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Digital competence of Higher Education teachers in research work: validation of an explanatory and confirmatory model

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Abstract

This article demonstrates the validity and reliability of an instrument to evaluate the level of digital competence of Higher Education (HE) teachers in the use of digital resources in research work. The initial instrument was made up of a total of 22 items classified into four dimensions: (DIM. 1. Digital skills to search for information, manage it, analyze it and communicate results; DIM. 2. Digital ethics in digital research; DIM. 3. Digital flow in research work; DIM. 4. Anxiety towards the use of ICT resources for research). The instrument was applied to a final sample of 1709 teachers from different higher education institutions in Spain, from an initial sample of 1740. Reliability was measured using Cronbach's Alpha and composite reliability. To check the validity of the instrument, the validity of understanding and exploration of dimensionality was analyzed using Exploratory Factor Analysis (EFA), and the instrument was adjusted for the different models using Confirmatory Factor Analysis (CFA). IBM SPSS V.24 software was used for the AFE and AMOS V.24 software was used for the AFC. The result of the reliability analyzes were adequate and, in relation to construct validity, the results found a good fit of the model, both in internal validity and factorial invariance. The final version of the instrument consists of 12 items.

KEYWORDS: Digital Competence, Research Work, Instrument, SEM, Teachers, Higher Education

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1. Introduction

The digital competence of university teachers is an area that is closely linked to many of the challenges currently faced by the higher education sector, both from a local and global perspective (Agustí et al., 2023; Tomczyk & Fedeli, 2022). An adequate level of digital competence of teachers is not only one of the determinants of the level of digital maturity achieved by educational institutions (Michel & Pierrot, 2023; Mabić & Garbin Praničević, 2021; Jiménez Sabino & Cabero, 2021), but is also indicative of the level of adaptation of key HE stakeholders to the stage of development of the information society (Dzib Goodin et al., 2015). Research on the level of digital competence of HE teachers has become particularly important in the period of pandemic e-learning (Tomczyk et al., 2021; Demeshkant et al., 2020), in which thought has been given to how information and communication technologies (ICTs) are used in the teaching process. Research over the past few years has shown varying levels of preparation of university teachers for the use of ICT, whether in achieving teaching goals, creating digital learning materials or other activities typical of an academic environment (Schröter & Grafe, 2020; Weninger, 2022). A review of the literature in preparing teachers to use ICT

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effectively in their professional work, which includes more than just teaching activities (Guillén-Gámez & Mayorga-Fernández, 2021), forces the research question to be posed - to what extent are contemporary university teachers prepared to make full use of ICT capabilities in their professional work?

Posing such a question is entirely appropriate in the context of conducting effective qualitative and quantitative research using ICT.

This article is a study that fills an existing empirical gap in the diagnosis of research process-oriented digital competences among Spanish university teachers.

The dynamic development of digital tools used in higher education brings many opportunities for academics. The intensive implementation of new media into research processes is now not only a necessity, but also a challenge (Degn, 2023; Medeshova, 2023). The topic of effective digitalization of HE becomes a starting point for discussions on strengthening the functioning of the specific sector as a whole. Given one of the overarching missions that is associated with universities, namely, to conduct research, the challenge arises to what extent to combine the potential of ICT with strengthening the digital competences of academics. Having an adequate level of digital competence in this group is a prerequisite for planning, implementing and communicating research results. Considering the acceleration process of e-services development, special attention should be paid to the fact of preparation for effective functioning of modern scientists in the information society (Rosak-Szyrocka, 2024; Popescu et al., 2020). Adequate preparation to effectively exploit the potential of new media requires, according to the model proposed by the staff of the Spanish research centre InnoEduca (Guillén-Gámez et al., 2023; 2024), having four main pillars in the form of:

1. digital literacy in terms of finding information, managing it, analyzing it and communicating results;
2. awareness of digital ethics in research;
3. ability to apply digital workflow in research work;
4. low anxiety in using ICT resources for research.

