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ARTICLE / ARTÍCULO

Digital Competence among Teacher Training Master's Degree Students: Differences by Gender, Age, and Field of Study

Competencia Digital en alumnado del Máster de Formación de Profesorado. Diferencias con base en el género, la edad y la especialización

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Abstract: Digital competence (DC) among education professionals is a very popular object of study in approaches oriented towards educational innovation. This study aims to analyse digital skills and relate them to sociodemographic characteristics in a sample of future teachers. Participants were 154 Teacher Training Master's Degree students. The Questionnaire for Studying the Digital Competence of Higher Education Students (CDAES) was used to measure DC. The results reveal that future teachers have a medium-low level in the different dimensions of DC. Specifically, they scored highly for basic tasks associated mainly with 'Digital Literacy', although shortcomings were observed in activities related to 'Creativity and Innovation' and 'Critical Thinking'. The results also revealed that DC decreases as age increases, and that students coming from Social Science degrees had the lowest CD indexes, whereas those from Technology and the Natural Science had the highest scores. There is a need for DC training plans that include personalised innovative educational strategies, or in other words, strategies specifically adapted to the characteristics of different university degrees.

Keywords: Digital Competence, Teacher Education, Postgraduate Students, Gender Differences, Age Differences, Academic Specialization.

Resumen: El estudio de la competencia digital (CD) entre agentes educativos constituye un objeto de estudio muy popular entre los abordajes orientados a la innovación educativa. Este trabajo persigue analizar las destrezas digitales y relacionarlas con características sociodemográficas en una muestra de futuro profesorado. Los y las participantes son 154 estudiantes del Máster de Formación de Profesorado. Para medir la CD, se utilizó el Cuestionario para el estudio de la Competencia Digital del Alumnado de Educación Superior (CDAES). Se aprecia que el futuro profesorado muestra un nivel medio-bajo en las distintas áreas que componen la CD. En concreto, destacan en tareas básicas asociadas, sobre todo, a la «Alfabetización Digital», aunque presentan lagunas en actividades vinculadas a la «Creatividad e Innovación» o «Pensamiento Crítico». Además, los datos revelan que según aumenta la edad disminuye la CD. También, que el alumnado que procede de titulaciones de Ciencias Sociales es el que peores índices de CD presenta, mientras que el de Tecnología o Ciencias Naturales es el que más destaca. Se necesitan planes formativos centrados en la promoción de la CD que incluyan estrategias educativas innovadoras personalizadas, es decir, adaptadas a las características de las titulaciones universitarias.

Palabras clave: Competencia Digital, Formación del Profesorado, Estudiantes de posgrado, Diferencias por género, Diferencias por edad, Especialización académica.

1. Introduction

Globalisation and the swift development and spread of Information and Communication Technology (ICT) have triggered deep-rooted changes in society that have greatly affected the way in which we work, live together and relate to each other (Grajales & Osorno, 2019). One of the spheres in which these changes are most evident is education (Carrasco-Mullins & Villero, 2022), which has undergone major transformations in key areas such as goals, content, resources and, above all, the role of both teachers and students in educational practice. All members of the classroom community have had to adapt to the demands of an ever-changing digitalised environment (Cabero-Almenara et al., 2020).

Digital Competence (DC), or the set of skills that enable individuals to use technology safely, critically, responsibly and efficiently to rise to the challenges posed by the new information society (Cabero-Almenara et al., 2020; Gisbert et al., 2016), has become a key requisite in (among others) the educational environment. In this environment, Digital Competence in Teaching (DCT) is particularly important and involves the development and acquisition of the attitudes and knowledge required to teach, learn, work with, research, share information and interact in an educational setting (Rodríguez-García et al., 2019). In other words, DCT enables teachers to create inclusive educational environments with specific didactic materials and strategies to support students' autonomous learning in a digitalised context (Domingo-Coscollola et al., 2020).

In this sense, Organic Act 3/2020 of 29 December, which modifies Organic Act 2/2006 of 3 May, on Education (LOMLOE), establishes that education administrations must commit to fostering the development of DC at all stages of the education system. It also states that each school must have sufficient material and resources to that end. Studies carried out in this field (Gisbert et al., 2016) have identified universities as a privileged environment that must rise to the challenge of offering ongoing, updated teacher training based on the key competencies of the 21st century (Ostanina et al., 2023), as stipulated by Organic Act 2/2023, of 22 March, on the University System (LOSU). The overarching aim is to guarantee the training and digital inclusion of citizens, as established in the National Digital Competence Plan, which forms part of the Recovery, Transformation and Resilience Plan (Spanish Government, 2021).

