Teacher Digital Competence in the education levels of Compulsory Education according to DigCompEdu: The impact of demographic predictors on its development.

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Abstract. New educational trends mediated by technology require the development of Teacher Digital Competence (TDC). These have been regulated by competence frameworks, such as DigCompEdu. The aim of the study is to determine and compare the level of self-perception of digital competence among teachers of the different stages of compulsory education (Early Childhood, Primary and Secondary Education) as a function of gender, considering different age ranges, years of teaching experience and hours of permanent education. This study also analysed how different predictors influence each other in the acquisition of TDC. To this end, an ex post facto non-experimental design is used with 78,966 teachers from Andalusia (Spain). The results show that the diagnosed level is low-medium and that the analysed variables had significant impact and prediction levels. Consequently, the casuistry of this phenomenon is discussed, concluding that it is necessary to develop personalised training programmes for teachers.

Keywords: Digital competence, compulsory education teachers, DigCompEdu, teacher training.

1 Introduction

Technology, as a fundamental ingredient for the advance of Knowledge Society, has acquired a crucial role in the scope of education. In this line, the importance of teacher competence in Information and Communication Technologies (ICTs) for their correct and effective incorporation in the classroom has become essential. The term Teacher Digital Competence (TDC) refers to the set of knowledge, abilities and/or skills in digital technologies of the teaching profession that help to solve the different professional and/or pedagogical problems [1]. The aim of TDC, as was highlighted by [2], is that the teacher acquires these competences to favour the development of the student competences. Moreover, as was pointed out by [3], there is a relationship between the didactic strategies applied by teachers and their level of TDC.

TDC has become a significant research line in the last years, according to the increase in the number of scientific studies published in academic journals and monographs exclusively dedicated to this topic [4, 5, 6, 7]. This fact explains, among other reasons, why the increasing implementation of plans to diagnose TDC [8, 9]. Therefore, it is necessary to establish training actions in the pedagogical-didactic and technological-instrumental aspect [10], since the self-perception of teachers toward their efficacy regarding their teaching competence is a variable that determines the use they make of technologies in their educational action. The commented aspects (definition, diagnosis and accreditation of DTC) require the analysis of this competence, since its low level results in a poor and unqualified educational use of ICTs by the teacher, and its high level has a positive influence on other competences that teachers must acquire for their professional development [11].

In relation to these TDCs, different frameworks have been published [12, 13], among which the European Framework of Teacher Digital Competence DigCompEdu is the most consolidated one in different education levels and in different countries and continents [14, 15]. The DigCompEdu model is organised around three macro-areas (professional, pedagogical and student digital competences), which comprise 6 different competence areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners´ digital competence (Figure 1).

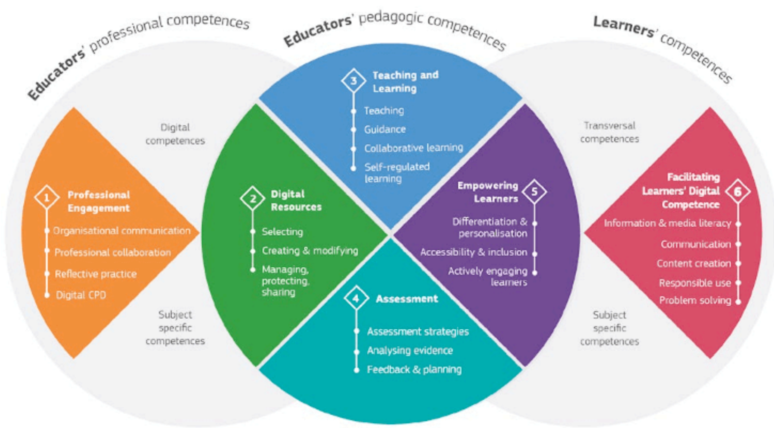

Fig. 1. Structure of DigCompEdu. Source: JRC

These areas are summarised into dimensions (DIM): (DIM. A) Professional commitment, which is focused on communication and collaboration with the rest of the educational agents involved in the educational process; (DIM. B) Digital resources, which is focused on the selection, creation, modification and management of ICTs, considering the protection of personal data, as well as the author's rights to use, modify or publish some digital resource; (DIM. C) Teaching and learning, which is related to the planning, design and organisation of ICTs and their subsequent implementation in the classroom; (DIM. D) Evaluation and feedback, which is focused on the use of ICTs to improve the teaching-learning processes with new or improved evaluation methods; (DIM. E) Student empowerment, which is aimed at creating digital activities and experiences that address the needs of the teaching-learning process, influencing the empowerment of the students; and (DIM. F) Facilitating digital competence to the students, which is focused on helping teachers to foster the development of digital competence in their students, teaching them both the risks of use and the safe and critical responsibility that the user must have.

Although the use of ICTs has proved beneficial in the teaching-learning process of students, some studies show that certain teachers barely include ICTs in their daily teaching practice [16], or they only use them in basic actions due to their low digital competence [17,18, 19]. The fact that a teacher has a basic digital competence does not entail that he/she has the knowledge, skills and attitudes required to be a teacher in the 21st century, like to integrate digital technologies into the day-to-day of the teaching profession [15]. The need or no need of having this competence leads the authors of this study to wonder whether teachers are qualified to respond to the needs of the so-called "knowledge society". Based on this reflection, what is the general and specific level of TDC of teachers of Early Childhood, Primary and Secondary Education? Are gender, age and educational stage determining and/or predictive variables of the level of TDC?

