities (2020).

**Table 4.** Geographical dispersion of teaching personnel. Academic year 2017–2018.

| | Faculty | Percentage |
|---|---|---|
| Galicia | 5,218 | 4.20% |
| Asturias | 2,111 | 1.70% |
| Cantabria | 1,388 | 1.10% |
| Basque Country | 5,560 | 4.50% |
| La Rioja | 2,295 | 1.90% |
| Aragon | 4,196 | 3.40% |
| Navarra | 1,356 | 1.10% |
| Catalonia | 21,842 | 17.80% |
| Castille and Leon | 8,021 | 6.50% |
| Madrid | 25,042 | 20.40% |
| Castilla la Mancha | 2,431 | 2.00% |
| Valencia Region | 13,937 | 11.30% |
| Extremadura | 1,872 | 1.50% |
| Murcia | 4,028 | 3.30% |
| Andalusia | 17,691 | 14.40% |
| Balearic Islands | 1,451 | 1.20% |
| Canary Islands | 3,285 | 2.70% |
| Others | 1,186 | 1.00% |
| | 122,910 | 100.00% |

*Source*: Prepared by the authors based on data from the Ministry of Universities (2020).

Business Schools. Following the snowball sampling technique, the sample selection was carried out (Scharager & Armijo, 2001).

An online questionnaire with 22 items from the DigCompEdu tool was sent to the databases of professors from different public and private universities in Madrid in November of 2020, obtaining 251 valid responses. The questionnaire was sent following the code of ethics of the universities. Therefore, anonymous data are guaranteed, as well as the consent to the use of personal information for academic research purposes.

**Table 5.** Example of calculating the evolution from basic competence to expert level for the competence area 1.1: Professional Commitment.

| Likert scale | Area 1-1: | Frequency Before COVID | Frequency After COVID | Total Before COVID | Total After COVID | Difference After-Before |
|---|---|---|---|---|---|---|
| 1 | I rarely use digital communication channels | 13 | 6 | 161 | 71 | −90 |
| 2 | I use basic digital communication channels, e.g., email. | 40 | 14 | | | |
| 3 | I combine diverse communication channels, e.g., email, blogs, the faculty or university website, and apps. | 108 | 51 | | | |
| 4 | I systematically select, adjust, and combine different digital solutions to communicate effectively. | 70 | 134 | 90 | 180 | 90 |
| 5 | I proactively reflect, debate, and develop my communication strategies. | 20 | 46 | | | |

*Source*: Prepared by the authors.

The sample is representative and balanced for the population analyzed with proportional representation according to the type of university, academic profiles, and years of experience. Regarding the gender of the educators 39.4% are female and 60.2% are male. This bias is due to the gender gap and is comparable to other research in this area. To conclude the methodological design of the research, it can be stated that the sample fulfills the requirements of heterogeneity, with a 95%c confidence level and a 6% margin of error.

### *3.4. Analysis and findings*

In order to analyze the increased performance of the digital competence of the professors based on the assessments made by the interviewees, we proceeded as follows:

The 22 competences assessed in the questionnaire using the DigCompEdu instrument offered a Likert rating scale from 1 to 5. Regarding the respondents' answers, the basic level of performance for each competence was set at levels 1, 2 and 3, while expert performance was set at levels 4 and 5.

For example, in the competence Area 1-1, Professional Commitment, one statement reads, 'I systematically use diverse digital channels to improve communication with my students and colleagues, e.g., emails, blogs, the faculty or university website, and apps'. The frequency results of the scale are shown in Table 5 as follows:

For this competence area, the number of occasions that levels 1, 2, and 3 of the Likert scale were selected before COVID was 161, and after COVID it was 71. This level has been referred to as the basic level of performance for this competence. In the case of the assessment considered to be expert, i.e., levels 4 and 5 on the Likert scale, it was selected 90 times before COVID and 180 times after COVID. Once the assessments had been classified into basic and expert evaluations for all 22 competences, the following totals were obtained (see Table 6).

