JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 49-61

Classification models in the digital competence of higher education teachers based on the DigCompEdu Framework: logistic regression and segment tree

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(submitted: 4/3/2021; accepted: 1/7/2021; published: 2/7/2021)

Abstract

To promote and develop the digital competence of higher education teachers is a key aim in the 21st century. Teachers must have a leader or expert digital competence in order to prepare future school-leavers for a competent professional qualification. Therefore, the purpose of this study is to determine the predictor variables encouraging high digital competence, using two statistical classification techniques: multiple logistic regression and classification trees. The analysis of teachers' digital competence was carried out in each of the areas of knowledge in which the teachers are assigned, as well as overall. For data collection, a non-experimental ex post facto design was used. A total of 1,104 higher education teachers from Andalusia (Spain) completed the DigCompEdu Check-In instrument prepared by the European Commission's Joint Research Centre. In terms of general classification, the results found that the logistic regression technique ranked teachers' digital competence with greater probability of success (83.7%) in comparison to the segment tree (81.7%). The results found that the level of digital competence of teachers in the creation and use of digital resources varies according to the area of knowledge to which the teachers are assigned. At a general level, the development of digital competence at the leader, expert or pioneer level is related to various factors, such as the time spent on creating web spaces and digital content, and the use of virtual reality, robotics, and gamification. Further research is recommended to validate these preliminary findings in each of the areas of knowledge.

KEYWORDS: Digital Competence, Digital Literacy, DigCompEdu, Higher Education, Teacher Training, Multiple Logistic Regression, Classification Trees, Research Methods

DOI
https://doi.org/10.20368/1971-8829/1135472

CITE AS
Cabero-Almenara, J., Guillén-Gámez, F.D., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2021). Classification models in the digital competence of higher education teachers based on the DigCompEdu Framework: logistic regression and segment tree. *Journal of e-Learning & Knowledge Society*, *17*(1), 49-61. https://doi.org/10.20368/1971-8829/1135472

1. Introduction

The significance of information and communication technologies (ICTs) in the information society and in the Fourth Industrial Revolution make digital competence a key domain to operate in such digital scenario, which has been defined as a competence that "involves the safe and critical use of information society technologies for work, leisure and communication purposes" (EU Council, 2018, p. 9). Its presence in society is also perceived in educational institutions, where teachers have never had so many technological resources available to carry out their professional activities (Falloon, 2020). And this presence, as successive Horizon reports have highlighted, requires teachers to be equipped with relevant levels of digital competence to manage these media educational environments (Alexander et al., 2019).

At the university level, research highlights the lack of teacher training for the incorporation of ICT in teaching (Guillén-Gámez & Mayorga-Fernández, 2020a; Rolf et al., 2019), and the need to develop training plans. These programmes should be carried out using models other than technological-instrumental ones, and be focused on the instrumental training of teachers in technologies, as well as adopting other perspectives, such as TPACK (Mishra & Koehler, 2006), the model for developing digital teacher competence by Krumsvik (2011), or the so-called SAMR (Substitution, Extension, Modification and Redefinition) Puentedura model (Garcia-Utrera et al., 2014). This lack of digital training is due to the fact that teachers often focus more on the pedagogical than on the didactic (Cabero & Martínez, 2019; Solís de Ovando & Jara, 2019), since pedagogical training is presented as a good predictor for its didactic use (Li et al., 2019), and who's training simultaneously improves teachers' beliefs and attitudes towards the educational use of ICT (Semerici & Kemal, 2018). It is also interesting to change from a traditional view of ICT to broader conceptions, such as LKT (Learning and Knowledge Technologies) and TEP (Technologies for Empowerment and Participation) (Pinto et al., 2017; Gómez-Triguero et al., 2019; Guillén-Gámez et al., 2020a).

Regarding teachers' level of digital skills, it should be noted that there is a low level of competence (Alarcón et al., 2020; Guillen-Gamez et al., 2020b). Thus, more study and analysis are required to establish training actions in regard to the pedagogical-didactic component than in the technological-instrumental component (Cabero-Almenara & Barroso, 2016; Pozos & Tejada, 2018; Mercader, 2019; Pérez-Díaz, 2019; Guillén-Gámez & Mayorga-Fernández, 2020b). These points require the analysis of this competence because teachers' low level of skills in this area results in less and unskilled educational use of ICT by teachers (Padilla-Hernández et al., 2020). On the other hand, as this domain has a cross-sectional impact on other competences that the teacher must have in their study and analysis, it becomes even more necessary (Almerich et al., 2019).

