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Design and validation of an instrument to measure digital competence in elementary school students

Diseño y validación de un instrumento para medir la competencia digital en estudiantes de educación primaria

用于衡量小学教育学生数字能力的工具的设计和验证

Разработка и валидация инструмента для измерения цифровой компетентности у учащихся начальной школы

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Abstract

Introduction: Recent technological advances have transformed the ways of interaction and participation in society. Therefore, digital skills are necessary for citizens of the digital age. This paper describes the design and validation of an instrument to analyze and describe the digital competence of elementary school students; because the subject has not been sufficiently studied in such population.

Method: An instrument comprised of 5 sections was designed and it was applied in a pilot test to 143 students of 4th, 5th, and 6th grades. The validity of content was analyzed by expert judgment and different statistical tests were performed with the data. The construct validity was analyzed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Reliability was analyzed with measures of internal consistency through Cronbach's alpha and McDonald's omega.

Results: The reliability of the instrument is evidenced by an internal consistency of .946. Appropriate adjustments were made analysis thanks to the answers given by the judges both to the structure and items of the instrument, and the results of the EFA and CFA identified a structure that was consistent with the proposal for this instrument.

Conclusions: Evidence showed that the instrument has high levels of reliability and validity to analyze the digital skills of this population.

Keywords: Technology, digital competence, elementary education, validation, reliability.

Resumen

Introducción: Los avances tecnológicos de los últimos años han trasformado las formas de interacción y participación en la sociedad, ante esto las competencias digitales resultan indispensables para los ciudadanos de la era digital. El presente artículo describe el diseño y validación de un instrumento que permite analizar y describir la competencia digital del alumnado de educación primaria; población poco estudiada en el tema.

Método: Por ello se diseña este instrumento compuesto de 5 secciones, el cual fue aplicado en una prueba piloto a 143 estudiantes de 4to, 5to y 6to de primaria. La validez de contenido se analizó mediante juicio de expertos, con los datos obtenidos se realizaron diferentes pruebas estadísticas, también a través del análisis factorial exploratorio (AFE) y confirmatorio (AFC) se analizó la validez de constructo. La confiablidad se analizó con medidas de consistencia interna a través del alfa de Cronbach y el omega de McDonald.

Resultados: La confiabilidad del instrumento se evidencia obteniendo una consistencia interna de .946. El análisis de las respuestas emitidas por los jueces permitió realizar las adecuaciones pertinentes a la estructura e ítems del instrumento, asimismo, los resultados del AFE y AFC identifican una estructura consistente con la propuesta para este instrumento.

Conclusiones: Por tanto, se concluye que, con la evidencia proporcionada, el instrumento pose altos niveles de confiabilidad y validez para analizar las competencias digitales de esta población.

Palabras clave: Tecnología, competencia digital, educación primaria, validación, confiabilidad.

概要

简介：近年来的技术进步改变了社会互动和参与的形式，因此，数字技能对于数字时代的公民来说至关重要。本文介绍了对一种工具的设计和验证，该工具可以分析和描述很少被研究的小学生的数字能力。

方法：为此，我们设计了由5个部分组成的仪器，对四、五、六年级的143名学生进行了试点测试。通过专家判断分析内容效度，对获得的数据进行不同的统计检验，并通过探索性因素分析（EFA）和验证性因素分析（AFC）对结构效度进行分析。通过 Cronbach's alpha 和 McDonald's omega 的内部一致性测量来分析可靠性。

结果：仪器的可靠性通过获得 0.946 的内部一致性得到证明。对评判员给出的答复进行分析，以便对该工具的结构和项目进行针对性的调整。同样，EFA和CFA的结果确定了与该工具提案一致的结构。