In light of this, it is vital to have a basic standard or framework of reference for DC and DCT (Recio-Muñoz et al., 2020) that is aligned with the guidelines established by the European Commission. To this end, the European Commission has designed the European Digital Competence Framework, or 'DigComp' (the current version is DigComp 2.2.) that defines five key components of digital competence for citizens: (1) information and data literacy, (2) communication and collaboration, (3) digital content creation, (4) safety, and (5) problem solving (European Commission, 2022). This approach has given rise to a number of proposals aimed at establishing priority areas in the process of developing the DC of the different stakeholders involved in the teaching-learning process (school staff, students, teachers, etc.). In relation to teachers, the following international proposals are worth mentioning: 'DigCompEdu' or the adaptation of the DigComp framework to educational contexts (Redecker, 2017), and the ICT Competency Framework for Teachers (UNESCO, 2018). At a national level, the

INTEF's Marco Común de Competencia Digital Docente - Common Framework for Digital Competence in Teaching (2017) is of particular importance.

Thanks to the complementary standardisation and publication of these frameworks, empirical research has begun to develop different instruments for assessing DC, mainly self-perceived DC, as a first step towards designing resources and proposals aimed at developing and fostering it. Although as yet no consensus has been reached regarding which instrument is the most appropriate, mainly because every study is based on a different standard (Nóbile & Gutiérrez-Porlán, 2022), one of the online instruments for measuring DC that best adapts to the guidelines established by the European Commission (2022) is the questionnaire for studying the Digital Competence of Higher Education Students (CDAES), developed by Gutiérrez-Castillo et al. (2017). This instrument is the most comprehensive because not only does it take the DigComp 2.2. (European Commission, 2022) proposal as its framework of reference, it also uses the National Educational Technology Standards for Teachers (NETS-T) (International Society for Technology in Education –ISTE-, 2023) to define six components of DC. Furthermore, similarly to the approach adopted by DigCompEdu (DCT) (Redecker, 2017), it establishes five levels of DC: novice (0 to 4.9 points), explorer (5 to 6.9 points), integrator (7 to 8.9 points), expert (9 to 9.49) and pioneer (9.5 to 10) (Romero-Tena et al., 2020; Gutiérrez-Castillo et al., 2017).

Using these instruments, some authors have started to measure the digital skills of students and teachers in the university setting (Solórzano, 2021), particularly in relation to teaching degrees (Colomo et al., 2023). The resulting studies, which mainly use a quantitative methodology, reveal that despite not having acquired the competencies necessary to use technological tools proficiently in their educational and professional environment, participants nevertheless consider themselves to be competent in more basic aspects, such as searching for information and using different programs to present and organise content (XXX, 2024). What is striking, however, is their low level of competence in using technologies that have recently been incorporated into the classroom for (among other tasks) creating and managing content (Andía et al., 2020; Jiménez-Hernández et al., 2020; Røkenes & Krumsvik, 2014; Su & Yang, 2024), for which the level obtained was low-medium (Basilotta et al., 2022; Cabero-Almenara et al., 2021; García-Vandewalle et al., 2023).

Other studies reveal differences in ICT skills in accordance with students' gender and age. Some authors, for example, found that men scored higher than women for DC and were more able to gather information by technological means (Cabanillas García et al., 2020; Garbada-Méndez et al., 2023; Su & Yang, 2024), whereas others, including López-Belmonte et al. (2019), found that women were more competent in the fields of communication and collaboration. Studies focusing on age have found generational differences in ICT proficiency, with young students being more able to use technology than their older counterparts, mainly because they are accustomed to using it frequently for their own personal communications and leisure (Cabero-Almenara et al., 2021; Esteve et al., 2020).

Another emerging avenue of research focuses on exploring and describing the digital capacities of students on Teacher Training Master's degrees for compulsory secondary education, further education (A-levels or Spanish Baccalaureate), vocational training and language teaching (from here on TTM students). In this field, although Cornejo-Valdivia et al. (2024) found that future secondary school teachers had an intermediate- high or advanced level of DC, most other initial studies report TTM students having a medium-low general DC level (García-Delgado et al., 2024), particularly in more specialist ICT activities such as generating codes in nEtiqueta or content creation (Napal et al., 2018). Some authors report differences in accordance with sociodemographic aspects such as gender (Pérez-Navío et al., 2021), age and university access pathway (Marín-Suelves et al., 2022). In this context, it should be mentioned that one study found differences in DC development in accordance with knowledge area. Specifically, in a longitudinal study with 485 TTM students, Jiménez-Hernández et al. (2020) found that those from the field of architecture or engineering had higher DC levels. However, the authors also acknowledge that this question has received very little attention to date and state that universities, which have different specialist areas within TTM and students with a wide range of academic-personal characteristics and diverse digital skills, should take it into consideration as part of their effort to promote fair and inclusive education that guarantees comprehensive training designed to enable students to participate effectively in our ever-changing digitalised world.