Such is the importance of these latter aspects, that the Horizon 2019 EDUCASE Report identified the following six emerging technologies as likely to have the most significant impact on higher education for the next five years (2019–2023): mobile learning, analytical technologies, mixed reality, artificial intelligence, blockchain, and virtual assistants (Alexander et al., 2019). To use these with their students, university teachers must possess sufficient competencies.

Different studies have identified a range of variables which may contribute to improving the level of digital teacher competence (DTC), including:

a) The teaching experience this professional group has of implementing ICT (Fernández et al., 2018; Oudeweetering & Voogt, 2018; Cheng et al., 2020).
b) Gender, which commonly reveals different uses (Pozo et al., 2020), and generally negative effects on women (Balta & Duran, 2015; Cabero et al., 2017; Ilkan et al., 2017; Guillén-Gámez et al., 2020); although the female gender is more favorable for virtual training (López et al., 2018).
c) The age of teachers, where younger teachers demonstrate a higher level of skill and a more positive attitude towards the use of ICT (Gallardo et al., 2018), and who are, in turn, more interested in their training regarding these competences (Garzón et al., 2020).
d) The time of use spent on technology, which represents a determining factor in the acquisition of new digital procedural skills (Krumsvik et al., 2016; García-Marco et al., 2020).
e) Profiles on social networks, where the use of these networks in didactic tasks supposes a moderate level of digital competence (García-Pérez et al., 2016; Porlan & Sanchez, 2016; Eyo, 2016; Sánchez-Gómez et al., 2017).
f) The creation of collaborative sites (webs, blogs, wikis) is related to the production of knowledge, promoting digital competence (Tusiime et al., 2019; Ligurgo et al., 2019; Varela-Ordorica & Valenzuela-González, 2020).
g) The ability to create digital content such as posters, concept maps, infographics, online activities, and online questionnaires (Yuyun, 2018; Badia et al., 2019).
h) The adequacy of incorporating gamification into the learning process for the acquisition of digital skills (Torres-Toukoumidis & Mäeots, 2019).
i) The use of virtual worlds to generate content, fostering an optimal learning environment (Lamb & Etopio, 2019; Sanglub et al., 2019).

All previous studies are based on self-made models. However, different competency frameworks have been proposed from an institutional perspective; according to different authors (Lázaro et al., 2019; Rodríguez-García et al., 2019; Feerrar, 2019; Silva et al., 2019; Cabero-Almenara & Palacios-Rodríguez, 2020; Ranieri & Bruni, 2018), the following can be considered as the most consolidated and significant of these: the European Union Framework for Digital Teacher Competence-DigCompEdu (Redecker & Punie, 2017); the Framework of the International Society for Technology in Education (ISTE) for teachers (Crompton, 2017); the UNESCO ICT skills framework for teachers (Butcher, 2019); the common framework of digital teaching competence of the National Institute of Educational Technology and Teacher Training (INTEF, 2017); the UK Digital Teaching Framework (Education and Training Foundation, 2019); ICT skills for the professional development of teachers in the Colombian National Ministry of Education (Fernanda et al., 2013); and ICT skills and standards for the teaching profession of the Chilean Ministry of Education (Elliot et al., 2011). These frameworks, besides proposing the competences teachers must be trained in, aim to identify training needs and propose personalized training plans (Flores-Lueg & Roig Vila, 2016; Leaning, 2019; Lee, 2019; Yazon et al., 2019).

Taking into consideration the scientific literature on digital competence in higher education teachers, as well as in current research DigCompEdu has been selected as the most appropriate model to measure digital competence of teachers (Cabero-Almenara et al., 2020a, 2020b), this study focuses on this competence framework. For this reason, the main objective of this study is the identification of those predictors that significantly influence the acquisition of digital competence (according to DigCompEdu) by university teachers at an expert, leader or pioneer level, depending on the area of knowledge to which they are assigned, as well as overall. To achieve this, two classification techniques are used: a multiple logistic regression model to identify the significant predictor variables; and, a segment tree to identify significant relationships between pairs of categories in the predictors presenting a greater probability of achieving high or low digital competence.

2. Materials and methods

2.1. Design

To achieve the objectives of the study, we applied a non-experimental design using surveys. Once the data was collected, inferential analysis was carried out to predict high digital competence among university teachers in the Andalusian territory.