1.1 Associated works: variables that influence teacher digital competence

In the case of the variable "gender", some studies show that there are statistically significant differences in digital competence between women and men. [20], who explored the perceptions of 281 Primary Education teachers from all over Spain, reported that the males had lower competences than the females in the use of webs and blogs, with the latter stating that they undertook more training courses in this respect. However, other studies demonstrate that gender is an important predictor of TDC, in favour of males [21, 22, 23, 24, 25, 26]. These two contradicting results do not clarify the impact of this predictor, since other studies have also observed that it is not a significant factor in this competence [27, 28] or that it depends on the analysed technological dimension. For instance, [29], in a sample of 115 Secondary Education teachers, showed that there were no significant differences as a function of gender in digital competences when using digital resources and applications, although they did find significant differences in the use of technological devices. These findings are also in line with those of [30], who, in a sample of 520 Spanish teachers from Early Childhood, Primary and Secondary Education, reported that the female teachers had a higher level of digital competence than the male teachers in the creation of digital content, whereas the males had a greater competence level in problem solving.Among the latest studies carried out, [31] found that there were no significant differences between the female and male gender regarding their basic skills in the use of the computer, among the teachers of the stages of Early Childhood Education, Primary Education and Secondary Education. These results were also similar in recent studies, finding no differences regarding gender, in the use of digital applications by teachers [19].

Regarding age, [1] state that the students of teachers with experience in the use of ICTs obtain significantly better marks, which demonstrates the fundamental value of the digital competence of teachers in the learning process. The literature shows that there is an inversely proportional relationship in terms of age and TDC level [21, 29, 32]. This could be due to the fact that younger teachers are more used to interacting with digital media from younger ages [33] and have received more digital training [34] in their personal and/or professional lives. This digital divide can be a direct consequence of the recent changes made around the promotion of this competence in the curricula of the Education degrees, given the obvious importance of this competence in future teacher training [7]. However, other authors have drawn opposing conclusions, stating that teachers with fewer years of teaching experience have poorer digital competence [17, 35]. The results are practically in line with age, since, in most cases, the younger teachers have fewer years of teaching experience; therefore, the younger teachers, both in age and professionally, are those with lower digital competence.

Furthermore, an adequate teacher digital competence in a pedagogical context is not guaranteed with initial teacher training alone, since teachers must continue their training within their own professional practice [36], as a requirement of social development, in line with the advances in humanity and the needs of society. That is, teacher training requires continuous professional development to improve their digital competences, since ICT resources are in constant evolution [37], and innovation programmes for teacher training have a significant impact on raising awareness about the pedagogy of ICTs and their subsequent integration in the classroom [38].

After this review on the state of the art, it is necessary to ask whether these predictors continue to have a significant influence when applying the DigCompEdu framework to teachers of all compulsory education stages (Early Childhood, Primary and Secondary Education) [39, 40]. In this context, the contribution of this study is linked to the large sample gathered for this work (n=78,966), which allows generalising the results in a more significant manner in the specific research context of compulsory education in Andalusia (Spain). Moreover, these results are in line with the objectives proposed by the European Commission's Skills Agenda for Europe and the 2020 European Strategy Initiative "an agenda for new skills and jobs" [41], since they can be used as reference in regional and national programmes [42] for the digital transformation of educational centres, thus facilitating the consensual creation of a European Education Area.

In view of this situation, and based on the research questions proposed, the following specific objectives were set for this study:

- O1. To determine the level of self-perception of digital competence in teachers of the different compulsory education stages (Early Childhood, Primary and Secondary Education) as a function of gender.
- O2. To comparatively analyse the existence of significant differences in the level of digital competence based on the gender of the teachers, for each internal category of the analysed variables (age, years of teaching experience and hours of permanent education).
- O3. To analyse the existence of significant differences in the competence level of the teachers between the internal categories of the analysed variables (age, years of teaching experience and hours of permanent education), for each gender separately.
- O4. To predict the teacher digital competence level as a function of the relationship of different covariables (described in the previous objectives).

2 Methodology

2.1 Design and participants

To carry out this study, a non-experimental, questionnaire-based design was used. Once the data were collected, inferential and descriptive analyses were carried out to attain the objectives of the study. The participants were recruited by non-probabilistic purposeful sampling. This sampling has been used by having all the people who have participated in the study to ensure the largest sample size. Purposive sampling allows researchers to select available and accessible participants, which can facilitate data collection in situations where it would be difficult using other methods.