The proposed model is based on profiling *digital competences* under a specific group of new media users (Guillén-Gámez et al., 2023), in which ICTs provide a basis for increasing the effectiveness of activities while changing attitudes towards new media with respect for ethics. The theoretical model adopted goes beyond the previous perception of teacher digital competence as skills narrowed down to the didactic or communication layer (Tomczyk et al., 2022). The present research is a unique attempt to understand the stage at which Spanish universities are at, where human capital characterized by adequately developed key competences is the main determinant of development.

The model proposed by Guillén-Gámez (2023) has a base pillar consisting of skills related to: finding the information necessary to conduct research, processing research data, producing research reports both addressed to professionals and research communications of a journalistic nature. Below is an infographic showing the research model used in the article.

Figure 1 - Scree Plot Graph. Own elaboration in Co-pilot.

An important component of this dimension is the skills of searching, processing, storing and sharing information. An important component of the first dimension is the ability to use software to process and organise qualitative data using popular software such as Atlas.ti, Nvivo, Ethnograph, Hyperresearch, Maxqda, QDA MINER, NUD*IST (Woods et al., 2016). Skills of this type are particularly useful for researchers anchored in the humanities and social sciences (Suyo-Vega et al., 2022). In the first pillar, Spanish researchers (Guillén-Gámez et al., 2023) highlight issues of skill in using audio and video editors to collect qualitative data. The ability to use software such as Adobe Premiere, iMovie, Windows Movie Maker, Audacity provides the ability to quickly archive statements in which audio and video are the focus of research (Birdsall & Tkaczyk, 2019). Without this skill, many important contexts may be missed, resulting in distorted conclusions. Among the determinants of baseline skills for any researcher, the ability to use statistical packages, such as: SPSS, EXCEL, JAMOVI, AMOS, R, Minitab (Bala, 2016). Among the key skills for any researcher is the ability to build a theoretical framework and interpret the collected results in relation to research conducted by other authors. To this end, the ability to search databases with scientific studies such as ScienceDirect, ProQuest, PsycINFO, Redalyc.org, Scielo, Academia.edu become a starting point in the process of preparing the research process, or attempting to summarize previous research developments in a given area (Harari et al., 2020). Knowledge of individual scientific databases in the Spanish model is combined with knowledge of the use of Boolean operators (AND, NOT, OR, XOR), which, when skilfully implemented, make it possible to speed up the data retrieval process while exploiting the potential of the most popular sites where researchers' work is archived (Chapman & Ellinger, 2019). In the adopted core competency model, an important element of the first pillar is the use of bibliographical managers (Mendeley Zotero Endnote, Refworks), which facilitate the creation of footnotes and also organise the papers of other authors (Butros & Taylor, 2010). The final two elements for this area are the skilful use of social media to promote and consult research findings, as well as to network with other researchers working in a similar area of research (Kavoura, 2014).

The second technical dimension of research is defined as *Digital ethics in digital research*. Research ethics is a starting point in all research, however, in the age of intensive digitalization it takes on particular importance due to the relative ease of intentional or accidental violation of the prevailing rules. In the proposed model, digital ethics refers to the issue of respecting copyright (Imfeld, 2003), the violation of which exposes researchers to legal and social consequences. An important skill in this category is the use of guidelines related to the structure of the article, including those related to the description of the research procedure, as well as the formatting of references sections according to APA v.7; Chicago, Harvard and others (Lipson, 2011). In digital ethics, it is not only the aforementioned technical formatting of research reports that is of particular importance, but also the verification of the originality of sources cited by other authors (Lawrence et al., 2001). The ability to verify data is linked to issues of being able to assess the quality of the journals in which the research results are presented. This issue is particularly important in the context of the need to weed out scientific reports from journals referred to as predatory journals (Severin & Low, 2019; Sarfraz et al., 2020). A final subcategory for digital ethics is the ability to assess the level of convergence of one's own with articles by other researchers. Such an activity requires competence in the use of software that searches for plagiarism levels (including self-plagiarism) (Bretag & Mahmud, 2009). Such an activity allows one to clearly identify the convergence of the definitions used and review the research in relation to other articles.