The present study therefore aims to analyse the DC of a sample of TTM students and to identify the sociodemographic and academic factors that may affect it. To fulfil this aim, several research questions were posed, linked to a number of different specific objectives:

1. What DC level do TTM students achieve in the Questionnaire for Studying the Digital Competence of Higher Education Students (CDAES)?

    1.1. To analyse participants' general self-perceived level of DC according to the CDAES scale.

    1.2. To analyse participant's self-perceived level of competence in the different dimensions and sub-dimensions of the CDAES scale.

2. Does DC differ in accordance with gender, age or specialist area?

    2.1. To study and compare participants' general and dimension-specific levels of DC in accordance with gender.

    2.2. To study and compare participants' general and dimension-specific levels of DC in accordance with age.

    2.3. To study and compare participants' general and dimension-specific levels of DC in accordance with their specialist knowledge area.

2. Method

To achieve the aforementioned aims, the present study follows a quantitative, exploratory, descriptive, comparative and correlational design.

2.1. Participants

Participants were recruited using a non-probabilistic sampling method. The sample comprised 154 students (from a total cohort of 182) enrolled on a face-to-face Teacher Training Master's degree for compulsory secondary education, further education (A-levels or Spanish Baccalaureate), vocational training and language teaching at a Spanish university. In terms of specialist knowledge area, 27 were from Educational Guidance, 41 from Social Science, 41 from Technology and 45 from Natural Science. Finally, 51.3% were men, 47.4% women and 1.3% chose the 'other' option (M= 26.91; SD= 6.39).

2.2. Instruments/Materials

Data were collected using an instrument containing a battery of sociodemographic questions (about gender, age, etc.), along with a scale for measuring self-perceived levels of the dependent variable (in this case, DC): the Questionnaire for Studying the Digital Competence of Higher Education Students (CDAES), validated and standardised for future teachers by Gutiérrez-Castillo et al. (2017). The questionnaire contains 44 items (rated on a Likert-type scale ranging from 1-10) and has been found to have adequate internal consistency (α= 0.966). It measures six areas of DC: (1) Digital Literacy (effective use and application of ICT): 'I can use different digital image, audio and video processing tools'; (2) Information Search and Processing (ability to find, analyse, assess and communicate information using ICT): 'I can organise, analyse and make ethical use of information from a variety of different sources and media'; (3) Critical Thinking (defining, planning, developing and managing projects using digital resources): 'I can identify and define problems and/or research questions using ICT'; (4) Communication and Collaboration (ability to collaborate and interact online): 'I can coordinate group activities using online tools and resources'; (5) Digital Citizenship (ethical, safe and responsible use of digital resources): 'I display leadership skills for digital citizenship within my group'; and (6) Creativity and Innovation (use of innovative tools to modify and improve existing knowledge): 'I develop materials in which I use ICT creatively, supporting the construction of my own knowledge'.

As in other studies carried out in the same field (Gutiérrez-Castillo et al., 2017; Romero-Tena et al., 2020, 2021), the reliability analysis of the questionnaire revealed good internal consistency, both at a general level (α = 0.954; Ω = 0.953), and for each dimension.

2.3. Procedure

A detailed description of the project (aims, method, etc.) was submitted to the programme leader for approval by the Academic Commission (AC) and help arranging the data collection with the lecturers teaching on the Master's degree. As one of the reasons for accepting the proposal, the AC highlighted the need to carry out a diagnostic study of students' DC in order to find a way of improving the syllabus for future academic years.

We then contacted the lecturers teaching in the different specialist areas, who recommended that the data be collected face-to-face rather than remotely, given the low level of student participation in recent studies. Lecturers who agreed to collaborate set aside 10 minutes in one of their classes to enable students to fill out an online questionnaire using Microsoft Forms, which they accessed using a QR code. Participation was anonymous and voluntary as stipulated in the informed consent form all participants were asked to complete beforehand, and no financial compensation was offered. The entire process was approved by the University of the Basque Country's Ethics Committee (CEISH) (Code: M10_2023_178).