Of a total population of 98,091 teachers who work in the non-university Educational System of Andalusia, the sample was constituted by 78,966 teachers teachers of Early Childhood, Primary and Secondary Education from the autonomous community of Andalusia (Spain) who taught in the academic year 2021/2022. The sample size ensures a margin of error of 0.3%, with a confidence level of 99.99%.The data were gathered using a digital questionnaire, guaranteeing the privacy of the responses provided by the teachers, who were previously informed about the objectives of the study. 67.20% (n= 53,074) were women, with a mean age of 45.65 years, whereas 33.80% (n= 25,892) were men, with a mean age of 46.26 years. Regarding the academic profile, the teachers of Early Childhood Education represented 11.20% (n= 8,881) of the sample, with an average teaching experience of 8.38 years, whereas the teachers of Primary Education represented 34.60% (n= 27,310) of the sample, with an average teaching experience of 6.65 years and, lastly, the Secondary Education teachers represented 54.20% (n= 42,775) of the sample, with an average teaching experience of 6.07 years.

2.2 Instrument

With the aim of measuring the level of self-perception in digital competence, the instrument developed by [43] was used. This study analysed the content validity through expert judgment. Then, the validity and reliability of the instrument were determined. It is important to point out that the instrument consists of 22 items that respond to the analysis of the six competence areas of the DigCompEdu framework, which were previously described in the introduction of this article.

To measure the self-perception of the participants in this instrument, a 5-point Likert scale was used. The interpretation of each qualitative value of the scale was associated with the following progressive levels: teacher with little technological experience (A1); teacher with little interaction with educational technology, requiring external help to use it in the classroom (A2); teacher who experiments with ICTs adapting them to his/her educational context (B1); teacher who uses a broad range of ICTs with his/her students (B2); teacher who can both adapt ICTs to the needs of his/her students and motivate other teachers with great innovating and digital creativity (C1) and teachers who use technology creatively and are leaders and role models for other peers in the use of educational technology (C2).

The instrument had adequate psychometric properties. The validity was verified through an exploratory factor analysis (EFA), which was carried out using SPSS software v24 (IBM), and a confirmatory factor analysis (CFA), using AMOS software v24.

In the EFA, the principal components method was used for the selection of factors. The obtained factors were orthogonally rotated using the Varimax method with Kaiser normalisation. The Kaiser-Meyer-Olkin index was appropriate and significant (KM = 0.988) and the result of Barlett's Chi-squared test was significant ($p < 0.05$). The model proposed with the 6 latent factors and their 22 corresponding items explained 74.21% of the true variance of the participants' scores. The CFA showed adequate psychometric properties, as is recommended by [44]: CMIN (mean chi square < 500) = 397.126, p = <0.05; NFI (normed Fit Index > 0.7) = 0.942; GFI (Goodness of Fit Index > .7) = .969; PGFI (Parsimony Goodness of Fit Index, > .7) = .735; PNFI (Parsimony Normed Fit Index, > .7) = .749. Then, the coefficients of Composite Reliability (CR), Average Variance Extracted (AVE) and Maximum Shared Variance (MSV) were calculated. Table 1 shows the results of these analyses, as well as the reference values used for the fit of the model [45]. All the values obtained fit the reference values, demonstrating that this is a good model to measure the digital competences of the teachers.

Table 1. Convergent and discriminant validity of the model

DIM	CR	FIT	AVE	FIT	MSV	FIT
DIM. A	.739		.689		.559	
DIM. B	.758		.686		.546	
DIM. C	.815	CR > .7	.652	AVE > .5	.549	MSV < AVE
DIM. D	.813		.685		.429	
DIM. E	.789		.669		.568	
DIM. F	.829		.697		.412	

Lastly, the internal consistency was verified through Cronbach's alpha and McDonald's Omega. Table 2 presents each coefficient for the different dimensions of the instrument. As can be observed, the levels are very satisfactory, both in the dimensions of the instrument and globally.

Table 2. Reliability of the instrument

Dimensions	DIM. 1	DIM. 2	DIM. 3	DIM. 4	DIM. 5	DIM. 6	TOTAL
Cronbach's Alpha	.797	.869	.842	.806	.821	.895	.971
McDonald's Omega	.821	.813	.815	.812	.826	.901	.980

2.3 Data analysis procedure and techniques

The following aspects were considered in the statistical analyses:
firstly, a descriptive analysis of the participants' level of self-perception in digital competence was performed through measures of central tendency (mean). This was determined by classifying different variables: as a function of gender (male vs female), age range (under 39 years, 40-49 years, and 50 years and older), years of teaching experience (0-10 years, 11-20 years, and over 20 years), hours of permanent education understood as the set of training activities aimed at improving their scientific, technical, didactic and professional preparation (no training, 1-99 hours, 100-199 hours, and 200 hours or more), and, lastly, educational stage (Early Childhood, Primary and Secondary Education).

Then, with the aim of conducting a differential and comparative analysis, the normality of the data was verified in the total scores of the sample. The Kolmogorov-Smirnov test revealed that the assumption of normality was not met (KS= .024; df= 78,966; p= .001 < .05). However, [46] asserts that the non-normality does not have a serious effect on the distribution of the data in large samples (in our case, n= 78,966 teachers). Furthermore, the F statistic of the ANOVA conducted was robust, in terms of type I errors when the distributions have asymmetry and kurtosis values that vary between -1 and 1. This was verified and the assumption was met in all the items of the instrument. Therefore, the statistical analyses were carried out with parametric techniques. More specifically, a Student's t-test was used for independent samples to compare the results by gender and a univariate ANOVA was applied to compare the ranges.