The third dimension entitled *Digital flow in research work* is a set of skills attributed to the motivational sphere of increasing research productivity through the use of ICT. According to the theory of J. V.Dijk (Scheerder et al., 2017) relating to increasing the level of digital competence, the motivational aspects are the starting point for effective inclusion, increasing the level of digitization, or increasing efficiency through the use of ICT in professional and private life (Van Laar et al., 2017).In this category, ICT use is linked to the visibility of achieving benefits through the implementation of ICT in the research process (Clark, 2010). The process of satisfaction with the use of new media in conducting quantitative and qualitative research is in realia with having an appropriate level of techno-optimism (Königs, 2022; Tomczyk et al., 2021), which becomes a major motivational factor for experimenting with new software to support research data collection and processing. The third pillar also includes a belief related to the motivation to use the software due to the achievement of goals relating to increased visibility through publication in prestigious journals (Stosic, 2017). It is worth noting at this point that many journals identified as prestigious have a requirement to use specific software, which allow research results to be presented in a standardized way. The final element in this category is the positive attitude towards exploring new software due to the increased efficiency of data analysis and effective dissemination. This category is also interesting in the context of supporting the development of research competences of academics and can be used as a starting point for designing solutions to support researchers in academia.

The last dimension of the theoretical framework proposed in this study is related to *anxiety towards the use of ICT resources for research*. It is a dimension that is linked not only to attitudes towards ICT, but more importantly to the emotional dimension that can be encapsulated in technopesimism (Tomczyk et al., 2021). Negative emotions and attitudes related to the use of ICT in education, is a relatively well-studied sphere (Moreira-Fontán et al., 2019; Adtani et al., 2023; Atiqah et al., 2024) and accounts for the frequency and effectiveness of the use of software capabilities in contemporary education. Within this category, several items related to the feeling of overwhelm that occurs in researchers who are forced by circumstances to have to learn new software to support the research process were identified. The issue of bitterness due to the changing coefficients describing the influence of journals also appears in this category (Pajić, 2015; Mason & Singh, 2022). The need to control parameters of this kind for some researchers appears as a waste of time, with no impact on the real level of research being conducted. For the fourth category, there also appears to be a determinant in the form of fatigue resulting from the need to control the impact of one's own research output on the level of recognition (Egghe, 2010) and the associated need to build a scientific profile in the media targeting scientists. The situation of having to increase one's own digitally mediated reputation can evoke a range of negative emotions and translate into a low evaluation of the contemporary model of evaluation of scientists. For the last category, a statement related to the occurrence of nervousness when there is a need to teach others how to use popular statistical packages was also proposed. This situation is related to the uneven level of digital skills related to the operation of software supporting the data analysis process among scientists. The fourth category also has a diagnostic indicator that generally summarizes negative attitudes towards ICT in the process of conducting research and reporting results. The last category, unlike the previous ones, marks the proposed theoretical framework's greater emphasis on the problems arising from the ubiquity of the digitization of the research process and the consequent need to accept or deny the typical activities undertaken in an increasingly digitalized higher education.

This paper fills an empirical gap on the digital competences necessary to function in an increasingly digitalized scientific environment. The study is part of an attempt to build an adequate and modern theoretical framework based on the diagnosis of elementary skills. The article also fills an empirical gap in terms of geographical focus. Currently, large-scale diagnoses of this type are rare and do not cover all the pillars outlined in the theoretical section above.

2. Method

2.1 Design and sample

A non-experimental ex post facto design was used. The type of sampling was non-probabilistic and intentional. The data are selected from a database belonging to the authors of 1740 Higher Education (HE) teachers belonging to the Spanish territory. To gather the necessary information, the main researcher of the study contacted the teachers via email, providing them with a link so they could complete a survey. Prior to beginning the questionnaire, teachers were informed about the importance of maintaining the confidentiality of the data. Table 1 shows the distribution of teachers by gender and age. In addition, teachers reported that they had participated in an average of 3.84±4.14 years in research projects in the last five years, as well as 50.84% of their working time was dedicated to research tasks.

2.2 Preliminary analyzes for the sample of participants

According to Kline (2023), there are some important things to keep in mind when validating a survey. First, missing data occurs when participants do not answer a question. We used Google Forms for the survey and marked all questions as required, which helped reduce unanswered responses. Second, we identify outliers using the Mahalanobis distance (D2). According to Kline (2023), it is suggested to eliminate observations with a p value less than 0.001 in the calculations of the distances P1 and P2. In this study, we removed 31 observations with p values reported by AMOS software. The final sample was 1709 participants.