2.4. Data analysis

Once the data had been obtained, they were processed and cleansed before being used to conduct the statistical analyses using SPSS (v. 28). The same software package was used to carry out the univariate descriptive analyses, reliability analyses and correlational analyses (Pearson). After the Kolmogorov-Smirnov test had determined that the data followed a normal distribution ($p \geq .05$), comparative analyses were conducted using parametric tests (Student's t and analysis of variance - ANOVA). We also calculated effect sizes using the Cohen's d and eta squared (η2) indexes, applying the criteria established by Camacho (n.d.): $d = 0.20$ and $\eta^2 = 0.01$ indicate a small effect size, $d = 0.50$ and $\eta^2 = 0.06$ indicate a medium effect size and $d = 0.80$ and $\eta^2 = 0.14$ indicate a large effect size.

3. Results

3.1. General results on the CDAES scale, by dimension

To respond to the first research question and its specific aims, descriptive analyses were conducted. The results revealed that, in general terms, participants had a medium-low level of DC in the different skills assessed by the CDAES. Specifically, the scores obtained revealed that the dimensions in which participants were most proficient were 'Digital Literacy' ($\bar{X}$= 7.26; SD= 1.31) and 'Information search and processing' ($\bar{X}$= 7.05; SD= 1.25), in which, according to the categorisation system proposed by Romero-Tena et al. (2020), most attained 'integrator' level. However, in all other areas, participants' self-perceived DC was lower, more akin to 'explorer' level, particularly in relation to 'Creativity and Innovation' ($\bar{X}$= 6.61; SD= 1.77) and 'Critical Thinking' ($\bar{X}$= 6.53; SD= 1.63), where the means were considerably lower (Figure 1).

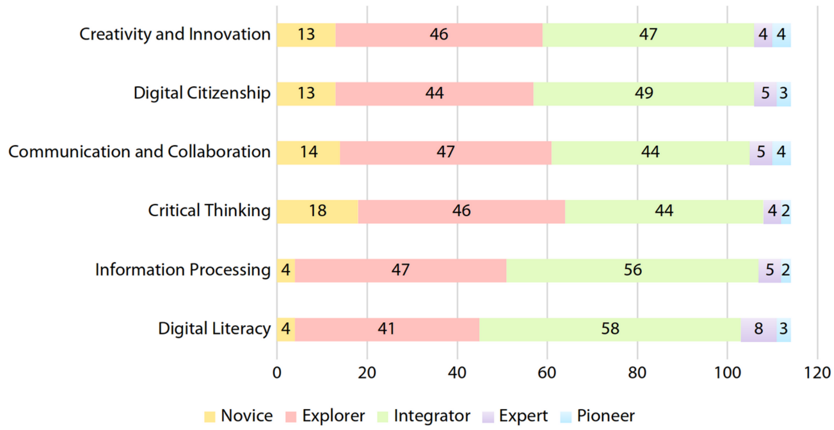

Figure 1. Self-perceived competence level in each dimension of DC.

A more specific analysis of the different sub-areas revealed that the activities in which participants considered themselves most competent involved basic tasks carried out as part of their everyday lives, such as using ICT systems (Area 1.1.: $\bar{X}$= 7.96; SD= 1.44), using learning management systems (Area 1.4.: $\bar{X}$= 7.97; SD= 1.59), participating in or coordinating online groups (Area 4.4.: $\bar{X}$= 7.83; SD = 1.79), planning strategies for conducting a study (Area 2.1.: $\bar{X}$= 8.38; SD= 1.20) and assessing and selecting appropriate information sources (Area 2.3.: $\bar{X}$= 7.96; SD= 1.30). In all these areas, their self-perceived level was that of 'integrator'. However, they had serious difficulties and an 'explorer' level in more complex and less common tasks, such as data processing (Area 2.4.: $\bar{X}$= 5.97; SD= 1.78), configuring software and hardware in order to resolve virtual problems (Area 3.4.: $\bar{X}$= 5.18; SD= 2.55) and using ICT models to create and develop digital material (Area 6.3.: $\bar{X}$= 5.84; SD= 2.22).

3.2. DC by gender

To respond to specific aim 2.1., a means comparison was carried out between men and women using Student's t test. The group who selected the 'other' option in response to the gender question were not included in the analyses due to the small size of this sub-sample. The results are presented in Table 1.

Table 1. Means, standard deviations and analyses of variance (ANOVAs), by gender.