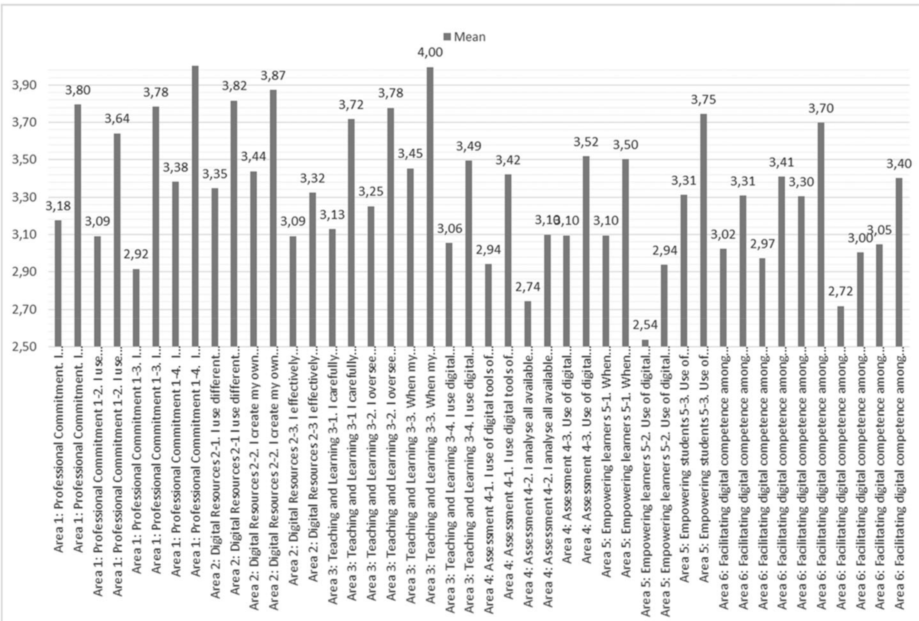
Based on the same analysis for each of the 22 competences, the results can be seen in Table 7 below. The self-assessment results of each of the competences before and

**Table 6.** Evolution of competence from basic to an expert before and after COVID.

| Type of Competence[1] | Before COVID (No. of times selected) | After COVID (No. of times selected) | % Improvement =((After-Before) / Before)*100 |
|---|---|---|---|
| Expert rating of 4 or 5 on the Likert scale | 2,047 | 3,081 | 51% |

*Source*: Prepared by the authors.

**Table 7.** Comparison mean of the 22 competences of the model before and after COVID.




Source: Prepared by the authors

*Source*: Prepared by the authors.

after COVID are grouped in pairs. Then, for each of the competences, the graph of the mean of their ratings is calculated and added.

As can be seen in all cases, the mean rating for each competence is significantly higher when the question is answered in the post-COVID context than the rating before COVID. For example, in competence Area 1: Professional Engagement 1-1. I systematically use different digital channels to improve communication with my students and colleagues, e.g., emails, blogs, the faculty or university website, and apps [My answer before March 2020 (COVID)] and [My answer after March 2020 (COVID)]. In this case, the mean rises from 3.18 before to 3.80 after. Another example is in Area 3 competence: Teaching and Learning 3-3. When students work in groups, they use digital technologies to acquire and utilize knowledge [Before March 2020 (COVID)] and [answer after March 2020 (COVID)]. Here we observe that the mean increases from 3.45 before to 4.00. The *t*-test to compare the means was also used to test the working hypothesis.

The comparison of the frequency means of the competences assessed in terms of their level of performance before and after COVID for the 22 competences studied obtained a significance level below 0.05 in all cases. This means that the null hypothesis, which states that there is no difference between the means for the same competence measured at different times, is rejected, and that the alternative hypothesis, which proposes that there is a difference between the means in each of the 22 variables studied, is accepted (see Table 8).

## 4. Discussion of results

The relationship between EDC and the digital skills improvement of professors before and after is significant for all variables. Therefore, this study has allowed measuring the professors' digital competence increase before and after COVID.

A descriptive analysis shows ratings of the 22 expert-level competencies rose from 2047 before COVID to 3081 after COVID, which is a 51% improvement between the two points in time. Moreover, if we consider the criterion of ranking the chosen values between the basic level (1 to 3 Likert scale) and the expert level (4 and 5), the significance of the difference is even greater.

Undoubtedly, the situation experienced by all educators forced to use technology resulted in the need to adapt and develop new skills to make teaching possible. This reality has been the trigger for exponential growth. In this sense, some researchers have confirmed that professors should be trained in digital literacy, content creation, data security, and problem-solving skills (Reisoğlu & Çebi, 2020). The COVID situation has contributed more to the increased digital literacy of university professors than any circumstance previously experienced.

The third enabling factor in the development of educators' digital competence has been the positive attitude toward technology, as confirmed by experts in recent studies, in which such an attitude toward digital media on the part of teachers has been associated with student learning (Ghomi & Redecker, 2019; Liesa-Orús et al., 2020; Ehuletche et al., 2018).