Thirdly, in those cases in which statistically significant differences were found, the effect size was calculated. [47] interpreted the magnitude of the effect size for educational contexts according to Cohen's formula as follows: development effects (values under 0.1); teaching effects (values between 0.2 and 0.3); and zone of desired effects (values over 0.4). This can be observed in the Tables by the letter "ES" (effect size).

3 Results

3.1 Comparative and differential analysis

Tables 3, 4 and 5 show the participants' level of self-perception in digital competence for each educational stage, as a function of gender and for the three variables (age range, teaching experience range and range of hours of permanent education). In those cases in which there was a significant difference in terms of gender, the effect size was calculated. Moreover, for each educational stage, we verified the existence of significant differences in teacher digital competence between the ranges of the three variables analysed. In this case, the effect size is shown when there are significant differences between ranges.

As can be observed in Table 3, there were significant differences regarding gender in the three educational stages and for all age ranges. However, the level of competence is intermediate for both genders, considering the measurement scale (five points), with the teachers being between the discoverer and integrator levels.

Regarding the comparison between the age ranges, significant differences were observed in both genders and in all three educational stages, with small effect sizes, although these effect sizes decrease from the initial stages to the stage of Secondary Education; that is, the older the age range, the lower the competence level.

Table 3. Teacher digital competence based on teacher age.

	Early Childhood Ed			Primary Ed			Secondary Ed		
Age	Female	Male	ES	Female	Male	ES	Female	Male	*ES*
> 39	2.39	2.63	.48*	2.90	3.10	.35*	3.17	3.29	.21*
<=40>50	2.23	2.46	.48*	2.70	2.99	.49*	3.05	3.25	.31*
=<50	2.14	2.29	.32*	2.68	2.80	.27*	2.95	3.11	.25*
Comparison between age ranges (ES – Partial eta^2)	.033*	.028*		.046*	.031*		.020*	.012*	

* Significance level at 0.05; F= female; M= male; ES= effect size

Table 4 shows that there were significant differences according to gender in the three educational stages and for all ranges of teaching experience. It is also observed that the significance of these differences decreases between stages, with the smallest effect sizes being obtained by the Secondary Education teachers. For both genders, the competence level was intermediate (between the discoverer and integrator levels).

Regarding the comparison for teaching experience ranges, there were differences for each gender and educational stage, although these differences are very small. Specifically, there was no tendency in any direction with respect to teaching experience in any educational stage.

Table 4. Teacher digital competence according to the participants' teaching experience.

	Early Childhood Ed			Primary Ed			Secondary Ed		
Teaching experience	F	M	ES	F	M	ES	F	M	*ES*
0-10	2.26	2.48	.45*	2.74	2.99	.41*	3.07	3.22	.24*
11-20	2.19	2.28	.19*	2.63	2.91	.47*	2.99	3.18	.31*
21 or more	2.12	2.14	.32*	2.57	2.79	.37*	2.89	3.08	.30*
Comparison between teaching experience ranges (ES – Partial eta^2)	.010*	.020*		.10*	.10*		.10*	.003*	

* Significance level at 0.05; F= female; M= male; ES= effect size

Table 5 shows that not all ranges and educational stages obtained significant differences in terms of gender. In the stage of Early Childhood Education, it was observed that there are significant differences only in the ranges in which the teachers had fewer or no hours of training. In the case of Primary and Secondary Education, significant differences were not found only in the group of teachers with over 200 hours of teaching training. Globally, the greatest level of digital competence was obtained by the teachers of Secondary Education (for both genders), between the integrator and expert levels. With respect to the comparison by ranges of training hours, the larger the number of training hours, the greater the differences between men and women, up to the range of 200 hours of training, in which there were no differences.

Table 5. Teacher digital competence according to the hours of permanent education of the participants.

	Early Childhood Ed			Primary Ed			Secondary Ed		
Hours of permanent education	F	M	ES	F	M	ES	F	M	*ES*
None	2.20	2.31	.26*	2.68	2.86	.30*	2.96	3.09	*.21**
1-99	2.44	2.47	.49*	2.72	3.00	.47*	3.08	3.26	.28*
100-199	2.56	2.57	-	2.97	3.32	.54*	3.34	3.56	.35*
200+	3.89	4.04	-	3.23	3.49	-	3.66	3.67	-
Comparison between ranges of training hours (ES – Partial eta^2)	.015*	.033		.001	.022		.022	.027	

* Significance level at 0.05; F= female; M= male; ES= effect size

3.2 Results of classification techniques (trees) for each educational stage

Up to this point, the obtained results have shown that there are significant differences in the level of total teacher digital competence for the three educational stages analysed. This was verified as a function of age range, teaching experience range and range of permanent education hours. However, it is also important to determine the order in which these significant predictors affect teacher digital competence, and whether they are related to each other in the acquisition of greater success rate (probability) regarding the level of digital competence. Classification tree analysis is the ideal method to answer this question and, consequently, to respond to Objective 3. Considering that the participants belonged to three different educational stages, three trees were extracted.