2.2. Participants

Non-probability sampling was used to purposefully select 1,104 higher education teachers in Andalusia (Spain) during the academic year 2019–2020. Specifically, 72.8% (n = 804) of the teaching staff belonged to the University of Seville, 14.3% (n = 158) to the University of Malaga, and 12.9% (n = 142) to the University of Almeria. Data privacy was guaranteed since the survey was anonymous, and participants were informed of the study purpose prior to completion of the survey. In terms of the demographic profile of participants, 46% (n = 508) were female, and 54% (n = 596) were male. Teachers under 29 years old represented 9.1% (n = 101) of the sample; 12.5% (n = 138) were between 30 and 39 years old; and 78.4% (n = 865) were over 39 years old.

In terms of academic profile, teaching staff from the Arts and Humanities area represented 13.6% (n = 150) of the sample; of these, 69.3% had at least ten years of teaching experience, 62.7% had been using educational technology for at least 10 years, and only 34.7% had more than four social media accounts. Science teachers represented 12.5% (n = 138) of the sample; of these, 83.3% possessed at least 10 years' experience, 72.5% had been using technology for at least 10 years, and 14.5% had more than three social media networks. Health sciences teachers represented 15.4% (n = 170) of the sample; of these, 71.8% had at least 10 years of teaching experience, 52.9% had been using technology for at least 10 years, and 67.1% had more than three social networks. Engineering and architecture teachers represented 22.8% (n = 252) of the sample; of these, 81.3% had at least 10 years of experience, 72.2% claimed to have been using technology for at least 10 years, and 25.4% had more than three social media accounts. Finally, social and legal sciences teachers represented 35.7% (n = 394) of the sample; of these, 73.1% had least 10 years teaching experience, 70.6% claimed to have been using educational technology for at least 10 years, and 35% had more than three social media accounts.

2.3 Instrument

The DigCompEdu Check-In instrument designed by Ghomi and Redecker (2018) and published by the Joint Research Centre (JRC) of the European Commission, was used to measure the digital competence of teachers.

It is a specific framework aimed at educators at all stages of an educational system, from early childhood to higher education, including vocational training, education for special needs and non-formal learning contexts. The authors chose this instrument as it is a general reference framework for those who develop models for the development of digital competence, such as the Member States of the European Union, regional governments, national agencies and both public and private vocational training centers.

The instrument was translated and adapted to the Spanish context by Cabero-Almenara and Palacios-Rodríguez (2020). The 22 items scored in the questionnaire relate to six areas of competence: the professional commitment dimension focuses on the teachers' work environment, in order to take into account the different agents of the educational community (4); the digital resources dimension is related to the creation and distribution of digital resources in the classroom, respecting copyright rules (3); the digital pedagogy dimension is associated with knowing how to design and plan the use of technologies in student learning, focusing on active methodologies (4); the evaluation and feedback dimension focuses on the use of ICT resources for student evaluation (3); the empowering students dimension relates to ensuring digital access to all students, offering learning activities adapted to their level of competence, their interests, and educational needs (3); and finally, the facilitating the digital competence of students dimension (5).

To measure the level of competence, a five-point Likert scale was used as well as the original DigCompEdu instrument (Cabero-Almenara & Palacios-Rodríguez, 2020; Ghomi & Redecker, 2018; Redecker & Punie, 2017), with the different values on the scale referring to the following progressive levels: novice, with very little experience and contact regarding educational technology (A1); explorer, little contact with educational technology, in need of external guidance for integration in the classroom (A2); integrative, who experiments with technology and tries to adapt it to their educational context (B1); expert, who makes use of a wide range of ICT resources to improve their teaching practice (B2); leader, who is able to adapt ICT resources to the individual needs of students, as well as provide inspiration and creativity for other teachers (C1): and pioneer (C2) who lead innovation with ICT and are a role model for other teachers.

However, the instrument and its psychometric properties had not been fully validated, as only content validity had been established, through expert judgement and reliability analysis, not construct validity (Caena & Redecker, 2019; Ghomi & Redecker, 2018).

2.4 Procedure and analysis

Once the sample data was collected, atypical cases were eliminated through exploratory graphic visualisation methods (blank answers). To test the internal structure of the test, Cronbach's alpha was used to check reliability, and exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to check construct validity. In terms of statistical software, SPSS V.22 and AMOS V.22 were used to check the modelling of structural equations (SEM) based on the relationships between the items of the instrument. For the logistic regression technique, the stepwise procedure (step by step) was used to select the best model, with all the variables described in Table 1. For the classification trees, the CHAID (Chi-square automatic interaction detection) method was applied to detect relationships between pairs of significant variables using the maximum likelihood technique. CHAID was chosen since it allowed the automatic detection of interactions using Chi-square. At each step, CHAID chose the independent variable that exhibits the strongest interaction with the dependent variable

For both classification techniques, the total score of the teachers' digital competence was recoded into a dummy variable with two categories: high digital competence at the expert, leader or pioneer level (value 1), and low digital competence at the novice, explorer or integrator levels (value 0). The characterization of variables employed in the study can be found in Table 1: all of them are nominal qualitative in nature.