Gender	Descriptive statistics		Comparison			
	Men M(SD)	**Women M(SD)**	***Dif***	$t_{(110)}$	***p***	***d***
Digital Literacy	7.33(1.39)	7.13(1.22)	0.20	.831	.408	---
Information Processing	6.78(1.25)	7.30(1.27)	-0.52	-2.226	.028	0.41
Critical Thinking	6.51(1.63)	6.46(1.61)	0.51	.167	.868	---
Communication and Collaboration	6.80(1.65)	6.54(1.56)	0.26	.847	.399	---
Digital Citizenship	6.72(1.69)	6.91(1.50)	-0.19	-.622	.535	---
Creativity and Innovation	6.73(1.74)	6.38(1.76)	0.35	1.069	.287	---

Note: Men (n= 79) and Women (n= 73). M(SD): Mean and Standard Deviation.

Men scored higher than women for 'Digital Literacy' (p= .408), 'Communication and Collaboration' (p= .399) and 'Creativity and Innovation' (p= .287), although the differences were not significant. For their part, women scored higher than men for 'Digital Citizenship' (p= .535) and, particularly 'Information Search and Processing' (p= .028; d= .41), with a medium effect size.

At the same time, an analysis of the specific digital skills reported by men and women revealed that men see themselves as more proficient in tasks linked to research and problem solving using online resources (Area 1.3.: p= .009; d= .50), as well as in using ICT to explore alternative solutions (Area 3.4.: p= .009; d= .50), with the results indicating explorer level in these areas. For their part, women see themselves as more competent in activities that require them to process data and communicate the results (Area 2.4.: p= .006; d= .53) (explorer level), as well as in planning activities online (Area 3.2.: p= .034; d= .40), in which area they attained 'integrator' level. The effect size of the differences between the two groups was medium-large.

3.3. DC by age

To respond to specific aim 2.2., i.e., to explore differences in DC in accordance with age, a bivariate Pearson correlation analysis was conducted. In addition to confirming the close relationship that exists between the different dimensions of DC ($p < .01$), this analysis also revealed that DC decreased with age, particularly in areas such as 'Communication and Collaboration' ($r = -.289^{**}$) and 'Digital Citizenship' ($r = -.263^{**}$). In other words, the older the participant, the poorer their ability to use digital resources and platforms to interact or work as part of a team, the less positive their attitude and the scarcer their knowledge of how to use ICT ethically and responsibly.

3.4. DC by specialist knowledge area

To respond to specific aim 2.3., i.e., to explore differences in DC in accordance with specialist knowledge area, another analysis of variance (ANOVA) was conducted. The results are presented in Table 2 and Figure 2.

The results reveal that students from degrees associated with Natural Science and Technology had a higher level of DC, attaining 'integrator' level in various sub-dimensions. In contrast, those from degrees associated with Social Science had the lowest level of DC, attaining only 'explorer' level in all dimensions of DC.

Table 2. Means, standard deviations and differences by specialist knowledge area.

	Descriptivos				Comparación		
Género	**Orientación M(SD)**	**Sociales M(SD)**	**Tecno M(SD)**	**Naturales M(SD)**	**F(gl)**	**p**	**η^2**
Digital Literacy	7.11(1.05)	6.92(1.32)	7.65(1.60)	7.30(1.10)	1,692(3)	.173	---
Information Processing	7.08(1.37)	6.87(1.12)	6.97(1.51)	7.26(1.07)	0,570(3)	.636	---
Critical Thinking	6.74(1.45)	5.76(1,64)	6.70(1.74)	6.95(1.44)	3,529(3)	.017	.088
Communication and Collaboration	6.56(1.31)	6.20(1.63)	7.15(1.80)	6.87(1.51)	1,980 (3)	.121	---
Digital Citizenship	6.93(1.11)	6.37(1.66)	6.61(1.87)	7.34(1.32)	2,418(3)	.070	---
Creativity and Innovation	6.77(1.77)	5.65(1.93)	6.95(1.58)	7.09(1.49)	4,760(3)	.004	.115

In general, it is important to note that, as shown by the eta squared indexes, no significant differences between knowledge areas were observed in the different dimensions, with the exception of 'Critical Thinking' ($p = .017$; $\eta^2 = .088$) and 'Creativity and Innovation' ($p = .004$; $\eta^2 = .115$), in which the effect size of the differences was large.