2.3 Instrument

In this study, an instrument is created through a structural equation model (SEM) with covariances. This model arises from the causal model created by the main author (Guillén-Gámez et al., 2023) which mediates the integration of ICT in the teacher's research work, based on a series of endogenous and exogenous factors, classified into the following factors: digital skills to search for information, manage it, analyze it and communicate the results; digital ethics in digital research; digital flow in research work; anxiety towards using ICT resources for research; quality of ICT resources related to research; and intention to use ICT for research work. An SEM model was chosen for this study since the objective was to describe and understand the relationships between the factors, without necessarily implying an explicit causal interpretation as is the PLS-SEM model. After several initial tests, it has been decided not to take into consideration three factors from the PLS-SEM version, since both factors were grammatically prepared to be causal factors, and furthermore, they have not met sufficient psychometric properties to be included in an SEM model. The scale used to assess the digital perceptions of teacher-researchers was a seven-level Likert scale, where a score of 1 represented the lowest rating and a score of 7 indicated the highest.

Table 1 - Sample distribution.

	Sample		Age	
	Teachers	*Percentage (%)*	*Mean*	*Typical deviation*
Male	969	56.69%	49.61	29.03
Female	740	43.31	48.15	9.13

2.4 Procedure and verification of assumptions

The study followed the advice of Hair et al. (2010) to evaluate the psychometric properties of an instrument. It is suggested to collect samples between five and ten times the number of items in the questionnaire. In this study, a ratio greater than 124 was obtained, which exceeds the author's recommendations. The recommendation of Hinkin et al. (1997) was followed by randomly dividing the sample into two subgroups to verify the internal structure of the instrument. 902 subjects were used for the exploratory factor analysis (EFA) and the rest for the confirmatory factor analysis (CFA). IBM SPSS V.24 software was used for the AFE and AMOS V.24 software was used for the AFC.

For the first type of analysis, an Oblimin rotation technique was applied together with the Principal Axis Factorization method. In the second type of analysis, a structural equation modeling approach was employed using the polychoric correlation matrix, and robust estimators were used along with the maximum likelihood method. Convergent validity, which determines the certainty that the proposed items measure the same latent factor, was also evaluated using the average of the variance extracted values (AVE), following the guidelines of Cheung and Wang (2017). For discriminant validity, the MSV (maximum squared shared variance) index was examined.

Once adequate validity was established, multivariate normality was examined. This analysis consisted of comparing the Mardia coefficient with an acceptable threshold determined by the formula p(p+2) (Raykov & Marcoulides, 2008), where p represents the number of items. The validation of this assumption was carried out by contrasting the multivariate kurtosis obtained in SPSS-AMOS with the kurtosis calculated using the formula suggested by Ping & Cunningham (2013). The calculation was carried out considering the final 12 items of the instrument. The application of the formula yielded a value of 168, while the multivariate kurtosis index obtained in SPSS Amos Mardia was 14.483. Therefore, by observing that the Mardia coefficient was lower than the value provided by the formula, it was concluded that the assumption of multivariate normality was confirmed.

The last procedure was to check the internal consistency of the instrument, where different reliability coefficients were used such as Cronbach's Alpha and Composite Reliability (CR).

3. Results

3.1 Comprehension validity: statistical analysis of the items

In a first review, three types of dispersion measures were calculated. According to the scientific literature, the use of kurtosis and asymmetry coefficients is recommended, which should be within the range of ±1.5 (Pérez & Medrano, 2010). Likewise, in this evaluation, Meroño et al. (2018) suggest eliminating those elements with a standard deviation less than 1. In this context, the following items were excluded for future analysis: 1.4 and 2.2. As can be seen, items 2.4 and 2.5 are at the limit regarding skewness and kurtosis in order to meet the criteria established by the authors. However, these items meet the criteria of Meroño et al. (2018), therefore, the authors have decided to maintain this in the next analyses, paying special attention to the behavior of these items and how they contribute to the rest of the instrument. As can be seen in Table 2, all elements meet this criterion.