3. Results

The results will be presented in the following sections: first, the psychometric properties of the instrument; second, the results of the multiple logistic regression model; and finally, the segment tree results.

3.1 Psychometric properties of the instrument

The reliability of the instrument was verified through two analyses: Cronbach's alpha and McDonald's omega coefficient. Both coefficients produced very satisfactory results, both in the dimensions of the instrument and as a whole. Table 2 shows the different calculated coefficients. All values, according to O'Dwyer and Bernauer (2014), denote high levels of reliability.

In the EFA, we used the maximum likelihood method using oblique rotations. The Kaiser-Meyer-Olkin index was appropriate (KM = 0.963), and the result for Bartlett's Chi Square test was significant (χ^2 =

Factors	Variable	Categories
VD	Digital competence of teachers	0: Low 1: High
Demographic and academic factors	Gender	0: Male - 1: Female
	Age	0: Up to 29 years old - 1: Between 30 and 39 - 2: Over 40 years old
	Teaching experience	0: Under 10 years - 1: Over 10 years
	Time using educational technology	0: Less than 10 years - 1: More than 10 years
	Number of social media	0: Up to three - 1: More than three
Factors in educational technology	Creation of educational websites	0: No - 1: Yes
	Creation of online activities	0: No - 1: Yes
	Creation of online questionnaires (test)	0: No - 1: Yes
	Digital posters, conceptual maps	0: No - 1: Yes
	Creation of blogs or wikis	0: No - 1: Yes
	Working with robotic technology	0: No - 1: Yes
	Use of gamification (Kahoot, Plickers, Menti)	0: No - 1: Yes
	Use of virtual reality	0: No - 1: Yes

Table 1 - Description of variables.

11701.781; df = 171; sig. <0.05). The proposed model explained 71.86% of the true variance in the instrument scores, sequentially classified as follows: 49.83% for the evaluation and feedback dimension; 5.98% for digital pedagogy; 4.68% for empowering students; 4.24% for digital resources; 3.87% for facilitating the digital competence of the students; and, finally, 3.25% for professional commitment. However, three items did not produce correct results in their dimensions and showed values below 0.3, and so were removed from the questionnaire.

	Cronbach's Alpha	McDonald's Omega
Professional commitment	0.767	0.957
Digital resources	0.691	0.958
Digital pedagogy	0.746	0.957
Evaluation and feedback	0.823	0.956
Empower students	0.810	0.957
Facilitate students' digital competence	0.835	0.967
TOTAL	0.942	0.993

Table 2 - Reliability of the instrument.

The CFA was verified with the theoretical proposal of the six dimensions with the 19 selected items. For this, the maximum likelihood method was selected, using the thresholds recommended by Bentler (1989) and Hu and Bentler (1999): CMIN/DF (mean chi square/degree of freedom<3) = 2,822, p = <0.05; CFI (comparative fit index>0.7) = 0.960; TLI (Tucker-Lewis index>0.7) = 0.950; IFI (incremental fit index>0.7) = 0.960; RMSEA (root mean square error of approximation<0.1) = 0.057, with thresholds between 0.051 and 0.064. The proposed model with 19 items and 6 correlated latent dimensions showed the factorial structure formulated in the CFA. Figure 1 shows the Structural Equation Model.

3.2 Verification of assumptions in classification techniques

The assumptions allowing this type of classification techniques were verified. It was found that there were no multicollinearity problems concerning the predictor variables, and no correlations greater than 0.6 were found (Silva & Barroso, 2004). The Hosmer and Lemeshow test (1989) determined that the interaction between the predictors and their logarithmic transformations was significant in the proposed model (χ^2 = 7.408; df = 8; sig.> 0.05), so there was a linear relationship with the logic one. Finally, Josephat and Ame (2018) explain that one of the general rules in logistic regression requires a sample size where N> 50 + (8 * the number of predictor variables). In our case, we relied on four predictor variables (50 + 8 * 14) = 162. In terms of segmentation techniques, Berlanga et al. (2013) advise avoiding samples with less than 1,000 cases. In the present study, a sample of 1,104 subjects was obtained, so we fulfilled the assumption.