结论：因此，可以得出结论，根据所提供的证据，该工具在分析该人群的数字技能方面具有高水平的信度和效度。

关键词：技术、数字能力、小学教育、验证、可靠性。

Аннотация

Технологический прогресс последних лет изменил формы взаимодействия и участия в жизни общества, сделав цифровые компетенции необходимыми для граждан цифровой эпохи. В данной статье описывается разработка и валидация инструмента, позволяющего проанализировать и описать цифровую компетентность учащихся начальной школы - малоизученной группы населения. Метод: Для этого был разработан инструмент, состоящий из 5 разделов, который был применен в пилотном тестировании к 143 учащимся 4, 5 и 6 классов начальной школы. Валидность содержания была проанализирована с помощью экспертной оценки, с полученными данными были проведены различные статистические анализы, а валидность конструкции была проанализирована с помощью эксплоративного факторного анализа (EFA) и конфирматорного факторного анализа (CFA). Надежность анализировалась с помощью показателей внутренней согласованности через альфа Кронбаха и омега Макдональда. Результаты: надежность инструмента подтверждается получением внутренней согласованности на уровне .946. Анализ ответов судей позволил внести соответствующие коррективы в структуру и пункты инструмента. Аналогичным образом, результаты AFE и AFC выявили структуру, соответствующую предложенной для данного инструмента. Выводы: Таким образом, можно сделать вывод, что с учетом представленных данных инструмент обладает высоким уровнем надежности и валидности для анализа цифровых компетенций данной группы населения.

Ключевые слова: технология, цифровая компетентность, начальное образование, валидация, надежность.

Introduction

Information and Communication Technologies (ICT) and the Internet have become increasingly important today and their use is necessary to perform various processes and activities in all aspects of our daily lives. That is why citizens of the digital age must have the knowledge, skills and attitudes that enable them to participate and collaborate in the knowledge society (Silva Quiroz & Lázaro-Cantabrana, 2020).

Digital competence is an important, necessary, essential, and permanent element to live in an increasingly digitized society and take advantage of the potential and benefits offered by ICT. For the United Nations Educational, Scientific and Cultural Organization (UNESCO) this concept refers to a set of skills that allow the use of digital devices, applications, and networks, to access and manage information, create, and share digital content, communicate, collaborate and solve problems in social activities in general (UNESCO, 2018).

This digital competence is not only comprised of digital knowledge and skills, which would represent the technical part, but also involves an attitudinal and affective component, as it seeks the development of a critical, ethical, and responsible stance (Wang et al., 2021; Falloon, 2020; Janssen et al., 2013). This is no longer considered optional but has become a critical and essential competence for all individuals (UNESCO, 2018; Organization for Economic Co-operation and Development [OECD], 2016).

Given this, in recent years part of the research in technology and educational technology has been focused on the analysis of digital competences in students, teachers and women (Domínguez et al., 2019; Gisbert et al., 2016, Domínguez, 2016), however, evaluating or assessing this competence has become a challenge. The development of instruments to assess the level of competence of individuals, either for diagnostic or certification purposes has been a concern for researchers in this field (Silva Quiroz & Lázaro-Cantabrana, 2020; Gisbert et al., 2016).

In specialized literature, it is found that different instruments and tools for the assessment of digital competence are mostly designed for higher education and sometimes do not consider all of the elements comprised in the concept (Luna Villanueva & Canto-Herrera, 2021; Silva Quiroz & Lazaro-Cantabrana, 2020; Larraz et al, 2012).

Although there are important precedents on the measurement of this concept at the elementary education level, the subject has not been amply analyzed in this population (Baeza-González et al., 2022; Martinez Serrano, 2018), specifically among elementary school students. In Latin America, no frameworks or guides have been developed on the digital competence of these students (Henriquez-Coronel et al., 2018) so the construction of instruments to assess or evaluate their digital competence is a complex and unfinished task.

As mentioned above, because there is no reference framework for measuring digital competence in this population, there are no definite or standardized tests, so most researchers design their own measurement instruments.

The following Table 1 show descriptions of some of the instruments that were identified after reviewing the literature, and that have been used among this population.

Table 1

Description of instruments to assess the digital competence of elementary school students.

Author	Population	Characteristics	Dimensions / Sections	Validity and reliability	Limitations
Aesaert et al. (2014)	Elementary school students aged 10 to 13	• Performance-based digital testing • Direct measure of competence using item response theory. • Simulation-based evaluation tasks • Dichotomous score (1: correct; 0: incorrect) • 27 items • Assesses 19 higher-order competencies and 15 technical skills	• Digital information retrieval and processing • Communication with a computer	• IRT Calibration • Classic item analysis • Indices of discrimination • Nonlinear factor analysis with values greater than .90 • Local independence • Test χ^2 • Expert judgement • α= .86	• Does not provide an item-level degree of mastery. • The test was conducted with 6th graders. • The instrument shows good reliability for measuring average to low skill levels but is less accurate for measuring higher skill levels. • Attitudinal and/or affective dimension is not included

Pérez Escoda et al. (2016)	Elementary school students	• Closed-ended questionnaire.
		• Five-point Likert scale (5= Strongly agree, 1= Strongly disagree)
		• 32 items
			• ICT use and frequency of use in informal settings.
			• Degree of integration of ICT into everyday activities
			• Dimensions of digital competence
			  • Information
			  • Communication
			  • Content creation
			  • Security
			  • Problem solving
				• Initial exploratory analysis
				• α= .89
					• Pilot test with 15 students
					• Lack of evidence of construct and criterion validity.
					• The attitudinal and/or affective dimension is not included.

