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Psychometric properties of the digital competences scale in regular basic education teachers

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ABSTRACT

Since the introduction of technology in the classroom, there has been a growing demand for digital competencies, which has driven the need for validated instruments to assess this concept more prominently. Therefore, this study determined the psychometric properties of a self-assessment scale of digital competencies for teachers of Regular Basic Education. The study was carried out in the Unidad de Gestión Educativa Local (UGEL)/District Education Management Unit of Barranca and Huaura located north of Lima, Peru. A cross-sectional and instrumental quantitative methodological strategy was used, in which exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) techniques were used, and 534 teachers were surveyed. The results show an EFA with two factors and loadings greater than 0.4, a KMO equal to 0.957, and a cumulative variance of 51.30%. The CFA analysis validated three models, where model 2 with three factors, Evaluación y Promoción (EP)/Evaluation and Promotion; Recursos Digitales en la Enseñanza (RDE)/Digital Resources in Teaching; and Participación Profesional en el Aprendizaje (PPA)/Professional Participation in Learning, yielded high correlations and adequate goodness-of-fit indices close to unity (X^2/df =1.476; RMSEA=0.042; TLI=0.97; and CFI=0.97). It can be observed that model 2, which includes three factors, presents more appropriate measures, which makes it the most suitable option for assessing digital competencies in teachers of Regular Basic Education.

Introduction

During the last few years, technology has progressively entered education classrooms around the world. In the specific case of Peru, this process began with the implementation of Plan Huascarán (Decreto Supremo No 067–2001-ED Crean El Proyecto Huascarán, 2001); after this initiative, governments have reduced their involvement in educational technology-related educational projects of similar magnitude. A report indicated that one of the factors contributing to improved pedagogical practice is access to technology and the Internet, accounting for 56.8% of this factor (Minedu, 2018). In addition, teachers consider it essential to receive information about digital competencies and the use of information and communication technologies (ICT), to strengthen and improve their performance in this area (Valencia-Molina et al., 2016). However, the challenge facing education is to enhance the use of ICTs and concentrate efforts on teaching practice, which is one of the main pillars in the process of transforming education (Valencia-Molina et al., 2016).

Digital competencies, defined by Tondeur et al. (2023) as the safe, critical, and responsible use of digital technologies to learn, work and participate in society, are fundamental in the current educational context. These competencies not only involve engagement with technology, but also the ability to integrate it effectively into the teaching and learning process. In this scenario, teachers play a fundamental role, being the main mediators between students and digital tools. It is essential that teachers possess digital competencies that enable them to understand, evaluate, and communicate effectively using educational technologies (Ferrari, 2012; Fraillon, Ainley, Schulz, Friedman & Gebhardt, 2014; Krumsvik, 2011; Sailer et al., 2021). The assessment of these digital competencies in teachers is vital to ensure that they have the necessary skills to facilitate effective and enriching learning in the digital classroom. Therefore, continuous training and assessment of teachers' digital competencies are key elements for the success of education in this technologically advanced era (Kelly & McAnear, 2002;

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Napal, Peñalva-Vélez & Mendióroz, 2018).

In order to assess the digital competences of teachers, different measurement instruments have been developed (Calderón-Garrido, Carrera & Gustems-Carnicer, 2021; Chávez-Melo, Cano-Robles & Navarro-Rangel, 2022; A. Pérez & Rodríguez, 2016; Pozo-Sánchez, López-Belmonte, Rodríguez-García & López-Núñez, 2020; Rubach & Lazarides, 2021). The scientific literature presents several instruments that have emerged in recent years to assess digital competences. For example, Agreda, Hinojo and Sola (2016) developed an instrument that encompasses 63.38% comprehension across 19 components. In the same year, Siddiq, Scherer and Tondeur (2016) presented an instrument that measures digital information and communication skills, with satisfactory goodness-of-fit indices. On the other hand, Tourón, Martín, Navarro, Pradas and Íñigo (2018) developed an instrument that aligns with the digital competencies framework and provides a meaningful measure of teachers' digital competencies.

In Portugal, Dias-Trindade, Moreira and Nunes (2019) developed and validated a self-assessment scale based on the instrument developed by the EU Science Hub (European Commission's Joint Research centre), which aims to assess the digital competencies of teachers (Redecker, 2017). In addition, we found the instrument developed by Usart, Lázaro and Gisbert (2020), which allows teachers to self-assess their competencies and obtain instant feedback. Likewise, the instrument of Cabero-Almenara, Barroso-Osuna, Gutiérrez-Castillo and Palacios-Rodríguez (2020) enables the assessment of digital competencies based on international standards and indicators. In this perspective, an instrument developed by Rubach and Lazarides (2021) allows the assessment of teachers' basic ICT competence beliefs. Finally, in the context of the COVID-19 pandemic, Viñoles-Cosentino, Esteve-Mon, Llopis-Nebot and Adell-Segura (2021) validated a platform for formative assessment of teachers' digital competence, obtaining significant results. On the other hand, in Spain, Guillén-Gámez, Ruiz-Palmero, Colomo-Magaña, and Cívico-Ariza (2023) conducted a study to validate an instrument that measures the digital competencies of teachers in the use of YouTube as an educational resource. This instrument was meticulously analyzed to ensure its reliability and validity, focusing on teachers' ability to choose, integrate and efficiently apply YouTube in their teaching. The results confirmed that the instrument is effective and reliable for assessing teachers' specific digital skills in this context.