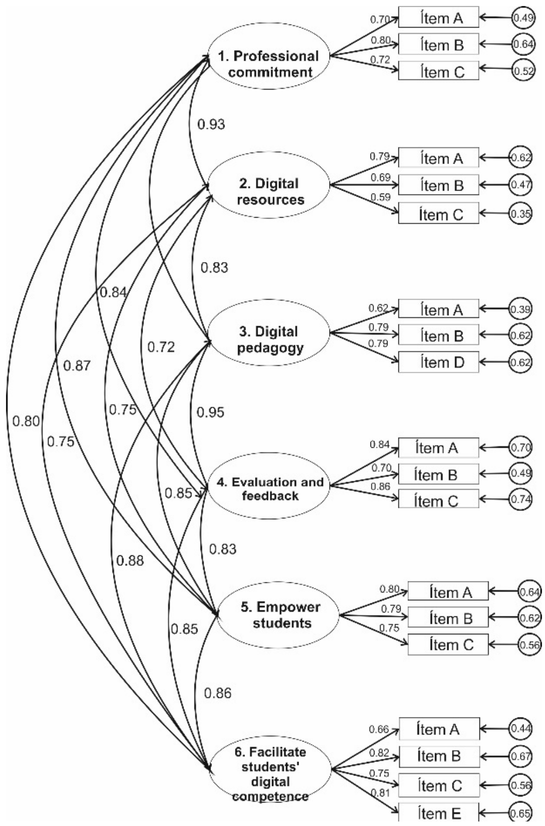

Figure 1 - Model of structural equations.

3.3 Determination of the multiple logistic regression model

The Omnibus test indicated that the proposed model contributed to predicting high digital competence by making a correct and significant estimation (χ^2 = 471.6516 df= 14; p. <0.05). The model explained 49.3% of the variance in VD according to Nagelkerke's R2. Likewise, we showed that it was able to correctly predict 83.7% of the cases; thus, the model produced satisfactory results (Table 3). Regarding the case of teachers who had low digital competence at the novice, explorer, or integrator level, we correctly classified a total of 91.74% of teachers having such levels (model specificity), and 62.62% who had high digital competence at a leader, expert or pioneer level.

	Predicted		
Observed	Low competence	High competence	% of accurate cases
Low digital competence	733	66	91.7
High digital competence	114	191	62.6
% of accurate cases			83.7

Table 3 - Number and percentage of cases correctly classified regarding the prediction of digital competence.

Table 4 shows that the proposed model contains 12 significant predictor variables: length of use of educational technology; number of social networks; length of educational experience; the creation of digital activities, as well as posters and concept maps; influence students to create blogs, work robotics, gamification, virtual reality, websites, just as age ranges up to 29 years old and between 30–39 years old. If p- is denoted as the probability of success in achieving high digital competence and q- as the probability of failure in low digital competence, it is true that p + q = 1, since there are not two possible outcomes. The linear function falls on the logarithm of the following equation, where β represents the constant, and χ is the factorial significance in view of the following predictive variable:

$\gamma = \beta 0 + \beta 1 * \chi 1 + \beta 2 * \chi 2 \ldots\ldots \beta k * \chi k$

Using the odd ratios of each predictor, the probability of success when acquiring a high digital competence at the leader or expert level can be calculated for the different values of each of the significant predictors.

The equation is: $\boldsymbol{p = \frac{1}{1+e^{-Y}}}$

For example, for a teacher aged between 30 and 39, who has been using ICT for at least 10 years, has at least 10 years of experience and knows how to create digital activities, posters and concept maps, blogs, works robotics, gamification and virtual reality with students, their probability of having a high digital competence at an expert, leader or pioneer level according to the coefficients in table 4 is:

Y=-3.073+1.169*1+0.814*1-1.202*1+0.772*1+1.288*1+0.924*1-0.757*1+0.612*1+0.812*1+0.766*1+1.009*1=3.134

$$\boldsymbol{p = \frac{1}{1 + e^{-(3.134)}} = 95.83\%}$$

To calculate the probabilities in each of the areas of knowledge the teaching staff are assigned to, the coefficients in Table 5 can be input to the equation $\gamma = \beta + \beta 1 * \chi 1$, as well as the exponential values of the Exp (β) themselves. It should be pointed out that in the area of sciences, no coefficient appears for the robotic variable since there was no teacher who employed this technology; thus, the regression model did not include it. Furthermore, the proposed model takes the age range as the reference characteristic of the category 0, so it does not provide coefficients.