Fifth and sixth grade elementary students	Standardized questionnaire Five-point Likert scale (5= Always, 1= Never) 30 items	• Knowledge and use of ICT in social communication and collaborative learning • Knowledge and use of ICT • Knowledge and use of applications • Knowledge and use of multimedia resources • Device and Internet accessibility	• α= .900	• Lack of validity tests. • Attitudinal and/or affective dimension is not included.	

Author	Population	Characteristics	Dimensions / Sections	Validity and reliability	Limitations
Elementary and secondary school students	Based on the contributions of Ala-Mutka (2011) and the European project DIGCOM Self-assessment scale Likert scale 22 items	• Basic computer and internet skills • Participation and collaboration through the network • Resource and content creation skills • Digital awareness • Computer as a mediating tool • Digital culture • Access and use of digital platforms.	• Exploratory factor analysis • α= .822	• Does not specify what dimensions were analyzed. • Attitudinal and/or affective dimension is not included	
Elementary school students	Based on the Digital Skills for All program (SEP, 2011) and the standards proposed by the ISTE (2007). Measures ICT use in general. Five-point Likert scale (5= Always, 1= Never) 11 items	• The use of ICT in daily life	• Confirmatory factor analysis	• Lack of reliability and validity testing. • Attitudinal and/or affective dimension is not included.	
Villegas Pérez et al. (2017)	Elementary school students	• Based on the Digital Skills for All program (SEP, 2011) and the standards proposed by the ISTE (2007). • It is related to the use of ICT in school. • Five-point Likert scale (5= Always, 1= Never) • 10 items	• Using ICT for communication at school • Use of ICT in schools	• Confirmatory factor analysis	• Lack of reliability and validity testing. • Attitudinal and/or affective dimension is not included.

Author	Population	Characteristics	Dimensions / Sections	Validity and reliability	Limitations
Martinez Serrano (2018)	Fifth and sixth grade elementary school students	• Five-point Likert scale (5= Never, 1= Always) • 31 items	• Unspecified	• Split-half reliability test. • Expert judgement • Exploratory factor analysis • α= 0.906	• Does not specify theoretical references or dimensions analyzed. • Attitudinal and/or affective dimension is not included.
Martínez-Piñeiro et al. (2019)	Sixth graders	• Based on the Competence model proposed by DIGCOMP • There are correct answers. • 108 items	• Knowledge • Capabilities • Attitudes	• Expert judgement • α= 0.890	• Lack of construct and criterion validity tests.
Baeza-González et al. (2022)	Fifth and sixth grade elementary students	• Online questionnaire • Based on the Departament d'Ensenyament • Multiple choice questions (4 choices, 1 correct) • 10 items	• 4 dimensions addressing 10 competencies	• Expert judgement • Point-Biserial correlation coefficient • Exploratory factor analysis • Ordinal alpha index (α=0.757)	• The test was conducted with 5th and 6th grade students. • Attitudinal and/or affective dimension is not included.

As can be seen, the instruments previously presented have characteristics that make them different from each other and in most cases exclude the attitudinal and affective component, which is a fundamental element for the development of a competence (García-Valcárcel, 2013).
Given this, it is a priority to have the necessary tools to identify, describe and evaluate the digital competence of younger students, since this represents fundamental processes for their future inclusion and participation in society (Díaz-Arce & Loyola-Illescas, 2021; Heidari et al., 2021; Barbudo et al., 2021); it also prepares them to be citizens of a globalized world order and equips them with the skills necessary for the twenty-first century (Casillas-Martín et al., 2020; Alvarado Martinez, 2020; Van Laar et al., 2020). Digital competence is not only socially and educationally important for children, but the development of this competence is also important for their health. The U.S. Department of Health and Human Services (2000) stresses how important it is for children to have suitable digital skills, so they can identify and evaluate health-related Internet-based information.