Finally, and within this type of validity, Asencio et al. (2017) advises checking the unidimensionality of the instrument through the correlation between the different dimensions of the instrument. The factorial correlation matrix in Table 3 shows how the correlations between factors range from small effect sizes to medium effects. For example, it is observed that there is a moderate correlation between dimension number 2 (Digital ethics in digital research) and dimension number 1 (Digital skills to search for information, manage it, analyze it and communicate results). A moderate relationship was also evident between dimension number 2 (Digital ethics in digital research) and dimension number 4 (Anxiety towards the use of ICT resources for research). The rest of the relationships obtained small weights.

3.2 Construct validity: exploratory Factor Analysis

Once the relationships between pairs of dimensions were verified, the unidimensionality of the instrument was analyzed through the EFA. For this, the Oblimin rotation method and the maximum likelihood method were used, since it was evident that multivariate normality existed through the Mardia coefficient. To check the adequacy of the items to their corresponding latent factors, Barlett's sphericity and the KMO index (Kaiser-Meyer-Olkin) were checked, whose values were adequate (KMO=0.814; χ^2=4320.000; sig.< 0.05).

Figure 2 illustrates the scree plot used to determine the final number of factors. It was observed that the number of factors in the scale was four. Table 3 presents the eigenvalues, explained variance, and cumulative variance of four factors with eigenvalues whose eigenvalues exceed the value one. According to the analysis and the values found in Table 3, it was found that the total variance of the 16 items was 59.36%.

Specifically, and as seen in Table 4, the first factor represents the highest percentage of true scores of the instrument (27.35%) and was dimension number 1 (digital skills to search for information, manage it, analyze it and communicate the results). The second factor with the highest percentage of variance (12.83%) was dimension number 4 (Anxiety about using ICT resources for research). The third factor was dimension number 3 (Digital Flow in research work), which explained 10.47% of the variance. The fourth factor was represented by dimension number 2 (Digital ethics in digital research) with 8.70% of the variance.

Table 2 - Central tendency and dispersion measurement statistics.

		TD	A	K
DIM. 1. Digital skills to search for information, manage it, analyze it and communicate results				
1.1	I know how to use software for the analysis of qualitative data (Atlas.ti, Nvivo, Ethnograph, Hyperresearch, Maxqda, QDA MINER, NUD*IST)	1.81	1.34	.55
1.2	I know how to use audio and video editors to create and edit collected information through interviews, focal groups, etc. (Adobe Premiere, iMovie, Windows Movie Maker, Audacity)	2.17	.02	-1.40
1.3	I have abilities necessary for analysing quantitative data (SPSS, EXCEL, JAMOVI, AMOS, R, Minitab)	2.04	-.59	-.93
1.4	I know how to search in scientific data bases (ScienceDirect, ProQuest, PsycINFO, Redalyc.org, Scielo, Academia.edu...)	1.40	-1.66	2.42
1.5	I know how to use Boolean operators (AND, NOT, OR, XOR) to refine my searches for scientific articles.	2.24	-.84	-.82
1.6	I have the skills to use bibliographical managers (Mendeley Zotero Endnote, Refworks) those which allow me to store bibliographic references and use such references in my studies following different citation rules.	2.12	-.44	-1.16
1.7	I have abilities in managing my scientific social media, add my published studies and/or consult their reading statistics	1.87	-.72	-.59
1.8	I usually use scientific social media to interact with other investigators.	2.00	.24	-1.15
DIM. 2. Digital ethics in digital research				
2.1	I apply the rules of copyright when I share the results of my studies through scientific social media.	2.33	-.35	-1.43
2.2	Before sending a study for its' publication, I digitally check it and apply the publication rules employed in every editorial/journal (APA v.7; Chicago, Harvard…)	1.64	-2.05	3.14
2.3	I check the original source, and the results of a study referenced by other authors in their original publications.	1.45	-1.41	1.47
2.4	I check that the bibliography selected for my study comes from journals with a certain grade of scientific prestige (for example, that they use paired revision "double blind")	1.44	-1.79	-3.00
2.5	I check that in my studies there is no self-plagiarism or plagiarism of other studies.	1.53	-1.79	2.58
DIM. 3. Digital flow in research work				
3.1	I find it gratifying to use ICT resources in my investigation works	1.51	-1.09	.80
3.2	I find it enjoyable to use software for the analysis of data both quantitative (SPSS, JAMOVI, R…) and qualitative, Atlas.ti, Nvivo…) to complete my research.	2.15	-.25	-1.30
3.3	I am motivated by the thought that by using digital software for data design and analysis I can more easily publish my scientific achievements in high-impact journals.	2.01	-.43	-1.00
3.4	I like to learn new digital resources that are going to allow me to analyse data and/or communicate the results in some software afterwards.	1.67	-1.17	.56
DIM. 4. Anxiety towards the use of ICT resources for research				
4.1	*It overwhelms me to think that I have to learn to use digital resources to collect data and analyse it with some software afterwards.	1.96	.61	-.88
4.2	*It makes me anxious to have to be constantly checking the impact indexes of the journals for if the quartile has increased or decreased.	2.13	.06	-1.35
4.3	* I get tired of having to constantly use ICTs to position and share my scientific publications and improve my digital reputation through the h-index and/or the i-index10.	2.09	.08	-1.31
4.4	* I get nervous when I have to teach a colleague and/or student some ICT resource related to research (Mendeley, SPSS, AMOS, Google form, Atlas.ti...).	1.73	1.21	.52
4.5	*In general, I would prefer not to have to learn or use ICT resources for my research.	1.66	1.43	1.26