3.4 Classification tree analysis

With the same sample of 1,104 university teachers and the same independent variables, we created a classification tree for digital competence using the CHAID algorithm. Digital competence was separated by category using the same characteristics as the logistic regression model: low digital competence with a novice, explorer, or integrator profile; or high digital competence with an expert, leader or pioneer profile. The analysis obtained 15 nodes (Figure 2). The first variable defining digital competence was encouraging students to create posters and concept maps, which two initial nodes were linked with. The most significant nodes were: node 1, which classifies those teachers who did not know how to create posters and concept maps, consequently representing 87.4% of the low digital competence group; node 3 reflected teachers who did not know how to create posters and concept maps, but who also did not know how to create digital activities, consequently representing 91.3% of the low digital competence group. Moreover, those who, in addition to not knowing how to create the aforementioned ICT resources, had not worked with gamification resources, representing 95% of the low digital competence group.

Node 2 classified those teachers who knew how to create posters and concept maps representing 54.8% of the high digital competence group. Aside from knowing how to correctly use these resources, they had the competency to create websites, representing 88.7% of the high digital competence group. In addition, those with profiles on more than three social networks represented 100% of the high digital competence.

Table 6 shows that the proposed model correctly described 81.7% of the teachers. Specifically for each category of the digital competence variable, the model offered a higher correct percentage for the "low digital competence" category, representing the 92.2%.

4. Discussion

The main objective of this study was to evaluate and compare two statistical classification techniques for the development of high digital competence among higher education teachers at the leader, expert or pioneer level: multiple logistic regression and classification trees. In addition to identifying which predictor variables can accurately predict the possibility that teachers possess high digital competence in the specific branches of knowledge they are attached to, the segmentation tree offers the additional opportunity to understand the associations between digital competence and the most significant predictor variables.

The results showed that the logistic regression leads to a slightly higher rate of correct classification of high education teachers' in regard to their level of digital competence (83.7%) compared to the classification tree (81.7%). However, the latter technique presents a better adjustment to the percentages corresponding to specificity (ability to correctly differentiate those with low digital competence), while sensitivity (ability to correctly differentiate those with high digital competence) is greater using the regression technique.

In relation to the logistic regression and the Wald statistic test, the most influential variable was knowing how to create digital content such as posters, concept maps, and blogs.

	B	Standard Error	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Higher
Length of use of technology	1.169	0.313	13.909	1	0.001	3.218	1.741	5.948
RRSS	0.814	0.188	18.826	1	0.001	2.257	1.563	3.260
Teaching experience	-1.202	0.326	13.617	1	0.001	0.300	0.159	0.569
Creation of activities	0.772	0.214	13.041	1	0.001	2.163	1.423	3.288
Creation of tests	0.324	0.214	2.292	1	0.130	1.383	0.909	2.104
Creation of posters and concept maps	1.288	0.186	47.801	1	0.001	3.627	2.517	5.226
Creation of blogs	0.924	0.209	19.602	1	0.001	2.520	1.674	3.794
Robotics	-0.757	0.350	4.675	1	0.031	0.469	0.236	0.932
Gamification	0.612	0.193	10.034	1	0.002	1.844	1.263	2.692
Virtual reality	0.812	0.242	11.299	1	0.001	2.253	1.403	3.618
Gender	0.115	0.184	0.392	1	0.531	1.122	0.783	1.608
Creation of websites	0.766	0.241	10.070	1	0.002	2.152	1.340	3.454
Age (0)			10.926	2	0.004			
Age (1)	1.009	0.318	10.027	1	0.002	2.742	1.469	5.118
Age (2)	0.057	0.297	0.036	1	0.849	1.058	0.591	1.894
Constant	-3.073	0.287	114.466	1	0.000	.046		

Table 4 - Influence of independent variables based on the probability of having a high digital competence (n =1104).