That is why this topic is progressively included in the official documents of government agencies around the world, to emphasize its importance and to provide students with these digital skills (Tzafilkou et al., 2022). In addition, this theme turns out to be of utmost importance in today's society since its study contributes to the achievement of the sustainable development goals (SDGs), of the agenda for 2030 of the United Nations (UN), contributing to objectives 4 and 10 related to the achievement of quality education and the reduction of inequalities respectively; as well as contributing to the increase of the amount and depth in the use of ICTs in citizens of all ages, an objective set out in the National Digital Agenda (NDA) for Mexico.

Because of the above mentioned, this project aims to develop and validate an instrument to analyze and describe the digital competence of elementary school students. This instrument aims to collect information to describe the digital competence of upper elementary students (4th, 5th and 6th grade), identifying the knowledge, skills and attitudes they have towards ICT, as well as the emotions they experience when using them.

Methods

This instrument consists of 5 sections: The first section collects general information such as age, sex, and grade; students are also asked for information about their technological devices at school and at home, as well as the frequency of their use.

Section two is about knowledge. It includes items to answer the question *"How much do you know about..."*. It has a Likert-type scale with four gradually ascending response options (which is used throughout the instrument) this scale aims to answer the question: "*how much do I know?*" The items included in this dimension talk about knowing how to search for information on the Internet, how to communicate and collaborate online, how to create digital resources, digital security and how to solve simple technical problems.

Section three of the instrument aims at completing the sentence *"I can..."* with the skills which correspond to the knowledge of using ICT presented in the previous section. This section answers the question: "*how well I am able?*"

Section four focuses on students' attitudes toward the use of ICT and aims at answering the question: *"How much do I act this way?"*

Finally, section 5 corresponds to the emotions experienced by students when they use ICT. As in the previous sections, the aim is to answer the question: *"To what extent do I experience?"*

Table 2 shows the distribution of the items in each of the sections already mentioned, as well as the scale of the response options.

Table 2

Distribution of the items of the instrument about Digital Competence

Section	Number of items	Items	Scale
General Information	25	1 - 25	1. Not at all 2. A little 3. Somewhat 4. To a great extent
Knowledge	16	26 – 41	
Skills	19	42 – 60	
Attitudes	10	61 – 70	
Emotions	26	71 - 96	
Total:	96		

As can be seen in the table above, we tried to maintain a relationship between the number of items in the knowledge section and the skills section, however, some knowledge is used to practice more than one skill, which is why the number of items in the skills section is slightly higher than that of knowledge.

The last section, about emotions, is the largest section of the instrument and that is due to the theoretical foundation on which it was built. For this section, the classification of emotions by Robert Plutchik (1980) was taken as a reference. This author identifies 32 emotions classified into four categories. However, for the purposes of the instrument, only 26 of them were considered, eliminating those that were not relevant to the study , because of their nature, or those that were difficult to understand because of the age of the participants.

Procedure to develop the instrument

The process of developing the instrument consisted of the following four phases:

Phase 1. In the first phase a literature review was carried out to identify reference frameworks or standards regarding the digital competences that elementary or basic education students must have. The lack of a guiding document focused on this specific population was evident.

Therefore, the European Framework of Digital Competences for Citizenship (DigComp 2.1) (2018), was taken as a reference to develop this instrument, as well as the Basic Education Curriculum of the Secretariat of Public Education (SEP), named Key Learnings for Integral Education (2017), and the Classification of Emotions through the wheel of emotions by Robert Plutchik (1980)

Phase 2. This phase consisted of the drafting of the items of the instrument, the aim was that the items were clear and brief, taking into consideration the information obtained from the literature review. We tried to maintain a language that was easy to understand throughout the instrument, so that the students can respond each item without problems.

Table 3

Example of the items

Section 3. Skills				
Remember: By "skills" we mean everything you can do.				
I can...	How well I can?			
	Not at all	A Little	Somewhat	To a great extent
1. Create a digital presentation by adding text, images, and visual effects on a topic of some kind.				
2. Use regular chats (e.g., Messenger or WhatsApp) to talk to my classmates.				

Phase 3. Once the instrument was completely developed, it was submitted to expert judges, who analyzed the instrument and issued recommendations, which were taken into consideration to make adequate modifications.

Phase 4. Finally, a pilot test was carried out with the last grades of elementary school students. It should be noted that the data collection was carried out at three moments between February and April 2022 in different institutions of the state of Yucatan, due to issues of logistics and organization with the relevant authorities in the participating institutions.