In Peru, the level of digital competence of regular basic education teachers has been examined, revealing a significantly high percentage of 49.89% (Laura-De La Cruz et al., 2023). However, to date, no rigorously constructed or scientifically adapted instruments have been identified in the Peruvian context to assess digital competencies in teachers. In addition, no evidence has been found of the existence of an instrument endorsed by the Ministry of Education or other public institutions to assess the development of these competences. Although several empirical studies and reviews about digital competencies in teachers have been documented in the Peruvian literature (Cateriano, Rodríguez, Patiño, Araujo & Villalba, 2021; Fernández, Leiva-Olivencia & López-Meneses, 2018; García, 2013; Holguin-Alvarez, Apaza-Quispe, Ruiz & Picoy, 2021; Rambay & De la Cruz, 2021; Sánchez, Fabián & Melgoza, 2021; Vieira, 2014), the lack of a validated instrument in this context is a priority issue. Therefore, it is essential to investigate the psychometric properties of the self-assessment scale in digital competencies of Regular Basic Education teachers, which was proposed by Dias-Trindade et al. (2019). This instrument, translated and adapted, allows both individual and general assessment of teachers' digital competencies.

The current research has addressed the lack of existing knowledge, as it has contributed by adapting an instrument and presenting psychometric properties through EFA and CFA. These analyses were supported by goodness-of-fit indices, such as chi-square (X^2), root mean square error of approximation (RMSEA), incremental fit indices (IFI, TLI, CFI), and PCLOSE. These indices have made it possible to evaluate the suitability of the proposed instrumental model. This allowed for methodological justification, given that many instruments in the Peruvian scenario have not been validated or adapted adequately in accordance with the established regulations (American Educational Research Association et al., 2018). In addition, the adaptation of this scale provides teachers with the opportunity to self-assess and evaluate their digital competence, which in turn allows them to reflect and take action for improvement. This tool also facilitates collaboration between stakeholders in educational institutions to improve teachers' digital competences. Therefore, the main objective of the study was to determine the psychometric properties of the self-assessment scale of digital competencies in teachers who teach in Regular Basic Education in the Unidad de Gestión Educativa Local/District Education Management Unit of Barranca and Huaura located north of Lima, Peru.

Digital competences

In the last decade, there has been a notable increase in the incorporation of digital tools in teaching and learning processes (Ramos, 2016). In this scenario, several theoretical perspectives have emerged to conceptualize digital competencies and their different dimensions within the educational environment. In relation to this, Koehler and Mishra (2008) highlighted the importance of examining teachers' knowledge regarding the integration of technology in their classrooms. In this sense, they proposed three types of knowledge: disciplinary, pedagogical, and technological. These dimensions make it possible to cover all aspects related to ICT that contribute to the improvement of teaching and learning. In contrast, Dias-Trindade et al. (2019) review six dimensions based on the digital competencies set out by the EU Science Hub (Redecker, 2017), which are mentioned below.

This study explores six key dimensions of teachers' digital competence. The first dimension, professional participation, focuses on the teacher's ability to communicate, collaborate, and develop professionally in a digital environment. The second dimension addresses the use, sharing and protection of digital technologies and resources. The third dimension focuses specifically on teaching and learning, highlighting how teachers can manage and organize digital technologies in the classroom. The fourth dimension examines assessment, considering how digital technologies can improve student assessment. The fifth dimension is dedicated to the training of students, emphasizing the use of digital technologies to promote inclusion, personalization, and active participation in the educational process. Finally, the sixth dimension highlights the importance of guiding students in the creative and responsible use of digital technologies (Dias-Trindade et al., 2019; Redecker, 2017).

This study focuses on the validation of a self-assessment instrument specifically designed to measure teachers' digital competences. Through this process, it is intended to establish a reliable and effective tool that allows educators to self-evaluate their skills in the integration of digital technologies in their pedagogical practices.

Materials and methods

Type and design of the study

The methodological strategy adopted was based on a cross-sectional and instrumental quantitative approach (Pérez, 2004; Pérez-Tejada, 2008). The main objective was the translation (Hambleton & Zenisky, 2011), adaptation, and validation of the instrument (Dias-Trindade et al., 2019). This process involved the participation of judges, conducting an initial pilot test and finally collecting data from the study population (Ato, López-García & Benavente, 2013; Muñiz, Elosua & Hambleton, 2013; Pérez-Tejada, 2008).

To determine the appropriate instrumental model, it was performed by means of the FEA and the equation $X=\Lambda \times \xi+\delta$ was considered as a starting point for the CFA that allowed to adequately explain the correlation between latent variables and these with the observable

variables (Manzano & Zamora, 2009).

Sample design

The participants under study are composed of teachers who are part of the Regular Basic Education in the UGEL of Barranca and Huaura, located north of Lima, Peru. This population is composed of 1710 teachers hired in UGEL N° 16 (Barranca) and 2661 teachers in UGEL N° 09 (Huaura), for a total of 4371 teachers, according to data obtained from the ESCALE, a system of the Education Statistics Unit of the Ministerio de Educación/Ministry of Education. Due to the circumstances caused by the COVID-19 pandemic, it was not possible to physically access all educational institutions in the UGELs, as teachers were teaching classes virtually and remotely. For this reason, we chose to use a non-probability convenience sampling method, which is one of the most used sampling techniques in similar situations (Stockemer, 2019).