Finally, the results are conclusive after testing whether there were significant differences between the means of the 22 competences analyzed and assessed before March 2020 (before COVID) and several months after the pandemic. In all the competences analyzed, the probability (p) of obtaining a non-zero difference in the case of both samples belonging to the same population, with no differences other than those that are purely random, is associated with the value obtained (t), which shows statistical significance when it is less than 0.05, the results obtained confirm that the differences between the means are significant.

## 5. Conclusions

The digital age and changes prompted by the unforeseen global pandemic have transformed higher education and directly affected the entire university teaching and learning process. As a result, institutions have perceived the need for a significant transformation. However, the professors have demonstrated their capacity for

**Table 8.** *t*-test for the equivalence of means for each of the 22 competences of the digital competence model, assessed before and after COVID.

| Competence | T | Dl | Sig (2-tailed) | Mean Difference | Standard error of difference | 95% confidence interval of the difference | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Area 1-1-A: Professional Commitment. I systematically use diverse digital channels to improve communication with students and colleagues, e.g., emails, blogs, the faculty or university website, and apps. | −7.500 | 496.212 | 0.000 | −0.622 | 0.083 | −0.784 | −0.459 |
| Area 1-2-A: Professional Commitment. I use digital technologies to work together with colleagues inside and outside my educational organisation. | −5.476 | 499.895 | 0.000 | −0.550 | 0.100 | −0.747 | −0.353 |
| Area 1-3-A: Professional Commitment. I actively develop my digital teaching skills | −8.783 | 490.617 | 0.000 | −0.869 | 0.099 | −1.063 | −0.674 |
| Area 1-4-A: Professional Commitment. I participate in online training courses, e.g., online courses, MOOCs, webinars, videoconferences, etc. | −6.307 | 494.466 | 0.000 | −0.625 | 0.099 | −0.820 | −0.431 |
| Area 2-1-A: Digital Resources. I use diverse websites and search strategies to find and select different digital resources. | −5.318 | 496.137 | 0.000 | −0.470 | 0.088 | −0.644 | −0.296 |
| Area 2-2-A: Digital Resources. I create my own digital resources and modify existing ones to adapt them to my needs. | −5.525 | 492.492 | 0.000 | −0.434 | 0.079 | −0.589 | −0.280 |
| Area 2-3-A: Digital Resources. I effectively protect personal data, e.g., exams, marks, personal data, etc. | −2.037 | 499.972 | 0.042 | −0.231 | 0.113 | −0.454 | −0.008 |
| Area 3-1-A: Teaching and Learning. I carefully consider how, when, and why to use digital technologies in the classroom in order to ensure that they add value. | −5.957 | 491.469 | 0.000 | −0.590 | 0.099 | −0.784 | −0.395 |
| Area 3-2-A: Teaching and Learning. I oversee the activities and | −4.406 | 420 | 0.000 | −0.527 | 0.120 | −0.762 | −0.292 |
| interactions of my students in the online collaborative environments we use. | −4.529 | 397.080 | 0.000 | −0.527 | 0.116 | −0.755 | −0.298 |
| Area 3-3-A: Teaching and Learning. When my students work in groups, they use digital technology to acquire and utilise knowledge. | −6.348 | 496.347 | 0.000 | −0.542 | 0.085 | −0.710 | −0.374 |
| Area 3-4-A: Teaching and Learning. I use digital technologies to enable my students to plan, document, and monitor their own learning, e.g. self-assessment, etc. | −4.656 | 499.184 | 0.000 | −0.438 | 0.094 | −0.623 | −0.253 |
| Area 4-1-A: Assessment. I use digital tools of assessment to monitor student progress. | −5.017 | 499.576 | 0.000 | −0.482 | 0.096 | −0.671 | −0.293 |
| Area 4-2-A: Assessment. I analyse all available data to effectively identify students who need additional support. 'Data' refers to | −3.600 | 499.566 | 0.000 | −0.359 | 0.100 | −0.554 | −0.163 |

(*continued*)