Participants

143 students attending the 4th, 5th and 6th grade of elementary education participated in this pilot test. The sample selection was carried out through a non-probability, purposive method (Otzen & Manterola, 2017), since only those elementary school students who attended some grade of upper elementary in public schools of the state of Yucatán participated. The final sample consisted mostly of women (n = 74; 51%) and they were between 9 and 14 years old, with a mean of 10.84 years (SD = .932). At the time of data collection, 48% (n = 69) of the students were in the 6th grade, 43% (n = 62) were in 5th grade and only 8% (n = 12) were in 4th grade.

Data analysis

The statistical program Statistical Package for the Social Science (SPSS) version 25 was used for the analysis of the data collected and to perform the relevant tests.

Cronbach's alpha and McDonald's omega were used to analyze the reliability of the instrument by measuring internal consistency, in which point estimates were reported, as well as confidence intervals of 95%.

The validity of content was analyzed by means of the judgment of experts and the calculation of the interquartile range of the scores provided by them. Additionally, Fleiss's Kappa was calculated to identify the degree of agreement between judges.

Finally, through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), the internal and construct validity of the instrument was analyzed. Prior to carrying out these tests, the Kaiser-Meyer-Olkin adequacy test (KMO) was carried out to check the degree of joint relationship between the variables, as well as the Bartlett's test for sphericity. The EFA was performed using the Principal Axis method of extraction with an oblique rotation (oblimin) and the items with a factorial loading higher than 0.30 were selected, using Parallel Analysis as a method of factor selection. Regarding CFA, the diagonal weighted least squares (DWLS) through a robust estimation method was used, and the model adequacy measures were reported.

Ethical considerations

This project was approved by the Academic Committee of the master's degree in educational research (CAMIE) of the College of Education, at the Autonomous University of Yucatan, through agreement number CAMIE-021-033. Permission from the educational institutions and the informed consent of the parents of the participating children was requested throughout the process. The instrument was anonymous, and the instrument was applied by the teacher in charge of the class.

Results

Reliability

The result of the analysis of Cronbach's alpha coefficient and McDonald's omega, presented below in Table 4, show high levels of internal consistency in all dimensions, since in all cases the values were higher than .70, which are considered as recommended levels. That is why the instrument is believed to have consistent and reliable values.

Table 4

Reliability results of the instrument about Digital Skills

Dimension	Cronbach's α	McDonald's ω
Knowledge	.890 (.861- .914)	.891 (.865- .917)
Skills	.946 (.932- .958)	.946 (.934- .960)
Attitudes	.881 (.849- .908)	.882 (.854- .911)
Emotions	.851 (.812- .884)	.859 (.738- .837)
Total scale	.936 (.920- .950)	.939 (.917- .949)

**Note*: confidence intervals are reported in parentheses

Content validity

Validation by expert judgment was performed to verify the validity of content, in order to identify the degree to which the instrument covers the content it is supposed to measure (Yaghmaie, 2003). The judging was carried out by three expert researchers in educational technology and in working with children at the ages of the participants.

Interquartile range

To interpret the expert judgment those items that had an interquartile range (IQR) between 0 and 1 are accepted without modifications, while those that were between 1 and 2 require some modifications before included. While, those items that scored above 2 would be eliminated from the instrument. The results of the interquartile analysis provided evidence that no item registered scores above 2, so the items in the instrument were accepted without modifications in the validation by expert judgment.

Fleiss's kappa

With this measurement, we aimed to identify the level of agreement among the judges who analyzed the instrument. Kappa values range from -1 to 1 this means that the higher the value, the stronger the agreement between judges (de Ullibarri Galparsoro & Pita Fernández, 1999). The results of this test helped us to identify that the level of agreement between judges was weak in all dimensions of the instrument (Knowledge (κ = .166); Skills (κ = - .161); Attitudes (κ = - .031); Emotions (κ = - .452)).

The analysis of these results, as well as the answers issued by the experts, led to the modification of some items, based on the recommendations they provided. Likewise, taking into consideration the above-mentioned, some items that were considered irrelevant were also eliminated.

Construct validity

The analysis of construct validity was carried out through the EFA and the CFA and it was necessary to analyze the result of the Kaiser-Meyer-Olkin test (KMO = .803) to select the appropriate matrix for factorization. Additionally, Bartlet's test for sphericity (x2 = 6479; gl = 2485; p = <.001) was performed, to reject the null hypothesis and conclude that the items are sufficiently correlated with each other to assume the existence of latent factors.