To obtain a minimum sample size, we used the formula of (Soper, 2022), which determines the sample size a priori, especially for structural equation models. We considered an anticipated effect size equal to 0.30, a statistical power equal to 0.95, with 6 latent variables (dimensions of the instrument) and 21 observable variables (total items of the instrument) under a probability level equal to 0.05, we obtained a minimum size of 236 teachers to be surveyed to detect the effect. In addition, a minimum sample size for the structural model equal to 138 teachers was found. However, when applying the questionnaire, the sample recommended by Soper (2022) was exceeded, reaching a total of 534 respondents who have a mean age equal to 47 years, a standard deviation of 9.11, with a minimum age of 23 and a maximum of 67 years.

Table 1 shows the characteristics of the respondents, where 86.3% correspond to teachers and directors of UGEL N° 16 (Barranca) and 13.7% of UGEL N° 09 (Huaura), of which 59.4% are women and 40.6% are men. Moreover, of the 100% of the respondents, 85.4% are teachers and the remaining 85.4% are directors. In addition, revealing data indicate that the academic training of teachers and directors reflects that 56.7% have a Bachelor's degree, followed by 18.4% with pedagogical training, and 17.4% with a Master's degree.

Data collection

The technique used was the survey, which made it possible to explore the information required from a certain number of individuals (Grasso, 2006). The instrument that was adapted to the Peruvian context was the scale of self-assessment of Competencias Digitales en Docentes (CDD)/Digital Competencies in Teachers built by Dias-Trindade et al. (2019) based on the instrument of Redecker (2017), which seeks to assess the digital competencies of teachers. This instrument has 21 items grouped in six dimensions or areas. The first dimension is Participación Profesional (PP)/Professional Participation and is composed of four items; the second, Tecnologías y Recursos Digitales (TRD)/Digital Technologies and Resources which consists of 2 items; the third, Enseñanza y Aprendizaje (EA)/Teaching and Learning which is grouped into five items; the fourth, Evaluación/(E) Evaluation which consists of 3 items; the fifth, Formación de Estudiantes o Desarrollo de las Capacidades de los Estudiantes (FE)/Student Training or Development of Students' Capabilities which consists of 2 items; finally, the sixth dimension, Promoción de la Competencia Digital de los Estudiantes (PCDE)/Promotion of Students' Digital Competence which consists of 5 items. A list of 5 options per item has been used for the measurement (Appendix 1: https://osf.io/2fa5u/?view_only=6a8905de0b75492184725a0a3f02f635).

Table 1
Characteristics of the study sample.

Variables	Categories	Frequencies	Percentages
Sex	Male	217	40.6 %
	Female	317	59.4 %
Position	Director	78	14.6 %
	Teacher	456	85.4 %
Level of education attained	Pedagogical	98	18.4 %
	Baccalaureate*	32	6.0 %
	Bachelor's degree	303	56.7 %
	Master's degree	93	17.4 %
	Doctorate	8	1.5 %
UGEL	N° 16 (Barranca)	461	86.3 %
	N° 09 (Huaura)	73	13.7 %

Note.
* In Peru, the baccalaureate is a higher education degree (at the end of 4 to 7 years of undergraduate studies). UGEL = Unidad de Gestión Educativa Local/District Education Management Unit.

As already indicated, for the objective use of this scale, the translation from Portuguese to Spanish was carried out by a language specialist (Appendix 1), and then the translation was verified using a quality control sheet (Hambleton & Zenisky, 2011; Muñiz et al., 2013). At the end, content-based validity was verified by 6 expert judges with training and experience in the educational area, who evaluated the items on three criteria (relevance, representativeness, and clarity). With the judges' scores, all items were quantified using Aiken's V formula (Escurra, 1988; J. Ventura-León, 2019), subsequently, the averages by criteria were obtained, reaching an overall average equal to 0.87 (Table 2).

Finally, a pilot test was carried out in order to corroborate the reactions of the test and verify the direction and sense of the items, as well as other aspects considered at this stage (Muñiz et al., 2013). The results were satisfactory in terms of reliability and internal consistency through item discrimination. In addition, there were no observations from the respondents, which allowed the instrument to be applied with complete confidence.

Statistical analysis

To carry out the statistical analysis of the data collected, Microsoft Excel was used for data quality control. Subsequently, the data were imported into Amoví version 1.6 software, in which descriptive analysis, reliability assessment, and EFA were performed. In addition, AMOS Graphics software was used to perform the CFA.

In the descriptive and reliability analysis, statistics such as mean, standard deviation, skewness and kurtosis were used. In addition, the corrected homogeneity index was calculated and Cronbach's α coefficient (Contreras & Novoa-Muñoz, 2018) and the omega coefficient (ω) were used, opting for more robust congeneric models (Dunn, Baguley & Brunsden, 2014), compared to Cronbach's Alpha coefficient, for this, values >0.70 were considered acceptable (Hunsley & Marsh, 2018; Ponterotto & Ruckdeschel, 2007). Correlation analyses were performed by means of polychoric correlations as these were ordinal variables (Freiberg, Stover, De la Iglesia & Fernández, 2013).

An EFA was then performed using 50% of the sample. The criteria used for the EFA included sample adequacy assessed by the KMO value (Kaiser, 1974), which was considered adequate if it was ≥ 0.80 (Costello & Osborne, 2005; Ferrando & Anguiano-Carrasco, 2010) In addition, Bartlett's test of sphericity was performed to verify whether the correlation matrix was an identity matrix (Bandalos & Finney, 2010). In the same way, it was performed by means of principal axis factorization extraction with "Varimax" rotation, with factor loading coefficients ≥0.4 (Anderson & Gerbing, 1988) based to that of parallel analysis, due to the fact that the selection of the necessary common factors usually presents higher eigenvalues than what would be obtained if it were analyzed randomly (Horn, 1965).