**Table 8.** Continued.

| Competence | T | Dl | Sig (2-tailed) | Mean Difference | Standard error of difference | 95% confidence interval of the difference | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| the following: engagement, performance, grades, student attendance, activities, and interaction. | | | | | | | |
| Area 4-3-A: Assessment. Use of digital technologies to provide effective feedback | −4.827 | 498.853 | 0.000 | −0.422 | 0.087 | −0.594 | −0.250 |
| Area 5-1-A: Empowering learners. When creating digital tasks for learners, I consider and address potential practical or technical difficulties, e.g., equal access to digital devices and resources; interoperability and conversion issues; lack of digital skills, etc. | −3.961 | 499.805 | 0.000 | −0.406 | 0.103 | −0.608 | −0.205 |
| Area 5-2-A: Empowering learners. Use of digital technologies to offer students personalised learning opportunities, e.g., I give distinct digital tasks to different students in order to address individual learning needs. | −3.350 | 499.551 | 0.001 | −0.398 | 0.119 | −0.632 | −0.165 |
| Area 5-3-A: Empowering learners. Use of digital technology to encourage students to participate actively in class. | −5.064 | 499.535 | 0.000 | −0.434 | 0.086 | −0.603 | −0.266 |
| Area 6-1-A: Facilitating digital competence among students. I teach students how to assess the reliability of information and identify misleading and biased information. | −2.650 | 499.628 | 0.008 | −0.283 | 0.107 | −0.493 | −0.073 |
| Area 6-2-A: Facilitating digital competence among students. I set tasks that require students to use digital media to communicate and collaborate with each other or with an external audience. | −4.771 | 499.972 | 0.000 | −0.438 | 0.092 | −0.619 | −0.258 |
| Area 6-3-A: Facilitating digital competence among students. I assign tasks that require students to create digital content, e.g., audio, video, photos, digital presentations, blogs, wikis, etc. | −3.968 | 499.870 | 0.000 | −0.394 | 0.099 | −0.590 | −0.199 |
| Area 6-4-A: Facilitating digital competence among students. I teach students to use digital technology safely and responsibly. | −2.720 | 496.322 | 0.007 | −0.287 | 0.105 | −0.494 | −0.080 |
| Area 6-5-A: Facilitating digital competence among students I encourage students to use digital technology in creative ways to solve specific problems, e.g., to overcome obstacles or to face emerging challenges in the learning process. | −3.469 | 499.806 | 0.001 | −0.355 | 0.102 | −0.555 | −0.154 |

*Source*: Prepared by the authors.

innovation and adaptation to change and managed to continue their educational activity during the confinement and throughout the subsequent 2020–2021 academic course, all within the context of an unprecedented situation. Initially perceived as a possible threat, this new paradigm has created new opportunities, consolidating all the changes brought by introducing technological means in the teaching and learning process as a pedagogical key element, making it more practical and effective outcomes.

In this evolution, the rapid adaptation to new forms of professor-learner interaction, far from the previous unimodal, teacher-centered approach, has required motivation and commitment at both the personal and institutional levels of the entire aggregate of professors. As a result, the professors' attitude has been highly positive in this time of great need, contributing to their competence and teaching development in the digital era.

Training in educational technology to enhance Educators' Digital Competence has proven fundamental in safeguarding the teaching-learning process and, consequently, learning outcomes achievement.

The digital competence of university educators involves much more than simply using ICT correctly. It also entails technology as an essential pedagogical element, which should be guaranteed to acquire knowledge and new skills. Adequate training in digital competencies and digital teaching is a challenge for universities to carry out their professional task effectively.

This research contributes to measuring the evolution of university professors' digital competence by comparing the results of the self-perception of educators before and after the coronavirus situation. We have presented a pioneer study assessing the COVID crisis's impact on universities' digitization and the hybrid educational model. The DigCompEdu tool, developed within the framework of the European Union, was used for this purpose. The research shows a clear improvement in digital competence, as stated in the initial hypothesis. It is also striking that such progress is being made in record time due to the need to change the pedagogical mentality that requires forced ICT integration. This study represents a starting point of research on the hybrid model, which should be further analyzed. Objective instruments for measuring the quality and impact of mixed format on student performance will need empirical analysis to draw definitive conclusions.

Technological advances must go hand in hand with progress in the skills and capabilities of educational agents. The commitment to training, development, and empowerment of faculty must be prioritized during educational transformation. The resources and possibilities presage an environment radically different from those experienced until now. Universities' governance and management must respond to these new challenges. Preparing for this change is both a social duty and a necessity for the professional development of students and professors. The effectiveness of the university system depends on the parallel integration of technological and human progress. Nevertheless, the conclusions give some clear implications for the regulations and governance of universities to provide training in digital competence and investment in technology.

The new challenges posed by the digital economy and the possibilities offered by technology in education must be considered in further research about the potential development of educators' skills and how this can impact on better learning and enhancement of knowledge and digital capabilities of future generations. Further research could also include differences in the EDC depending on educators' gender and universities' financial resources' dependency on the government or student fees. From an educational efficacy point of view, new research lines are opened to measure the quality of the hybrid method compared with face-to-face and traditional online learning.

We acknowledge some limitations in our study that can be completed with longitudinal analysis and other methodologies as qualitative studies to compare results. Moreover, an international comparison is also a pretty exciting research field to observe the difference between countries and regions.

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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