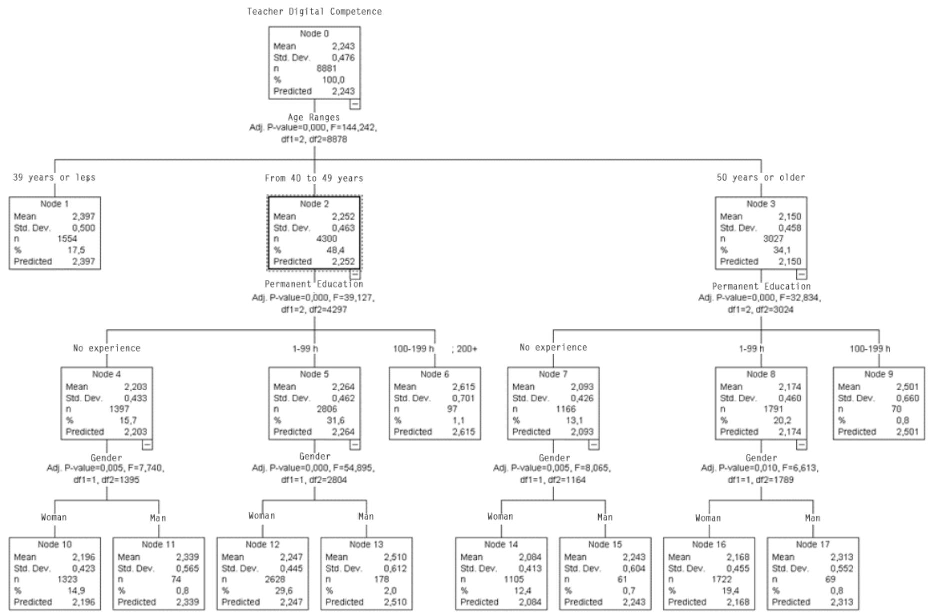

Fig. 2. Classification tree for the Early Childhood Education teachers.

The tree presented in Figure 2 shows the global competence level of the Early Childhood teachers (node 0, M= 2.24 ± 0.48), between the discoverer and integrator levels. As can be observed, the direct predictor of digital competence is the age of the teacher. In those teachers aged between 40 and 49 years, the competence level is low (node 5, M=2.25 ± 0.46), and both the number of permanent education hours and gender can have a negative effect on it. For instance, for the teachers in this age range and without permanent education, the competence level is low (node 4, M= 2.20 ± 2.20), and even lower for the female teachers (node 10, M= 2.19 ± 2.19). However, the male teachers in this age range with 1-100 hours of permanent education have a higher competence level (node 13, M= 2.51 ± 2.51), and those with over 100 hours of permanent education have an even higher competence level (node 6, M= 2.62 ± 2.62). In regard with the teachers aged 50 years and older, the competence level varies considerably as a function of these variables. For example, it was observed that, in this age group, those teachers without permanent education have a low competence level (node 7, M= 2.09 ± 2.09), with female teachers showing an even lower level (node 14, M= 2.08 ± 2.08) with respect to the male teachers (node 15, M= 2.24 ± 2.24). In positive terms, the highest competence level in this age range was obtained by those with over 100 hours of permanent education (node 9, M= 2.50 ± 2.50).

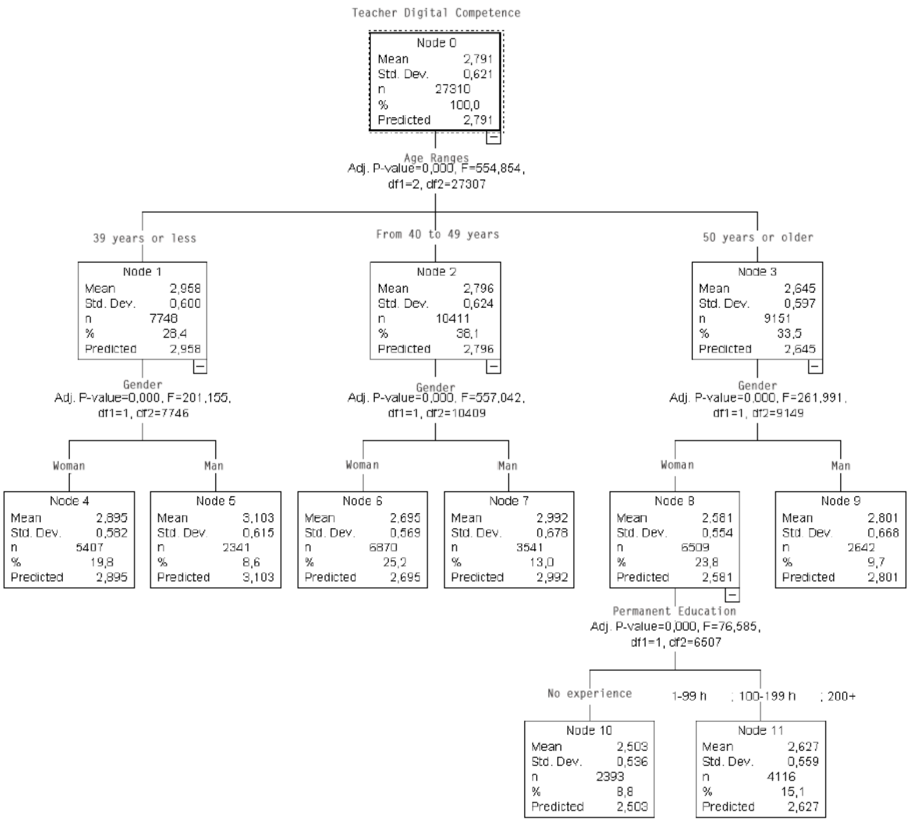

Fig. 3. Classification tree for the Primary Education teachers.