Variables / Areas	A-H		C		CS		I-A		CS-J	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Length of use	1.77	5.89*	5.92	374.06*	1.27	3.55	2.34	10.35*	0.67	1.958
RRSS	0.02	1.02	0.02	1.02	2.93	18.77*	1.07	2.93*	0.95	2.59*
Experience	-1.03	0.36	-5.30	0.01*	1.05	2.86	-0.86	0.43	-1.42	0.24*
Creation of activities	0.42	1.52	2.28	9.80*	2.52	12.44*	1.87	6.51*	0.67	1.95*
Creation of tests	0.46	1.58	3.48	32.59*	0.81	2.25	-2.04	0.13*	0.75	2.12*
Creation of posters	2.230	9.30*	-1.45	0.24	0.82	2.27	2.30	9.97*	1.20	3.31*
Creation of blogs	2.10	8.13*	3.58	36.03*	-2.57	0.08*	0.45	1.57	1.07	2.92*
Robotics	-3.14	0.04*	-		-2.26	.10	0.70	2.00	-0.48	0.62
Gamification	0.34	1.41	0.48	1.62	1.79	5.99*	1.61	4.98*	0.16	1.17
Virtual reality	1.77	5.85*	3.07	21.44*	-3.32	0.04*	0.40	1.50	1.13	3.11*
Gender	0.14	1.15	-0.90	0.41	0.31	1.36	1.18	3.27	0.11	1.11
Creation of website	-0.54	0.58	1.49	4.44	6.11	450.94*	2.06	7.88*	0.55	1.74
Age (range 0)	-		-		-		-		-	
Age (range 1)	1.45	4.24	-17.00	0.00	1.65	5.22	2.00	7.42	0.68	1.97
Age (range 2)	0.74	2.10	0.30	1.34	0.80	2.23	1.40	4.05	-0.10	0.90
Constant	-3.454	0.032	-3.812	0.022	-6.746	0.001	-6.097	0.002	-2.527	0.080

Legend: A-H) Art and Humanities; C) Sciences; CS) Health Sciences; I-A) Engineering and Architecture; CS-J) Social and Legal Sciences. * Predictive variables significant at 95% confidence

Table 5 - Variables in the multiple logistic regression equation.

Observed	Predicted Low competence	High competence	Correct percentage
Low competence	737 (92.24 %) *	62	92.2%
High competence	140	165 (54.10%) *	54.1%
Total percentage	79.4%	20.6%	81.7%

* The percentages of the main diagonal correspond to the sensitivity and specificity characteristics.

Table 6 - The decision tree ranking.