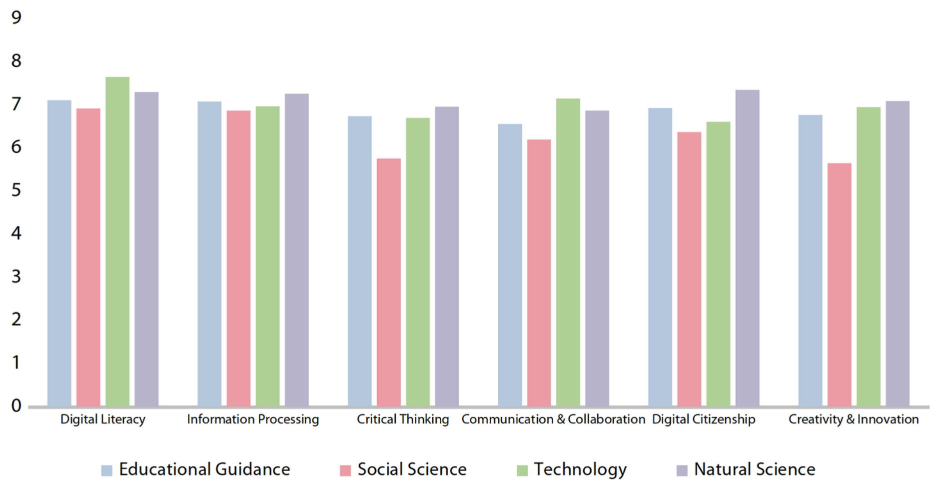

Figure 2. Visual comparison of DC by specialist knowledge area.

In both these dimensions, those from Natural Science degrees scored higher than the others; in the 'Critical Thinking' dimension, the difference in comparison to Social Science students (p= .002; d= 0.78) had a medium-large effect size, and in 'Creativity and Innovation', Natural Science students were the only ones to achieve 'integrator' level. For their part, students from Technology degrees scored highest for 'Digital Literacy' and, above all, 'Communication and Collaboration'. Indeed, this was the only group that perceived themselves as 'integrators' in this last dimension, with significant differences being observed between them and the Social Science group, with a medium effect size (p= .034; d= 0.50). The greatest differences between students from Natural Science and Technology degrees were observed in 'Digital Citizenship', in which the former perceived themselves as 'integrators' and the latter as 'explorers', even though the differences failed to reach significance level (p= .066).

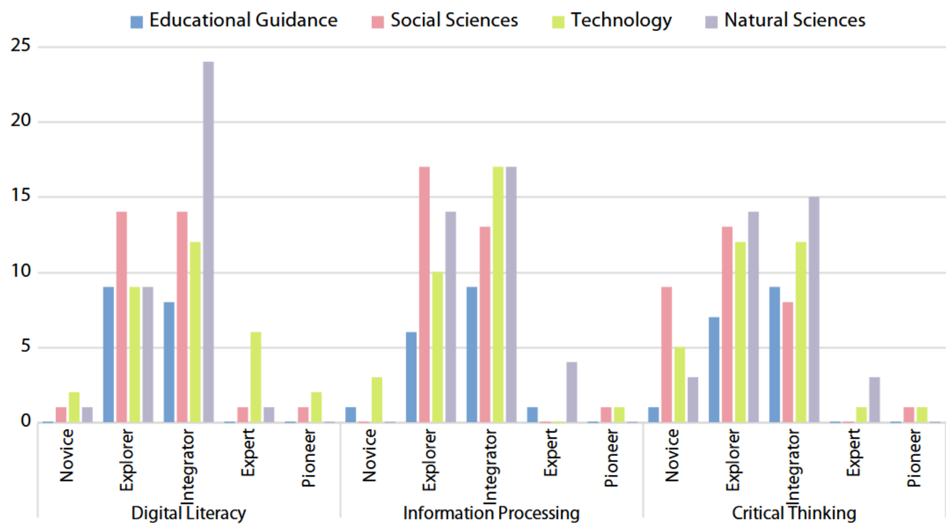

Figure 3. Competence level in the first three dimensions, in accordance with specialist area.

Competence levels are shown in Figures 3 and 4, which reveal that most participants, regardless of their specialist area, attained an intermediate level (explorer or integrator). The figures also show that, in general, students from the Technology and Natural Science areas were represented most at the higher levels and that (with a few exceptions) those from Social Science were represented most at the lower levels.