The tree presented in Figure 3 shows the global competence level of the Primary Education teachers (node 0, M= 2.79 ± 0.62), between the discoverer and integrator levels. According to this tree, the teachers aged 39 years and younger obtained a higher competence level (node 1, M= 2.96 ± 0.60) compared to the rest of the age groups. Moreover, regarding gender, for this age range, the male teachers showed a higher competence level (node 5, M= 3.10 ± 0.62). Similarly, for the teachers aged 40-49 years, gender has an impact on the acquisition of digital competence. Thus, it was observed that the female teachers obtained a lower competence level (node 6, M= 2.70 ± 0.60) compared to the male teachers (node 7, M= 3.00 ± 0.68). Lastly, the teachers aged 50 years and older showed the lowest competence level (node 3, M= 2.65 ± 0.60). Furthermore, in this age range, the competence level was even lower for the female teachers (node 8, M= 2.58 ± 0.55) and those teachers without permanent education (node 10, M= 2.50 ± 0.54). On the other hand, the male teachers in this age group obtained a higher digital competence (node 9, M=2.80 ± 0.67).

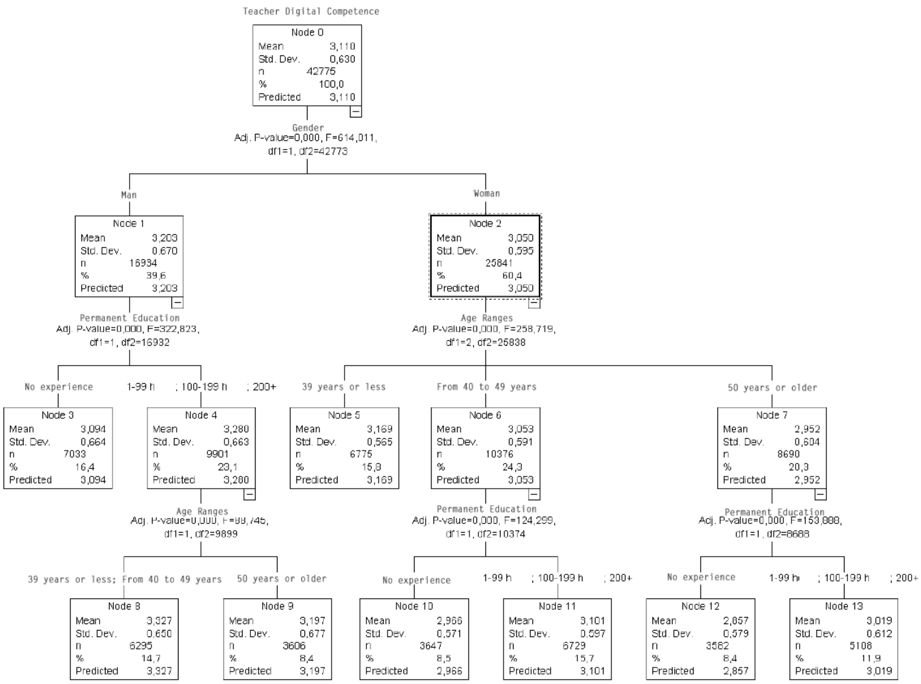

Fig. 4. Classification tree for the Secondary Education teachers.

The tree presented in Figure 4 shows the global competence level of the Secondary Education teachers (node 0, M= 3.11 ± 0.63), between the integrator and expert levels. As can be observed for this educational stage, gender has a greater direct effect than the age range, which is in line with the results obtained in the previous educational stages. The male teachers showed a higher competence level (node 1, M= 3.20 ± 0.67) with respect to the female teachers (node 2, M= 3.05, ± 0.60). Moreover, an even higher competence level was obtained by the male teachers with at least 100 hours of permanent education (node 4, M= 3.28 ± 0.066) under 50 years of age (node 8, M= 3.33 ± 0.65). In the case of the female teachers, the digital competence level was lower, especially for those aged 50 years or older (node 7, M= 2.95 ± 0.60). Furthermore, the female teachers aged 50 years or older without permanent education obtained a considerably lower digital competence level (node 12, M= 2.86 ± 0.58). The best case for the female teachers was observed for those aged 39 years or younger (node 5, M= M= 3.17 ±0.57). That is, the older the female teacher, the lower her competence level.