The factorial structure was confirmed using CFA, which sampled 50% of the remaining data, considering the goodness-of-fit indices and established criteria (Alaminos, Francés, Penalva & Santacreu, 2015; Bollen, 1989; Brown, 2015; Catena, Ramos & Trujillo, 2003; De la Fuente, 2011; Hirschfeld & Von Brachel, 2014; Lorenzo-Seva &

Table 2
Content-based validity using Aiken's V judges and interpretation.

Criteria	M	SD	V de Aiken	V Interpretation	Confidence Interval	
					Lower	Superior
Relevance	2.74	0.44	0.91	Valid	0.71	0.97
Representativeness	2.63	0.60	0.88	Valid	0.66	0.96
Clarity	2.49	0.74	0.83	Valid	0.61	0.93

Note. *M*=mean; SD=standard deviation.

Ferrando, 2006; Ruiz, Pardo & San Martín, 2013; Westland, 2019). Prior to the analysis, the estimation and results outputs were configured in the AMOS software, maximum likelihood estimation, saturated and independent model fitting, standardized estimator outputs, minimization history, index modification, and other parameters necessary for this type of analysis were requested (Muthén, 1984, Muthén, du Toit, & Spisic, 1997); since this is a robust procedure for nominal or ordinal variables (Brown, 2015; Contreras & Novoa-Muñoz, 2018; Lei, 2009; Raykov, 2012); the verification of factor loadings was also taken into account. (Brown, 2015; Tabachnick & Fidell, 2019). Therefore, in the interpretation process, the model was contrasted through the absolute fit measures X^2, degrees of freedom, p-value, $X^2/df<3$, RMSEA, and P-CLOSE. On the other hand, the model was interpreted using the incremental fit index, comparative fit index, and Tucker Lewis (IFI, CFI, and TLI ≥ 0.95, respectively (Hu & Bentler, 1999), which allowed identifying the best indexes of the model.

Ethical aspects

This study was carried out considering all possible ethical aspects, so that an adequate responsible conduct of the research has been observed. In addition, we considered the rules of writing and citation style, in order to avoid plagiarism, in this sense, we requested permission from the authors of the instrument. Likewise, access permits were obtained from UGEL N° 16 (Barranca), who issued authorization N° 1826–2021-DUGEL-JAGP-UGEL N° 16-BCA, and from UGEL N° 9 (Huaura), who authorized access through the following authorization N° 095–2021/EEF-AGP-UGEL N° 09-H. With the permissions obtained, the survey was carried out both in person and through a Google form. The distribution of the survey was carried out in the educational institutions and through emails and WhatsApp messages, using the data provided by the UGELs and educational institutions. It is important to note that the survey included detailed instructions and informed consent on its first page. This allowed each teacher to have access to the necessary information and to decide whether to accept or refuse to participate in the study.

Results

Descriptive and reliability statistics

Table 3 presents the descriptive results, where the average mean is 3.11, the overall mode is equal to 3, and the standard deviation is 0.784. In addition, it is observed that the kurtosis of the items is negative, suggesting a relatively flat distribution. On the other hand, the skewness of most of the items is also negative, indicating a distribution skewed to the left. In all cases, the skewness and kurtosis values are within the acceptable range of −1.5 and 1.5, which indicates adequate variation in the distribution of the data and is suitable for factor analysis (Gravetter & Wallnau, 2013; Pérez & Medrano, 2010). Likewise, Table 3 shows the corrected homogeneity index, which values are >0.43 and the Cronbach's α values are above 0.8 as well as the McDonald's ω values (0.945), whose values show adequate reliability, and it is not necessary to eliminate or restate the items.

Table 3
Descriptive statistics and reliability of the items.

Items	M (3.11)	Mo (3)	SD (0.784)	As	Curtosis	CHI	If the Items is deleted	
							Cronbach's α (0.945)	McDonald's ω (0.945)
PP1	3.42	4	0.91	−0.33	−0.62	0.43	0.95	0.95
PP2	3.28	4	0.86	−0.36	−0.30	0.50	0.95	0.95
PP3	3.34	4	1.15	−0.28	−0.82	0.60	0.94	0.94
PP4	3.06	4	1.27	−0.24	−1.09	0.74	0.94	0.94
TRD1	3.31	3	0.96	−0.04	−0.26	0.50	0.94	0.95
TRD2	3.07	2	1.23	0.03	−1.04	0.72	0.94	0.94
EA1	2.89	3	1.06	0.21	−0.34	0.60	0.94	0.94
EA2	3.21	3	1.07	−0.13	−0.35	0.58	0.94	0.94
EA3	3.21	4	1.42	−0.36	−1.16	0.69	0.94	0.94
EA4	3.06	3	1.04	−0.26	−0.46	0.74	0.94	0.94
EA5	3.05	3	1.36	−0.19	−0.98	0.71	0.94	0.94
E1	2.86	3	1.12	0.10	−0.48	0.69	0.94	0.94
E2	3.60	4	1.15	−0.54	−0.61	0.50	0.95	0.95
E3	2.92	3	1.09	0.07	−0.55	0.75	0.94	0.94
FE1	3.19	3	1.16	0.02	−0.76	0.77	0.94	0.94
FE2	3.02	3	1.28	−0.13	−0.93	0.73	0.94	0.94
PCDE1	3.03	3	1.06	0.00	−0.77	0.56	0.94	0.94
PCDE2	2.90	3	1.03	0.02	−0.08	0.67	0.94	0.94
PCDE3	2.94	3	1.11	−0.11	−0.39	0.69	0.94	0.94
PCDE4	3.02	3	1.13	−0.17	−0.50	0.70	0.94	0.94
PCDE5	3.05	3	1.22	−0.16	−0.77	0.77	0.94	0.94