Exploratory factor analysis

The EFA was performed to identify the underlying structure of the items, the results obtained from this analysis identified a distribution of six factors that explain 45% of the variance, as shown in Table 5.

Table 5

Summary of the factors obtained in the exploratory factor analysis

Factor	Sc Loads	% of variance	% Cumulative
1	10.23	14.41	14.4
2	5.66	7.98	22.4
3	5.80	8.17	30.6
4	3.87	5.45	36.0
5	3.37	4.74	40.8
6	3.16	4.46	45.2

The distribution of the items in the six identified factors is presented in Table 6; the first factor identified is made up of 20 items, of which 19 correspond to skills and only one is about digital knowledge. On the other hand, the second factor consists of 11 items focused on negative emotions. In the third factor, the items related to attitudes are grouped and only one corresponding to an emotion is included, giving a total of 11 items in this factor. The fourth factor contains items related to emotions; in this factor positive emotions are presented, but three negative emotions are also present. The last two factors are comprised by knowledge; Factor five contains six items related to the search for information and the creation of digital resources. The last one, factor six, is comprised of six items focused on the use of websites and applications.

Table 6

Factor analysis extraction of main axis with oblimin rotation

Item	Factor					
	1	2	3	4	5	6
Identifying websites to search for information (S)	.764					
Search for websites tailored to their needs (S)	.749					
Cloud-based storage (S)	.730					
Rating appropriate websites for information (S)	.725					
Cloud-based storage (S)	.695					
Digital risks and threats (S)	.686					
Digital resources (S)	.673					
Browsing on different websites (S)	.659					
Collaborative work in digital environments (S)	.658					
Online questionnaires (S)	.655					
Animated presentations (S)	.645					
Netiquette (S)	.642					

Item	Factor					
	1	2	3	4	5	6
Licenses, Restricted Material and Copyright (S)	.635					
Common chats (S)	.634					
Online forums (S)	.628					
Audiovisual material (S)	.607					
Identification of simple technical problems (S)	.545					
Keywords to search for information (S)	.523					
Accessing the internet on different devices (S)	.440					
Netiquette (K)	.384					
Anger (E)		.764				
Annoyance (E)		.760				
Boredom/nuisance (E)		.750				
Rage (E)		.719				
Horror (E)		.650				
Fright (E)		.629				
Disappointment (E)		.620				
Distraction (E)		.580				
Hate (E)		.572				
Fear (E)		.506				
Sadness (E)		.491				
Flexibility (A)			.762			
Patience (A)			.688			
Innovation (A)			.684			
Discipline (A)			.654			
Tolerance (A)			.634			
Organization (A)			.609			
Responsibility (A)			.606			
Self-assessment (A)			.592			
Willingness (A)			.553			
Respect (A)			.510			
Approval (E)			.394			
Excitement (E)				.628		

Item	Factor					
	1	2	3	4	5	6
Astonishment (E)				.612		
Admiration (E)				.591		
Surprise (E)				.535		
Optimism (E)				.498		
Joy (E)				.459		
Interest (E)				.439		
Peacefulness (E)				.407		
Fear (E)				.396		
Shyness (E)				.391		
Anticipation (E)				.362		
Aversion (E)				.350		
Alertness (E)				.320		
Confidence (E)				.317		
Digital resources (K)					.559	
Search for websites tailored to your needs (K)					.491	
Operation of digital devices (K)					.457	
Digital resources (K)					.402	
Digital risks and threats (K)					.402	
Audiovisual material (K)					.400	
Identifying websites to search for information (K)					.356	
Identification of simple technical problems (K)					.342	
*Online study strategies (K)						
Licenses, Restricted Material and Copyright (K)						.613
Cloud-based storage (K)						.552
Educational platforms (K)						.546
Videoconferencing (K)						.451
Common chats (K)						.423
Videoconferencing (K)						.397
Internal consistency						
Cronbach's α	.947	.881	.883	.819	.811	.832
McDonald's ω	.947	.888	.884	.822	.815	.832

Note. Knowledge (K), Skills (S), Attitudes (A) and Emotions (E)

In addition to identifying the 6 factors, this analysis showed that the item related to the online study strategies is not included into any of the identified factors. The internal consistency analyses for each factor (see Table 6) indicate that the first factor has a higher reliability than the rest, with factor 5 being the lowest, but in all cases, with values higher than .70.