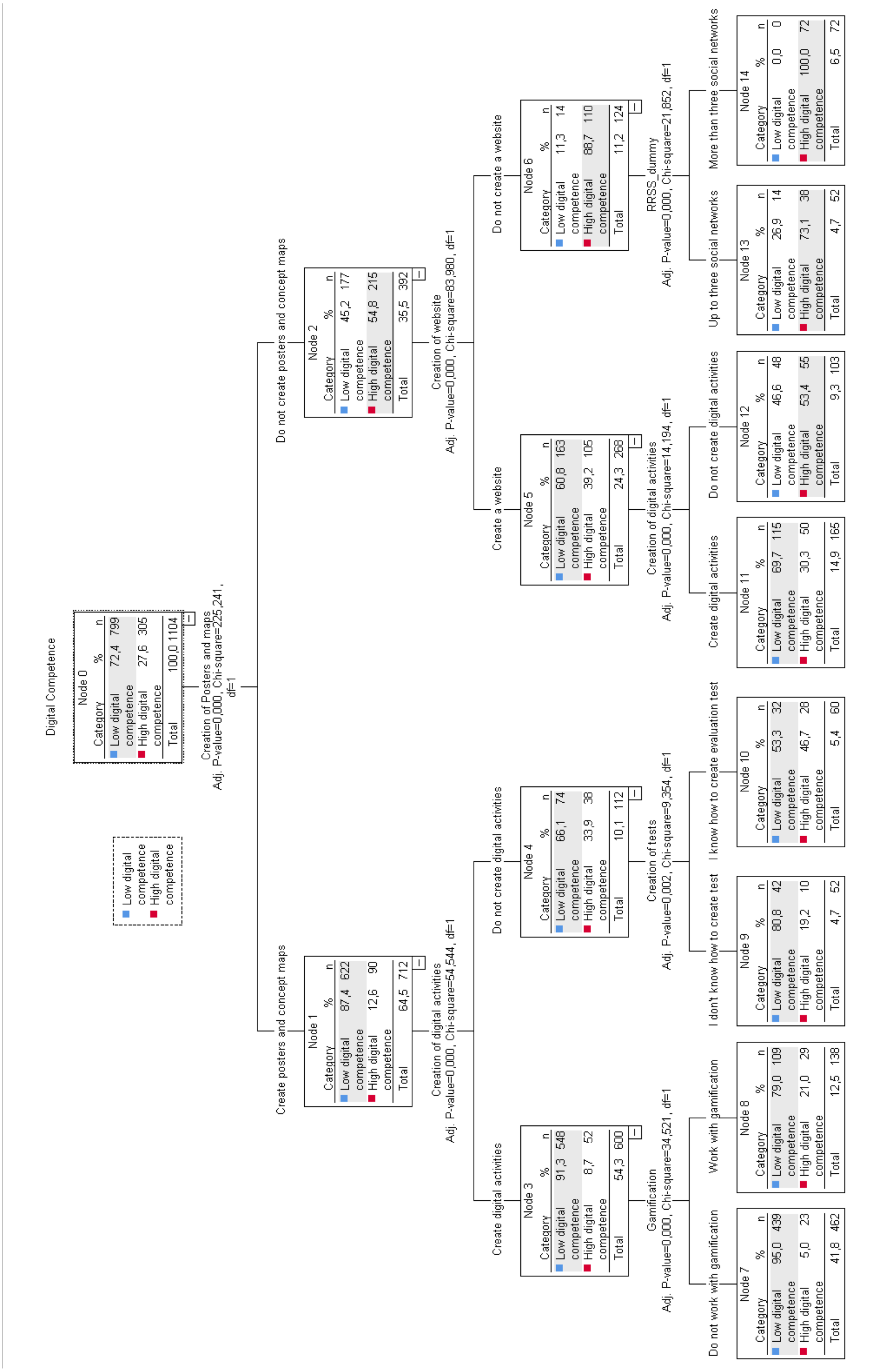

Figure 2 - Segmentation of teachers' digital competence.

These results are similar to those of Gago and Gómez-Gonzalvo (2016), Yuyun (2018), Tusiime et al. (2019), Ligurgo et al. (2019), Badia et al. (2019), and Varela-Ordorica and Valenzuela-González (2020). These results support the assumption that, although Parsons et al. (2020) observe that computational thinking is a fundamental resource which may have great effects on the development of digital competence, teachers are still influenced by the creation and management of more traditional ICT resources that emerged at the beginning of the 21st century.

It should be highlighted that the number of social network accounts held by the teachers who participated in our study is a good indicator of digital competence, supporting the findings of García-Pérez et al. (2016), Porlan and Sanchez (2016), Eyo (2016) and Sánchez-Gómez et al. (2017). These results make us reflect on the time required by teachers to use technology correctly, which is in turn related to the significant results we have found concerning the time spent using technology, similar to Krumsvik et al. (2016) and García-Marco et al. (2020). Instead, two variables appear as a reflection of the decrease observed in the level of competence, teaching experience and age, which are related. These results reflect those of Gallardo et al. (2018) and Garzón et al. (2020), where younger teachers were found to be more interested in receiving training in these skills.

In regard to the classification established by areas of knowledge, the use of augmented reality and the creation of blogs seem to be determining factors in the areas of art and humanities, sciences, health sciences, and social sciences. Although there is no consensus among the areas in terms of significant predictors, gamification and robotic technology begin to emerge in the development of digital competence in some areas. These findings support the view of Pinto, Cortés and Alfaro (2017) and Gómez-Triguero, Ruiz-Bañuls and Ortega-Sánchez (2019) that teachers are moving from a digital conception focused on the use of ICT resources, to a broader conception including, for example, knowledge creation through LKTs and participation in collaborative environments through TEPs. Regardless of the area, what remains clear is the need to train teachers in these competences, since their poor knowledge implies an education not focused on the most-demanded professions in the 21st century (Padilla-Hernández et al., 2020).

Regarding the classification tree, the results support those already found in the regression concerning the high significance of the creation of activities and digital content (posters, concept maps, collaborative websites), indicating that those teachers who also have several social media accounts and have begun to gamification in the classroom are immersed in the development of high competence in order to achieve some of the aims proposed in the 2019 Horizon Report (Alexander et al., 2019). These findings highlight the need to implement relevant teacher training plans.

5. Conclusion

The results of the study have identified the predictors that influence in a special way the acquisition of high digital competence by university teachers at a leader, expert or pioneer level. Twelve significant predictive variables were obtained using the multiple logistic regression model, which revealed the importance of the age range of teachers to possessing adequate digital competence, as well as their ability to create digital materials, and to use gamification or robotic technology, as the most relevant variables. Therefore, it is necessary to promote adequate training plans that will enable the incorporation of ICT in high-quality education to be adapted to meet current demands and social conditions.

We understand that the conclusions proposed in this study should be interpreted cautiously. The non-experimental design and the nature of the non-probability sampling employed are associated with some limitations regarding the generalization and application of the results. Future research may consider a larger sample, differentiated by knowledge area. Furthermore, it is important to carry out international studies in order to extend the scope of the results and statistical techniques. Therefore, the aim is to continue improving and expanding the characteristics of this study to validate these preliminary findings.

Funding. This work was supported by the Department of Economy, Knowledge, Business and University of the Junta de Andalucía (Spain) under grant number US-1260616.

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