Note. *M*=mean; Mo=mod; SD=standard deviation; As=Asymmetry; CHI=corrected homogeneity index. PP = Participación Profesional / Participación Profesional; TRD = Tecnologías y Recursos Digitales/Digital Technologies and Resources; EA = Enseñanza y Aprendizaje/Teaching and Learning; *E* = Evaluación/Evaluation; FE = Formación de Estudiantes o Desarrollo de las Capacidades de los Estudiantes/Student Training or Development of Students' Capabilities; PCDE = Promoción de la Competencia Digital de los Estudiantes /Promotion of Students' Digital Competence.

Correlation and EFA analysis for evidence of validity of the internal structure of the items

Table 4 shows the polychoric correlation matrix, where positive correlations are observed with values > 0.2 <0.73 in the items. Knowing this correlation result, we proceeded to perform an EFA on 50% of the total sample, in which we found an overall KMO=0.957 and a significant Bartlett's Test of Sphericity ($\chi^2 = 3272$, df = 210 and a $p < .001$), which indicates that the correlation is an identity matrix, therefore, there is correlation between the items and we can proceed with the factor analysis. The analysis using the principal axis extraction method and Varimax rotation yielded 2 clearly identified factors: (1) the first factor by the grouping of its items we will call Formación, Enseñanza y Promoción (FEP)/Training, Teaching and Promotion, which contains factor loadings >0.447 and (2) the second factor we will call Participación Profesional con Recursos Digitales (PPRD)/Professional Participation with Digital Resources, where the items have loadings >0.419 with communalities >0.339. Additionally, it was determined that the first factor explains 32.4% of the variance, while the second factor explains 18.9% of the variance. The accumulated variance for both factors reached 51.30%, which exceeds the acceptable threshold established.

The CFA was performed using AMOS software, where the factor structure of the AFE analysis was followed to confirm the two-factor model (Fig. 1). This analysis allowed us to know and identify those high modification indexes (MI) in order to search for their covariances, which was not necessary since model 1 with 2 factors contained measures of absolute and incremental fit above the established parameters (TLI>0.90; CFI>0.90 and RMSEA <0.08) and with a high correlation between factors.

In order to find a better RMSEA, we proceeded to make a model 2 based on three factors (Fig. 1). These three factors have a cumulative variance of 52.1%, where Factor 1 is dominated by Evaluación y Promoción (EP)/Evaluation and Promotion, which has an explained variance of 22.3%. Factor 2 was named Recursos Digitales en la Enseñanza (RDE) / Digital Resources in Education, which achieved a variance equal to 15.4%. Finally, Factor 3, due to the characteristics of its items, was called Participación Profesional en el Aprendizaje (PPA)/ Professional Participation in Learning and has a variance equal to 14.7%. As can be seen in Fig. 1, high correlations between the three factors and adequate goodness-of-fit indices were obtained, reporting an X^2/df =1.476 with an RMSEA=0.042 and incremental measures of fit close to unity. However, despite having good goodness-of-fit indices, it was proposed to carry out a Model 3 (1 factor) and determine whether the instrument fits a single factor structure (Table 5). The results showed that the instrument can be used as only one factor since its absolute and incremental fit indices are above the statistically established parameters (TLI>0.90; CFI>0.90 and RMSEA <0.08).

Discussion

The main objective was to determine the psychometric properties of the scale for self-assessment of digital competencies in teachers, in which, in the first instance, content-based validity was found according to the criteria of relevance, representativeness, and clarity with valid Aiken V indicators. Then, it was possible to find an adequate factorial structure that extracted three models that determine the adequate structure of the digital competence self-assessment scale by obtaining adequate goodness-of-fit indices. The factor structure found in this study differs from the original structure of the Dias-Trindade et al. (2019), instrument, which consists of six factors: professional engagement, digital technologies and resources, teaching and learning, assessment, student training, and promoting students' digital competence. In contrast, in this study, the 21 items of the scale were grouped into a single factor, two factors, or even three factors, the latter factor structure being the most appropriate according to goodness-of-fit indicators.

The parameters established to validate the factor structure of the digital competencies self-assessment scale make it a suitable instrument for the context of Regular Basic Education institutions. In comparison with other instruments, such as the one developed by Pérez and Rodríguez (2016) the "Self-perception of teachers' digital competence" scale validated in this study shows high validity, with values above 0.80 in terms of clarity and relevance. These results suggest that teachers who participated in this study have a strong perception of their digital skills for pedagogical use, in contrast to the previous study that reported a lack of digital skills among faculty. Likewise, Siddiq et al. (2016) carried out the validation of digital information and communication skills, identifying three factors (access to digital information, evaluation of digital information, sharing, and communicating digital information) with goodness-of-fit indices within acceptable limits. These findings support construct validity and suggest that these digital skills are positively related to ICT self-efficacy for teaching, ICT use, and perceived usefulness of ICT. In addition, they highlight the importance that teachers attach to these digital skills in their sessions, beyond the frequency of ICT use.