As can be seen, the results of this test do not differ from the original structure proposed. Only subdimensions are identified in the dimensions included in the instrument. Like the dimension about emotions, which is divided between emotions that are considered positive and negative.

Confirmatory factor analysis

The CFA was conducted to analyze the adjustment of the proposed model for this instrument; that is, the presence of four dimensions distributed as follows: dimension one (knowledge) composed of items 26 to 41; dimension two (skills) composed of items 42 to 60; dimension 3 (attitudes) composed of items 61 to 70 and dimension 4 (emotions) composed of items 71 to 96.

The CFA result showed good adjustment levels ($\chi 2 = 5834.402$; gl = 2408; p = < .001; CFI = .920; TLI = .918; RMSEA = .100 [90% CI: .097- .103]; SRMR = .133), which prove that the adjustment of the model as appropriate, although with a minor adjustment than that identified by the EFA. This may also be because a larger sample than the one used in this study is required.

Discussion and conclusions

As it could be seen in the development of this project, the determination of a valid and reliable instrument for the analysis of digital competence is highly important, because currently, and in response to recent events, education is in a phase of transition to blended and distance learning, therefore it is crucial to evaluate the levels of digital competence of students in order to design educational programs that would be beneficial for them (Katerina et al., 2022).

However, the measurement of this construct remains a complicated task due to, among other factors, the multiple existing definitions of the construct and the elements that it comprises. That is the reason for this study, to design and validate an instrument to analyze the digital competence of elementary school students; consequently, the following paragraphs describe the main findings.

First, it should be noted that this instrument has a solid theoretical basis. Although each instrument takes different theoretical references as basis for its development, the European Framework of Digital Competences for Citizenship (DigComp 2.1) is widely used in the specialized literature, like in this instrument and in those developed by Colás-Bravo et al. (2017) and Martínez-Piñeiro (2019).

Regarding this argument, it should be noted that sometimes not all areas of competence or levels of aptitude stablished in the framework are included. In the development of this instrument, we tried to include at least one item of the five areas of competence established in DigComp 2.1. Considering the age of the participants, the knowledge and skills of aptitude level 4 were included. Likewise, the items selected

were carefully aligned with the exit profile of elementary education established by the Secretariat of Education.

This study identified and presented evidence of construct and content validity of the instrument. The selection of expert judgment as a content validation technique is consistent with similar studies (Baeza-González et al., 2022; Martínez-Piñeiro et al., 2019; Martinez Serrano, 2018; Aesaert et al., 2014).

The structure of 4 dimensions (knowledge, skills, attitudes, and emotions) proposed for this instrument was consistent with that found after the performance of the EFA and CFA, which is similar to the structure used in other instruments that evaluate the same construct in this population, such as that of Martínez-Piñeiro et al. (2019). Also, when analyzing the structure, it is found that online study strategies are grouped as a knowledge that is independent of the rest.

The decision to apply a typical performance test with a Likert scale as a response option coincides with several instruments with similar design (Pérez Escoda et al., 2016; García-Martínez et al., 2016; Colás-Bravo et al., 2017; Villegas Pérez et al., 2017; Martinez Serrano, 2018; Martínez-Piñeiro, 2019).

Since this is a typical performance test, problems such as social desirability bias and other biases may arise, which are the results of a self-perception process. However, due to the convenience of this type of tests in terms of their application and cost, it is a common way of approaching the study of this topic (Luna-Villanueva & Canto-Herrera, 2021).

In view of the above, it would be appropriate to contrast the results of this test with maximum performance tests, such as those proposed by Baeza-González et al. (2022) and Aesaert et al. (2014) to identify whether there are different associations between constructs and measurements obtained in both tests. Additionally, it is important to be able to continue with construct validity studies because the application of this instrument is recommended in combination with other instruments that measure theoretically related constructs, such as digital literacy and digital citizenship.

In conclusion, it can be pointed out that the validation process has sufficiently demonstrated the reliability and validity of the instrument presented here. However, it is necessary to make some slight modifications in this instrument because it is necessary to reduce the number of items. During the pilot test, it was observed that the time it took the students to answer the instrument was longer than expected. The sample size is among the possible limitations identified in this study, so one of the main recommendations for subsequent studies is the validation of this instrument with a larger sample and in other contexts as well.

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Conflict of interest

The authors declare no conflict of interest.

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