4 Discussion and conclusions

Although it was not a specific objective of the study, the first conclusion refers to the validity of the competence framework DigCompEdu to diagnose the TDC of teachers, both for the reliability shown by the instrument and for the complexity of the analyses and results that it allowed obtaining. This fact supports the decisions made by different authors to use such framework and the instrument derived for the analysis of TDC, as was pointed out in the introduction of this article.

This study allowed generating and providing significant information about the four objectives proposed in it, and the significance of the sample size used increases the value of the obtained results.

The different variables that were incorporated in the model (gender, age, teaching experience and educational level) showed their significance with respect to the mastery reached by the teachers in their TDC.

It is important to highlight that gender was one of the variables with greater influence on the mastery of TDC, both on its own and in relation to the years of teaching experience, age and educational stage. In all cases, the men perceived themselves with greater mastery of TDC compared to the women. In this case, our results are in line with those reported by other authors [23, 48]. However, there are studies with opposing results [3, 28], although some of these studies were conducted with student teachers. On the other hand, our findings are in agreement with the meta-analysis of studies on TDC that considered gender as a variable [21, 22], where most of the participants who perceived themselves in a positive manner were males.

Few studies have jointly considered the educational stage as a variable. Therefore, one of the most significant aspects of the findings of our study is the differences in the mastery of TDC as a function of the educational stage in which the participant performs his/her teaching practice. In our case, the teachers who taught in the lower levels were the ones who showed a lower mastery of TDC, with a progressive increase in competence with the advancing stages. In this case, the results obtained in this study are in line with those reported by [21] and [27], who found that Higher Education teachers had higher levels of TDC than the teachers of lower levels.

The reflection provided highlights the influence of gender on the mastery of Teacher Digital Competence (TDC), indicating that men tend to perceive themselves as having greater mastery compared to women. The practical implications of this reflection can be as follows:

1. Gender-Inclusive Professional Development: The results suggest a need for targeted professional development programs that address the gender gap in TDC. These programs should focus on equipping both male and female educators with the necessary skills and knowledge to effectively integrate technology into their teaching practices. Special attention should be given to empowering female teachers by providing mentorship, support networks, and resources to enhance their confidence and competence in using digital tools.
2. Equity in Access and Resources: To bridge the gender gap in TDC, educational institutions should ensure equal access to technology and resources for all teachers. This includes providing equal opportunities for training, professional development, and access to digital tools and platforms. Efforts should be made to eliminate any systemic biases or barriers that may hinder women's access to technology and limit their opportunities for developing TDC.
3. Gender-Responsive Pedagogy: Teachers and educators should be encouraged to adopt a gender-responsive approach in their teaching practices. This involves creating an inclusive and supportive classroom environment where both male and female students can develop their digital competences without gender-based stereotypes or biases. Teachers can implement strategies that engage all students, regardless of gender, and promote equal participation and opportunities for learning with technology.

4. Research and Evaluation: The reflection highlights conflicting findings from different studies, indicating the need for further research on gender and TDC. Future studies should investigate the underlying factors contributing to the gender differences in TDC perception and identify effective strategies to mitigate them. Additionally, ongoing evaluation of TDC programs should include a gender lens to monitor progress, identify areas for improvement, and ensure that gender disparities are being addressed effectively.

By addressing these practical implications, educational institutions can work towards narrowing the gender gap in TDC, fostering equitable and inclusive learning environments, and preparing teachers of all genders to effectively leverage technology in their educational practices. In addition to showing the need for teacher training, the above mentioned indicates the need to initiate the strategy of teacher training in TDC with the teachers of Early Childhood and Primary Education. Likewise, it suggests the need to pay special attention to the curricula of teacher training in the university degrees in Education for the development of these competences. This training is key, since our work shows that the level of general training influences the qualification of teachers in their TDC. Therefore, it is necessary to establish policies for both the initial and permanent education of teachers.

It is also necessary to point out that an inverse relationship was obtained between the mastery of TDC and age, which is in agreement with the results reported by different authors [7, 21]. These data could be the result of the recent changes made in the study plans of the university degrees in Education (Degree in Early Childhood Education and Degree in Primary Education), given the importance of such competence in the training of future teachers [7]. The practical implications of this reflection can be as follows:

1. Gender-Inclusive Professional Development: The results suggest a need for targeted professional development programs that address the gender gap in TDC. These programs should focus on equipping both male and female educators with the necessary skills and knowledge to effectively integrate technology into their teaching practices. Special attention should be given to empowering female teachers by providing mentorship, support networks, and resources to enhance their confidence and competence in using digital tools.
2. Equity in Access and Resources: To bridge the gender gap in TDC, educational institutions should ensure equal access to technology and resources for all teachers. This includes providing equal opportunities for training, professional development, and access to digital tools and platforms. Efforts should be made to eliminate any systemic biases or barriers that may hinder women's access to technology and limit their opportunities for developing TDC.
3. Gender-Responsive Pedagogy: Teachers and educators should be encouraged to adopt a gender-responsive approach in their teaching practices. This involves creating an inclusive and supportive classroom environment where both male and female students can develop their digital competences without gender-based stereotypes or biases. Teachers can implement strategies that engage all students, regardless of gender, and promote equal participation and opportunities for learning with technology.
4. Research and Evaluation: The reflection highlights conflicting findings from different studies, indicating the need for further research on gender and TDC. Future studies should investigate the underlying factors contributing to the gender differences in TDC perception and identify effective strategies to mitigate them. Additionally, ongoing evaluation of TDC programs should

include a gender lens to monitor progress, identify areas for improvement, and ensure that gender disparities are being addressed effectively.