Cronbach's Alpha coefficient is a measure of reliability that assumes that scores have a normal distribution. Therefore, when ordinal scales are used, as in this study, Cronbach's Alpha values tend to be underestimated. In this sense, the McDonald omega coefficient (ω) was used, which yielded values similar to those of the Alpha coefficient. This confirms the internal consistency of the instrument used in this study (Flora, 2020; Oyanedel, Vargas, Mella & Páez, 2017; Ventura-León & Caycho-Rodríguez, 2017). In relation to other instrumental studies on teachers' digital competencies they only report Cronbach's Alpha (Agreda et al., 2016; Aznar, Cáceres & Romero-Rodríguez, 2020; Chávez-Melo et al., 2022; Ruiz-Cabezas, Medina, Pérez & Medina, 2020; Sailer et al., 2021; Tourón et al., 2018); however, they do not report McDonald's ω, being adequate to determine reliability.

The goodness-of-fit indices suggest that the instrumental model used is adequate to assess the digital competencies of teachers in regular basic education. These results are partly related to the parameters found in the study by Tourón et al. (2018), which focused on validating teachers' digital competence, where they found factor loadings above 0.5 and mostly above 0.70, obtaining adequate overall goodness-of-fit measures. Therefore, the instrument made it possible to assess the competencies of the teaching staff. For their part, Aznar et al. (2020) validated a scale of digital competence based on information and literacy, and were able to obtain adequate indices, indicating that their instrument is valid and reliable for measuring digital competence in this specific area. In contrast to the other instrumental studies Sailer et al. (2021) highlights that there are no instruments that assess teachers' skills and attitudes for teaching with digital technologies. Their research, however, confirmed the factor structure and the relationship between the dimensions in their instrument, which supports the predictive validity of the construct. This suggests that teachers' self-assessment of technology-related skills can have a positive impact on facilitating learning activities, which is critical for student progress.

Studies by Agreda et al. (2016) and Ruiz-Cabezas et al. (2020) have contributed to the identification and validation of dimensions related to digital competencies in educational contexts. In the case of Agreda et al., four dimensions were identified and validated by expert judgment and internal structure analysis, showing that these dimensions explain a large part of the variance (63.38%). Ruiz-Cabezas et al. found the validity of the construct of digital competencies through expert opinion and obtained a high reliability with two factors with Alpha coefficients above 0.8. This indicates that their instrument is valid and reliable for measuring digital competencies, and that the identified factors explain 51.44% of the variance. However, in an initial educational setting, Usart et al. (2020) validated a tool (COMDID-A) for the self-assessment of teachers' digital competence, defining four dimensions: The first is aligned with didactic, curricular and methodological aspects; the second, with the planning, organization and management of digital resources; the third, with ethical, legal and security considerations; and

Table 4
Exploratory factor analysis and polychoric correlation matrix between items (EFA=267).

Items	Factor		h2	KMO (0.957)	Polychoric Correlation																		
	1	2			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PP1		0.57	0.65	0.91	1																				
PP2		0.55	0.64	0.95	0.45	1																			
PP3		0.59	0.55	0.93	0.50	0.43	1																		
PP4	0.65		0.42	0.94	0.37	0.45	0.59	1																	
TRD1		0.53	0.63	0.94	0.45	0.40	0.50	0.44	1																
TRD2	0.55	0.49	0.46	0.96	0.36	0.39	0.52	0.67	0.44	1															
EA1		0.70	0.45	0.96	0.48	0.48	0.55	0.48	0.46	0.53	1														
EA2	0.45	0.46	0.59	0.96	0.32	0.42	0.35	0.51	0.43	0.55	0.50	1													
EA3	0.65		0.46	0.97	0.35	0.39	0.47	0.64	0.42	0.59	0.46	0.55	1												
EA4	0.66		0.45	0.97	0.27	0.43	0.46	0.69	0.43	0.59	0.48	0.58	0.65	1											
EA5	0.70		0.40	0.97	0.35	0.37	0.48	0.65	0.48	0.62	0.49	0.53	0.60	0.67	1										
E1	0.65		0.50	0.96	0.35	0.40	0.36	0.54	0.43	0.49	0.41	0.45	0.59	0.56	0.63	1									
E2		0.50	0.67	0.91	0.34	0.46	0.42	0.28	0.32	0.47	0.50	0.45	0.39	0.38	0.35	0.42	1								
E3	0.72		0.36	0.97	0.26	0.39	0.46	0.67	0.39	0.61	0.50	0.55	0.60	0.69	0.67	0.60	0.48	1							
FE1	0.68	0.42	0.36	0.96	0.29	0.44	0.49	0.66	0.57	0.66	0.49	0.56	0.58	0.67	0.68	0.59	0.49	0.70	1						
FE2	0.73		0.39	0.97	0.30	0.38	0.52	0.63	0.40	0.60	0.45	0.48	0.59	0.63	0.64	0.64	0.39	0.67	0.68	1					
PCDE1		0.48	0.63	0.96	0.32	0.36	0.39	0.38	0.43	0.43	0.55	0.50	0.39	0.41	0.49	0.41	0.44	0.52	0.48	0.44	1				
PCDE2	0.62		0.50	0.97	0.30	0.34	0.50	0.58	0.43	0.57	0.44	0.44	0.50	0.54	0.60	0.54	0.35	0.66	0.66	0.60	0.52	1			
PCDE3	0.72		0.40	0.96	0.40	0.43	0.41	0.59	0.38	0.51	0.42	0.42	0.61	0.55	0.65	0.69	0.42	0.62	0.63	0.65	0.47	0.62	1		
PCDE4	0.75		0.38	0.95	0.29	0.35	0.40	0.52	0.35	0.56	0.38	0.52	0.64	0.60	0.59	0.65	0.43	0.64	0.66	0.72	0.45	0.60	0.68	1	
PCDE5	0.75		0.34	0.96	0.44	0.35	0.50	0.67	0.47	0.57	0.45	0.51	0.64	0.59	0.67	0.63	0.45	0.69	0.71	0.69	0.47	0.64	0.73	0.73	1