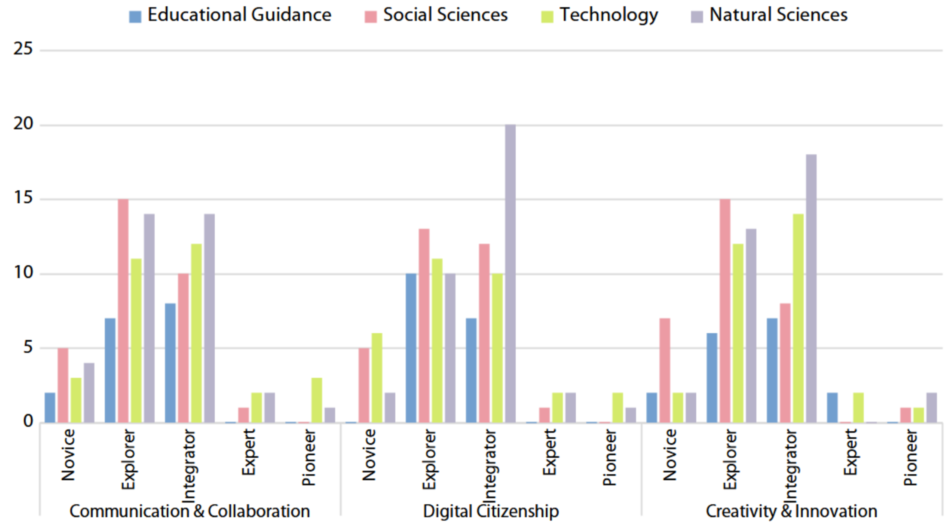

Figure 4. Competence level in the last three dimensions, in accordance with specialist area.

4. Discussion

There is broad consensus in the literature regarding the fact that, alongside critical thinking, flexibility and collaboration (García-Correa et al., 2022), DC constitutes one of the most basic skills that citizens living in this 'digitalised' century must acquire in order to participate in society, engage in lifelong learning and progress in their lives (Gabarda-Méndez et al., 2020; European Commission, 2022). In this context, in which the Spanish government has recently made a commitment to Europe to train teachers in DC (Omedes, 2022) in order to guarantee interactive and motivating learning processes that foster students' active engagement in the classroom and lead to meaningful learning (Recio-Muñoz et al., 2020), many diagnostic studies have been carried out (Basillota et al., 2022), similar to the one presented here.

The present study had several different aims that can be summed up as follows: to determine the level of a group of Master's degree students in the different dimensions and sub-dimensions of DC, using the CDAES, and to describe and analyse differences in accordance with gender, age and specialist knowledge area.

In relation to the first aim, the results reveal that trainee teachers have a basic-intermediate level of DC, also referred to as 'explorer' level, although they sometimes attain 'integrator' level. These findings are similar to those reported by García-Delgado et al. (2024) with a sample of Pre-school and Primary Education undergraduates, as well as to those presented by authors who, despite not establishing specific competence levels, nevertheless highlight the fact that future teachers currently have a medium-low level of DC that is significantly below the threshold established by European governments (Andía et al., 2020; Cabero-Almenara et al., 2021, XXX, 2024). In other words, the findings confirm the existence of a notable gap between the training received and the expectations and demands of 21st century society (Marín-Suelves et al., 2022).

The best results were attained in the 'Digital Literacy' and 'Information Search and Processing' dimensions of DC. In contrast to that found in previous studies (Marín-Suelves et al., 2022; Pozo-Sánchez et al., 2020), our results did not indicate that the 'Communication and Collaboration' dimension was the one in which students scored highest. Indeed, our findings suggest that students (or future teachers) have significant gaps in their knowledge of how to engage in digital activities linked to interaction (Su & Yang, 2024). Consistently with previous studies, however, our results do support the idea that although participants use ICT, they do so only at a very basic or traditional level, and fail to take full advantage of all the possibilities it offers (García-Vandewalle et al., 2023; Jiménez-Hernández et al., 2020; Pérez-Navío et al., 2021). In other words, their DC is higher in activities such as searching for information, using learning management systems like Moodle, and managing programs designed to create presentations or organise content (García-Varcárcel & Martín del Pozo, 2016), but significantly lower in other areas such as 'Digital Content Creation', 'Problem Solving' (Jiménez-Hernández et al., 2020; Pozo-Sánchez et al., 2020) and 'Creative Use of ICT' (Aguilar et al., 2021).

In relation to the second aim, the different comparisons carried out in accordance with gender, age and specialist knowledge area returned varying results.

In terms of gender, in contrast to that reported by Jiménez-Hernández et al. (2020), our results fail to indicate any gender gap in favour of men. However, similarly to that observed by Pérez-Navío et al. (2021) in a sample of Teacher Training Master's (TTM) students, our results did indicate that men were more able to make effective use of ICT in different digitalised contexts, whereas women were more proficient at using digital resources to search for or process information for publication. We also found that men see themselves as being more proficient at using ICT creatively and innovatively to explore alternative solutions to problems, possibly due to the fact that they generally express more interest in this field (Siddiq & Scherer, 2019). Furthermore, in contrast to that reported by López-Belmonte et al. (2019), the men in our sample scored higher than their female counterparts for communication and collaboration. It is important to note, however, that none of these differences reached statistical significance (Marín Suelves et al., 2022).