By addressing these practical implications, educational institutions can work towards narrowing the gender gap in TDC, fostering equitable and inclusive learning environments, and preparing teachers of all genders to effectively leverage technology in their educational practices. The practical implications of this reflection are as follows:

1. Continuous Professional Development: Given the inverse relationship between TDC mastery and age, it is crucial to provide continuous professional development opportunities for experienced teachers. Training programs should be designed to address the specific needs and challenges faced by older teachers in adopting and integrating technology in their teaching practices. These programs can focus on enhancing digital literacy, exploring new tools and trends, and providing hands-on support to build confidence and competence in using technology effectively.
2. Pedagogical Transformation: The changing study plans in university degrees in Education, emphasizing the importance of TDC, indicate the need for pedagogical transformation in teacher education. Teacher training institutions should integrate digital competence development throughout the curriculum, ensuring that future teachers are well-equipped to navigate the digital landscape and meet the demands of the digital age. This includes incorporating technology-rich pedagogies, encouraging critical thinking about technology integration, and providing practical experiences to develop TDC from the start of their education.
3. Mentoring and Collaboration: Establishing mentoring programs and promoting collaboration between younger and older teachers can be beneficial. Younger teachers can share their knowledge and skills in TDC with their more experienced counterparts, while older teachers can provide valuable insights and guidance based on their teaching experience. By fostering an environment of mutual support and learning, both groups can enhance their TDC competences, fostering professional growth and improving overall instructional practices.
4. Recognition and Valuing Experience: While younger teachers may have an advantage in TDC, it is essential to recognize and value the experience and expertise of older teachers. Establishing platforms for sharing best practices and success stories can highlight the unique contributions of experienced educators. Recognizing the value of their experience can also help alleviate any feelings of inadequacy and empower older teachers to embrace technology in their teaching with confidence.
5. Research and Innovation: The inverse relationship between TDC mastery and age calls for further research and innovation in the field of teacher education. Ongoing research can explore effective strategies for bridging the gap between younger and older teachers in terms of TDC. This can involve investigating age-specific challenges, exploring innovative approaches to professional development, and identifying successful models of collaboration and mentorship.

By addressing these practical implications, educational institutions and teacher training programs can support older teachers in developing their TDC competences, ensure a smooth transition into technology-rich classrooms, and leverage the collective expertise of both younger and older teachers to enhance overall educational outcomes.

Regarding the limitations of this study, it is worth highlighting the application of a single questionnaire-like instrument based on the self-perception of the teachers. This is justified by the large sample size of the study, which covers almost the entirety of the teachers who teach in the region of Andalusia. However, these results should be compared with others obtained in local studies that explain the reality of each educational context. Moreover, the self-perception questionnaires must evolve toward other questionnaires in which the mastery of the competence level is shown. To address these limitations and enhance the validity and reliability of future research, several considerations and improvements can be made:

1. Diversify Research Methods: While self-perception questionnaires provide valuable insights, future studies should consider using a mixed-methods approach. This would involve combining self-perception questionnaires with objective measures of TDC mastery, such as performance-based assessments or classroom observations. This triangulation of data sources can provide a more comprehensive understanding of teachers' actual competency levels.
2. Contextualize Findings: It is important to acknowledge that educational contexts vary, and the results of this study may not be generalizable to other regions or countries. Future research should consider conducting local studies that delve into specific educational contexts to provide a more nuanced understanding of the factors influencing TDC mastery. This would help identify context-specific challenges and inform targeted interventions and policies.
3. Longitudinal Studies: Conducting longitudinal studies can provide insights into the development of TDC over time. By examining changes in teachers' self-perception and actual competency levels at different points in their careers, researchers can better understand the trajectory of TDC mastery and identify factors that contribute to its growth or decline. Longitudinal studies can also shed light on the effectiveness of professional development initiatives aimed at enhancing TDC.
4. Collaboration with Practitioners: Collaborating with teachers and educational practitioners in the research process can enhance the relevance and applicability of findings. Involving teachers in the design, implementation, and evaluation of TDC research can ensure that research questions are aligned with their needs and experiences. Additionally, practitioners can provide valuable insights into the practical implications of the research findings and help bridge the gap between research and practice.
5. Multi-dimensional Competency Assessment: Moving beyond self-perception questionnaires, future research should explore multi-dimensional approaches to assessing TDC mastery. This can include incorporating rubrics or competency frameworks that provide a detailed assessment of teachers' skills across different dimensions of TDC. Such assessments can capture a more nuanced picture of teachers' competences and identify specific areas for improvement.

By considering these suggestions, researchers can strengthen the rigor and applicability of their studies on TDC, facilitating a better understanding of teachers' actual mastery levels, identifying context-specific challenges, and informing targeted interventions to promote TDC development among educators.

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