Note. The extraction method "principal axis factorization" was used in combination with a "Varimax" rotation h2: communalities; KMO: master adequacy [Kaiser Mayer Olkin]. PP = Participación Profesional / Participación Profesional; TRD = Tecnologías y Recursos Digitales/Digital Technologies and Resources; EA = Enseñanza y Aprendizaje/Teaching and Learning; *E* = Evaluación/Evaluation; FE = Formación de Estudiantes o Desarrollo de las Capacidades de los Estudiantes/Student Training or Development of Students' Capabilities; PCDE = Promoción de la Competencia Digital de los Estudiantes /Promotion of Students' Digital Competence.

CFA analysis for evidence of validity of the internal structure of the items.

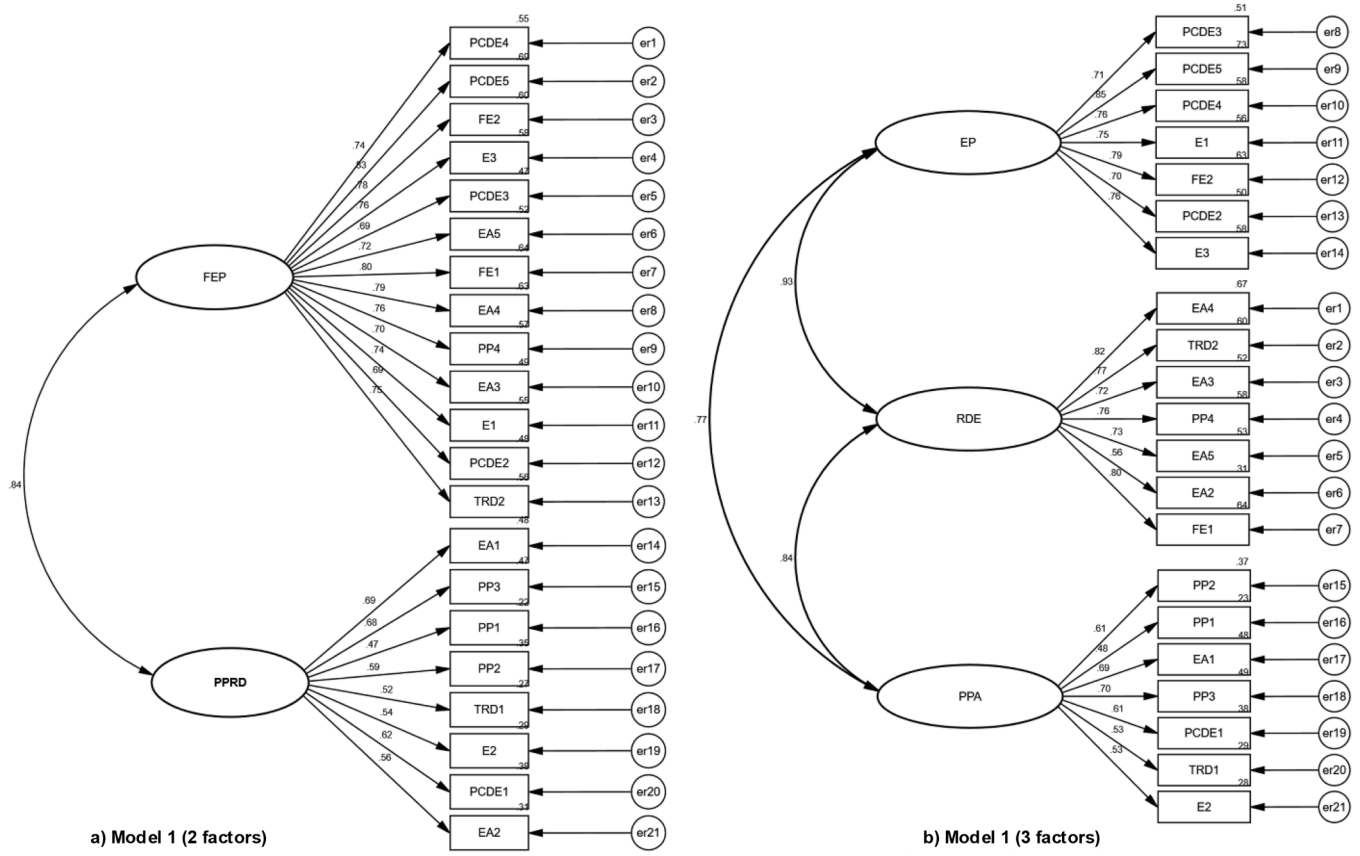

Fig. 1. Models with better goodness-of-fit indices (CFA=267).
Note. FEP = Formación, Enseñanza y Promoción/Training, Teaching and Promotion; PPRD = Participación Profesional con Recursos Digitales/Professional Participation with Digital Resources; EP = Evaluación y Promoción/Evaluation and Promotion; RDE = Recursos Digitales en la Enseñanza (RDE) / Digital Resources in Education; PPA = Participación Profesional en el Aprendizaje (PPA)/Professional Participation in Learning; PCDE = Promoción de la Competencia Digital de los Estudiantes /Promotion of Students' Digital Competence; FE = Formación de Estudiantes o Desarrollo de las Capacidades de los Estudiantes/Student Training or Development of Students' Capabilities; *E* = Evaluación/Evaluation; EA = Enseñanza y Aprendizaje/Teaching and Learning; PP = Participación Profesional / Participación Profesional; TRD = Tecnologías y Recursos Digitales/Digital Technologies and Resources.