Note: TD: standard deviation; A: asymmetry; K: kurtosis. Own elaboration. *Inverse items

Table 5 shows the latent dimensions obtained with their respective items, which show their factor weights. Items 1.1, 1.3, 1.5 and 2.1 were also eliminated when they showed coefficients below 0.4, as recommended by Lloret-Segura et al. (2014). For factor number 1 (digital skills to search for information, manage it, analyze it and communicate the results), this dimension included items 1.7, 1.8, 1.6 and 1.2. The second factor (Anxiety to use ICT resources for research) items 4.2, 4.3, 4.4, 4.1 and 4.5. The third factor (Digital Flow in research work) included items 3.3, 3.2, 3.4 and 3.1. The last factor (Digital ethics in digital research) included items 2.3, 2.4 and 2.5. The minimum value of the saturation values of the items was the minimum 0.437 and the maximum value 0.891. The rotation has converged in eight iterations.

3.3 Construct validity (confirmatory)

A CFA was carried out in order to evaluate the adequacy of the structure obtained in the EFA to measure the desired construct (Bandalos & Finney, 2016). The objective was to develop an instrument that was as simple and clear as possible, with fewer items, without compromising its reliability or validity. We began by evaluating the first model based on the latent structure obtained in the EFA. However, Table 6 showed that this model did not meet some of the fit criteria recommended by Hu and Bentler (1999), which led to the creation of a second model. In this new model, items that showed an excessively high correlation with other items of the instrument were eliminated, following Byrne's (2013) recommendation on modifications of indices (MIs) of correlations between items. Specifically, the following items were eliminated: 1.6, 3.1, 4.4 and 4.5. The indices analyzed have been the following: CMIN/DF (Mean Chi Square/Degree of Freedom), CFI (Comparative Fit Index) TLI (Tucker-Lewis index), NFI (Nomed Fix Index), IFI (incremental Fit Index), y RMSEA (Root Mean Square Error of Approximation).

Figure 3 presents the conclusive factor model derived from the CFA, along with findings related to the interaction between the underlying factors and their individual components. Furthermore, the normalized correlation coefficients are represented in Figure 1, which were obtained from the CFA results.

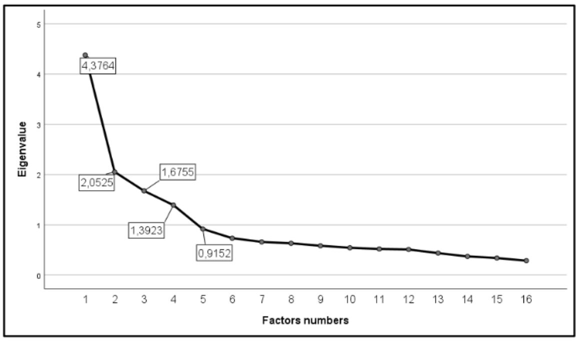

Figure 2 - Scree Plot Graph. Own elaboration.