In terms of age, our results are consistent with those reported by other studies that detected significant generational differences in the use of ICT in all dimensions of CD. In other words, our results confirm that older individuals have more difficulties in this field than their younger counterparts (Cabero-Almenara et al., 2021; Esteve et al., 2020). However, it is important to note that, in the present study, this trend was only found to be significant in the 'Communication and Collaboration' and 'Digital Citizenship' dimensions of DC.

Significant differences were found in the development of CD in accordance with the specialist knowledge area from which participants came (Cabero-Almenara et al., 2021). Consistently with that reported by Jiménez-Hernández et al. (2020), the group that came from Social Science had the lowest level of DC, whereas those who came from Technology had the highest. However, unlike the aforementioned authors, we also found that participants from Natural Science degrees also saw themselves as being more proficient in terms of DC. This is one of the novel findings of the present study. However, the differences observed between the groups, even in relation to those who came from the field of Educational Guidance, were not particularly large, suggesting that the education system trains all students in a similar manner. One finding that was particularly striking was the fact that this last group (from the field of Educational Guidance) had an acceptable level of DC in dimensions such as 'Critical Thinking' and 'Creativity and Innovation', in which students generally tend to score lower (Andía et al., 2020; Røkenes & Krumsvik, 2014). Given that many of these people come from different degrees in the general field of Education, in which a concerted effort is made to develop students' capacity for critical, innovative and creative thinking (Varías & Callao, 2022), it may be that the training they received on their undergraduate degree is responsible for their scores in these dimensions.

5. Conclusions

The results of the present study enable us to conclude that the DC of future teachers could be improved, since most participants attained only 'explorer' level. Given that teacher training has a direct impact on teaching quality, it is essential to focus more on the different dimensions of DC in order to ensure that trainee teachers feel capable and confident about integrating and using ICT in the classroom.

Bearing in mind the importance of the topic under study and the scarcity of research to date focusing on TTM students, the present study constitutes an important step forward for both the field in general and the institution in which it was carried out in particular. Although further research is required to ensure a more accurate diagnosis of the situation and to validate and generalise the preliminary results presented here, our findings provide important insights that will help inform the design of the specific strategies for fostering DC that need to be included in university teacher training syllabuses and adapted to each area of specialist knowledge. Although we currently have good instruments for diagnosing the DC of (future) teachers, there is still a need to design standardised strategies for fostering the acquisition of DC among university students, or perhaps even an official qualification earned by completing a dedicated subject taught across multiple academic years and specialist areas.

The present study has a series of limitations that should be taken into consideration in future research, given that they prevent the results from being generalised due to issues linked to the size of the sample and the methodology used. The first is that the groups were formed by a maximum of 35 people who participated voluntarily with no inclusion criteria being established beyond being a student on a TTM in one of the specialist areas to which we had access, a circumstance that may have influenced the results. In this sense, future studies should strive to recruit larger and more representative samples that encompass other specialist areas and types of TTM, in order to explore any differences or similarities that may exist in terms of DC. Another important limitation is linked to the type of instrument used to measure CD, which was based on participants' self-perceptions. These types of self-report instruments do not generally provide a comprehensive picture of the true situation, but rather reflect each respondent's subjective perception, which may, on occasions, be influenced by social desirability bias (Alcaraz et al., 2006). Although we tried to reduce the effect of this lack of objectivity by taking the means for the different sub-areas into account, future studies may wish to collect data using techniques that assess participants' real DC and compare it with their self-perceived level, as in the study by Gabarda-Méndez et al. (2017). In terms of exploring different means of improving DC in this context, quantitative methodologies offer only a limited view. Future studies may therefore wish to use a qualitative or mixed methodology to analyse the situation in greater depth, including the specificities of each area and the factors that affect their development, in order to provide a more efficient and defective response.

Despite the limitations outlined above, our results confirm the need for continued research in this field. Future studies may wish to explore the differential educational practices that are fostered in each degree course and have an impact on improving DC, as a first step towards designing innovative educational strategies specifically adapted to the demands of today's digital society. Researchers may also wish to conduct comparative studies that focus on different university access pathways or other variables associated with learning, such as motivation, satisfaction, autonomy and academic performance, none of which have received much attention to date in the literature.

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