Table 5
Confirmatory factor analysis (CFA=267).

Models	Absolute adjustment measures								Incremental adjustment measures		
	X^2	df	p-valor	X^2/df	RMSEA	LL 90	UL 90	PCLOSE	IFI	TLI	CFI
Model 1, (2 factors)	328.01	188	0.000	1.745	0.053	0.04	0.06	0.299	0.95	0.95	0.95
Model 2, (3 factors)	274.61	186	0.000	1.476	0.042	0.03	0.05	0.886	0.97	0.97	0.97
Model 3, (1 factor)	399.8	189	0.000	2.115	0.065	0.06	0.07	0.004	0.93	0.92	0.93

Note. The lower and upper limit (LL and UL) of the RMSEA parameter was performed with a 90% confidence interval.

the fourth, with the personal and professional development of the institution.

In contrast, Cabero-Almenara et al. (2020) focused on analyzing the validity and reliability of the digital construct for prospective teachers in a graduate setting. They discovered adequate indicators of validity and reliability, so that the digital competence questionnaire made it possible to generate scientific knowledge and knowledge to improve the quality of education. In contrast, Soldatova and Shlyapnikov (2015) conducted a study involving teachers, students, and parents for the purpose of assessing digital competencies. The results of this study revealed that teachers outperformed both students and parents in several aspects related to digital competencies. Specifically, teachers showed a higher frequency of Internet use, spent more time online each day, and had a stronger preference for using devices other than computers to carry out Internet-related activities. In addition, the researchers observed that teachers were more likely than students and parents to use smartphones and tablets as part of their digital activities.

Limitations

This study focuses on the evaluation of three significant models of teachers' digital competency self-assessment scale. However, it has some limitations, such as sample size. Although a significant sample was used, it was not sufficient to generalize the results because it was based on a specific population of Regular Basic Education teachers from two important UGEL in Barranca and Huaura (Peru), and the latter did not have a significant participation; the findings of the study remain valuable and provide relevant information on the digital competencies of teachers in this specific geographic area. On the other hand, it is important to mention that while the convenience sampling used in this study is justified by the constraints and challenges imposed by the COVID-19 pandemic, it is important to recognize the potential biases

inherent in this approach. This type of sampling may not be fully representative of the general population of teachers, as it relies on the accessibility and voluntariness of the participants; therefore, the findings should be interpreted with caution.

Future research

In future research, it would be beneficial to address some limitations identified in this study. First, it is recommended that the sample be expanded to include a greater diversity of regions and educational contexts, thus improving the generalizability of the results to a broader teaching population. In addition, it is important to employ sampling methods that ensure a more accurate representativeness of the general population of teachers, overcoming the limitations of the convenience sampling used in this study. Conducting research in different geographic and educational contexts would provide a more complete understanding of teachers' digital competencies in diverse settings. It would also be valuable to conduct longitudinal studies to observe the evolution of these competencies over time, as well as to investigate the influence of other factors such as access to technology and institutional support. These approaches would significantly enrich our understanding of digital competences in teaching and help overcome the limitations of the present study.

Implications for educational research

This study has significant implications for educational research. First, the validation of this scale in Spanish facilitates its application in educational contexts where Spanish is the predominant language, contributing to a better understanding and evaluation of the digital competencies of teachers in these regions. In addition, by identifying the three main factors - EP, RDE, and PPA - this study highlights critical areas of digital competence that need to be developed and improved in teacher education programs. This is especially relevant in the current era, where the integration of technology in education has become essential. Finally, by providing a reliable tool to measure teachers' digital competences, this study supports ongoing efforts to improve digital pedagogical practices in classrooms. This not only benefits the professional preparation of teachers, but also directly improves the quality of education students receive, better preparing them for an increasingly digitized world.

Conclusion

In conclusion, the teacher's digital competencies self-assessment scale, which consists of 21 items and has been translated into Spanish, is composed of three key factors in the context of regular basic education: (1) Evaluación y Promoción (EP)/Evaluation and Promotion, (2) Recursos digitales en la Enseñanza (RDE)/Digital Resources in Teaching, and (3) Participación Profesional en el Aprendizaje (PPA)/Professional Participation in Learning. The findings of this study indicate that the scale has adequate psychometric properties, ensuring a reliable and valid collection of information from the unit of study for teachers of Regular Basic Education.

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CRediT authorship contribution statement

Luis Alberto Geraldo-Campos: Conceptualization, Data curation, Formal analysis, Writing – original draft. **Romel Arturo Rosales-Gomero:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Juan Jesús Soria Quijaite:** Data curation, Formal analysis, Supervision, Writing – review & editing. **Jacksaint Saintila:** Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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