Table 3 - Factor correlation matrix (λ = 1).

Factor	DIM. 2	DIM. 3	DIM. 4	DIM. 1
DIM. 2	1.000			
DIM. 3	.295	1.000		
DIM. 4	.380	.269	1.000	
DIM. 1	.348	.130	.249	1.000

Note: own elaboration

Table 4 - Eigenvalue and Explained Variance Table.

Factors	Total (Eigenvalue > 1)	% variance	% accumulated
1	4.376	27.353	27.353
2	2.053	12.828	40.181
3	1.676	10.472	50.653
4	1.392	8.702	59.355

Note: own elaboration

Table 5 - Rotated factor loadings.

	Factors			
Items	1	2	3	4
1.7	.891			
1.8	.730			
1.6	.467			
1.2	.437			
4.2		.735		
4.3		.733		
4.4		.626		
4.1		.587		
4.5		.466		
3.3			.828	
3.2			.695	
3.4			.653	
3.1			.509	
2.3				.724
2.4				.584
2.5				.577

Note: own elaboration

Table 6 - Model goodness-of-fit indicators.

Modelos	χ^2	C.M./df	CFI	IFI	TLI	NFI	RMSEA	90% CI
1º	739.779	7.549	.837	.838	.800	.818	.90	.084 - .096
2º	185.185	3.940	.947	.947	.925	.931	.060	.051 - .070

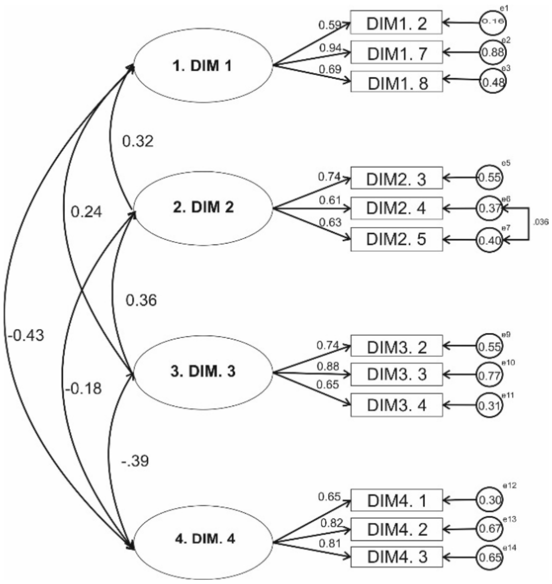

Figure 3 - Diagram of Confirmatory Factor Analysis.

The properties of this last model were also evaluated through convergent validity through several techniques. On the one hand, the AVE (Average Variance Extracted) coefficient was used, which must be greater than or equal to the threshold of 0.50, in recommendations by Hair et al. (2010) and Henseler et al. (2015). After carrying out the analysis, it was found that the AVE coefficients for the dimensions of the instrument had an acceptable level of convergent validity: DIM. 1 (.51), DIM. 2 (.50), DIM. 3 (.54) and DIM.4 (.54). On the other hand, the MSV index (Maximum Squared Shared Variance) was used to evaluate discriminant validity, which must be less than the AVE value for each factor (Fornell & Larcker, 1981). When examining the results, the discriminant validity between them is maintained: DIM. 1 (.088), DIM.2 (.088), DIM.3 (.059) and DIM. 4 (.036).

3.4 Reliability analysis

According to the literature, various techniques are used to evaluate the reliability of the instruments (Souza et al., 2017). According to Mallery (1999), it is preferred that the Cronbach's alpha value be close to or greater than .70. since a value less than .50 is generally unacceptable. These coefficients were calculated with CFA sample of study participants. The Composite Reliability (CR) index was very satisfactory: DIM.1 (.74), DIM. 2 (.74), DIM. 3 (.78) and DIM. 4 (.78). Cronbach's alpha also obtained values close to 7 or higher: DIM. 1 (.68), DIM. 2 (.70), DIM. 3 (.76) and DIM. 4 (.76). The total value of the instrument is .72 (taking into consideration that there are inverse items which must be changed in direction when doing the calculations).

4. Conclusions

The educational system is now completely digitalized, teachers at all levels are required to have digital skills, which are necessary to be able to do their jobs to the best of their ability. Most work processes now have a digital flow, and the same thing has happened to teaching, learning and research in the academic field. HE teachers cannot exempt themselves from this demand, also because nowadays the sharing of knowledge and science, travels through the main online search engines and within computerized databases containing articles from all the research institutions of the world (Ribeiro et al., 2023). Even the system of evaluation of a teacher's career no longer takes place only locally, but globally evaluation and recognition take place through the publication of articles on specific sites designated for this purpose.

For all the reasons listed, also in the light of the digital acceleration that took place during COVID-19, educational systems are called upon to provide adequate training and to have streamlined and effective tools available to detect the presence of the required digital competence (Saidy & Sura, 2020). Digitalization is a complex process; it can often create stress and anxiety for the teachers, in anyway, multifarious factors influence teachers' digitalization, and they can be individual or contextual (Cataudella et al., 2021). For example, Maican and colleagues (2019) find that teachers with higher levels of seniority in the academic field were more anxious and had lower levels of technology self-efficacy and, in general, they had a less favorable attitude towards the use of online technologies, focused on low performance and effort expectancy, low levels of hedonic motivation, and, consequently, low intention to use these applications in the future.

Digitization in doing research, in processing data, in creating a bibliography according to precise criteria and by means of specific computer programs, are aspects in which specific digital skills are necessary, otherwise one runs the risk of being cut off from a system that has precise 'digital' rules. In general, the main goal is to support the well-being of the HE teacher and help they're in being able to easily and daily use tools that can give feedback on what are their work and the results of their research.

The tool we present in this paper aims to be able to detect in advance what digital gaps are present among HE teachers so that we can intervene promptly with specific and appropriate support, so that we can also help designers to think more and more from the perspective of accessibility and usability of systems. The study shown good psychometric properties of the instrument. To validate the scale, various techniques were used: comprehension, construct, convergent and discriminant validity. The initial selection consisted of 22 items. First, the dispersion values were reviewed to adjust the successive correlations of the items, following the recommendations of Pérez & Medrano (2010) and Meroño et al. (2018). In addition, the Bartlett test was applied to perform the Exploratory Factor Analysis (EFA) and the principal axis factorization method with oblimin rotation was used. After the EFA study, a scale of 16 items distributed in four dimensions was developed. Two CFA models were tested where the second version was satisfactory, with a final version of 12 items. For this process, several fit indices were used, and the results were compared with the acceptable values indicated by Hu & Bentler (1999) and Kline (2011). When evaluating these indices, several models were created, and the final model showed that the results obtained were within the acceptable ranges specified in the literature. Furthermore, the discriminant and convergent validity of the instrument was verified, finding satisfactory values in both the Average Extracted Variance (AVE) index and the Maximum Shared Variance (MSV) index, as recommended by Hair et al. (2010) and Fornell and Larcker (1981).

In addition to evaluating and concluding on the psychometric properties of this measurement instrument, it is essential to consider future lines of research and its practical applications. To advance in this field, it is important to explore new samples and contexts to corroborate the robustness and generalizability of the instrument. This involves conducting longitudinal studies to observe its stability and consistency over time, as well as its sensitivity to changes in different settings and populations. As future work, it is particularly interesting to apply the questionnaire to a population of future teachers. These individuals, in their role as researchers in the classroom, must explore and refine the teaching-learning process for their future students. To do this, they need to develop advanced digital skills, crucial in contemporary educational research. Assessing these competencies in future teachers not only provides valuable data on their preparation and skills, but also identifies areas where specific training interventions are required. The implementation of this design in both national and international contexts allows a cross-cultural comparison, revealing differences and similarities in the formation of digital competencies in research work between different educational systems. This can inform educational policies and teacher training strategies at a global level, promoting a more homogeneous and effective approach in the preparation of Higher Education teachers.

Datasets and reproducibility

Datasets will be published as an addendum to the main paper.

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