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Design and validation of a questionnaire to assess digital skills for research

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Abstract

The fast evolution of technology makes digital competencies mandatories in all professional contexts. The aim was to systematize the design and validation of a questionnaire to measure digital skills for research. The methodology included a literature review to identify the theoretical bases and the dimensions or components of digital skills and the design of the questionnaire. Secondly, its validity was tested through the Content Validity Index (CVI) with the judgment of six experts and the Exploratory Factor Analysis (EFA) with a sample of 96 researchers. Finally, Cronbach's alpha coefficient test was performed to assess reliability. The Kaiser-Meyer-Olkin (KMO) determined sampling adequacy (KMO= .830) and the analysis showed significant Bartlett's sphericity test (p= .000). The anti-image matrix showed high values except for the first item that did not reach the critical threshold in the communality's values; so, it was removed. The validity test showed high content validity coefficient (IVC= .98). Regarding the EFA, the six-factor analysis revealed that nine out of the 14 items showed factor loading > 0.7. The reliability test also showed positive results (α=.874). The six dimensions measured with this questionnaire are consistent with the European Framework for Digital Skills and with previous proposals for the study of digital skills in teaching and learning contexts. Also, they match important theories that explain digital skills usefulness in research. In conclusion, this may be a useful instrument in the initial phases of policy planning for strengthening scientific production and closing gaps in digital competencies in universities.

KEYWORDS: Digital Skills, Researchers, Content Validity, Factorial Analysis.

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1. Introduction

The mastery of digital competence has become a fundamental component both for daily life and for professional and academic performance in the contemporary era (Arroba-Freire et al., 2022; Centeno-Caamal, 2021; Vera & Aguilera, 2024). Digital competencies encompass a set of skills that enable individuals to effectively interact with digital technologies, manage complex information, communicate globally, and solve problems in dynamic digital environments (Massieu et al., 2024; Verdú-Pina et al., 2023). Those skills are needed for active participation in the digital society and for scientific research. Then, the study of digital competencies in the university should be part of all universities' agenda (Silva et al., 2023).

In addition, the development of digital and research skills empowers critical thinking and communication as well as other skills needed for the production of new knowledge (Churampi-Cangalaya et al., 2024; Perdomo, 2023).

In the academic and research arena, researchers need digital skills to access, manage, analyze and communicate information. In that context, the information literacy (i.e., the ability to identify, evaluate and effectively use information from diverse sources) is closely intertwined with the development of digital skills, providing an essential framework for

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evidence-based research and informed decision-making. That is why Kuhlthau's (2004) Theory of Information Literacy may be seen as part of the theoretical framework for digital skills study. It highlights the importance of a procedural approach to gather and use of information, which is fundamental for success in scientific production. This widely recognized theory has supported studies aiming to comprehensively explore the processes of undergraduate students engaged in becoming properly informed (Buba et al., 2021).

In the literature there is not consensus to reach a unique definition for digital skills (Barbazan et al., 2021; Paz et al., 2021; Perdomo et al., 2020). The General Directorate of Evaluation and Territorial Cooperation for the Reference Framework of Teaching Digital Competence (MRCDD) summarized digital skills as the safe, critical and creative use of information and communication technologies to achieve proposed objectives in the workplace and in educational, scientific and leisure contexts (Resolution of May 4th 2022, from the General Bureau of Territory Evaluation and Cooperation, 2022). However, for this research we share the definition provided by Le et al. (2023) who see digital skills as the ability and confidence to apply knowledge to complete tasks by using information technology that includes computing devices, software and the internet.

The development and evaluation of digital skills in the context of scientific research impacts the efficiency and effectiveness of research processes and results' quality and relevance (Perdomo & Morales, 2022). Previous studies have documented that university instructors must properly guide their students in research skills to increase their academic performance (Guillén-Gámez et al., 2020), they also have found evidence suggesting that digital research competences may be related to other transversal skills (Guillén-Gámez et al., 2023, 2024).

Researchers with a high level of digital skills are able to use of the technological tools to explore new methodologies, manage large volumes of data, and collaborate effectively with colleagues locally and internationally. In this regard, the Digital Competence Framework (DigComp) provides structured guidance on the necessary competences, covering areas such as digital content creation, security and technical problem solving (Mattar et al., 2020; Saidi et al., 2023; Segura et al., 2023).

In addition to specific technical skills, the mastery of digital competencies encompasses the ability to adapt to the continuous changing technological settings and the effective resolution of technical problems that may arise in the research process (Segura et al., 2023). The Self-Efficacy Theory proposed by Bandura (1997) suggest that digitally-skilled researchers are more likely to face technological challenges with confidence and overcome technology-related hindrances more effectively. These skills promote better performance when conducting rigorous and efficient research and also promote innovation and creativity in the generation of new knowledge. Finally, Davis' (1989) Technology Acceptance Model (TAM) helps to understand how perceptions of usefulness and ease of use of digital technologies can influence their adoption and use by researchers.

Various authors have addressed the study of digital skills. Some of them have been oriented towards their conceptualization and measurement in teachers (Barbazan et al., 2021; Churampi-Cangalaya et al., 2024; Claro et al., 2024; García-Ruiz et al., 2023; Vera & Aguilera, 2024) and students (Arroba-Freire et al., 2022; Martzoukou et al., 2020; Sánchez-Caballé et al., 2020). However, there is a gap in terms of the construction and validation of an instrument that measures digital competencies in researchers.

This study aimed to systematize the design and validation of an instrument for the measurement of digital skills for research. It was expected to offer a useful instrument to obtain evidence useful for planning policies to enhance digital competencies in researchers. This instrument was meant to facilitates evidence-based decision-making and to evaluate the results of the established programs and policies. Hence, we conducted a study through a process that included the confirmation of theoretical basis, design of the instrument and the use of different techniques to assess the questionnaire in terms of validity and reliability.

2. Methods

The first step was to conduct a literature review to identify the dimensions of digital competence. In this sense, the five dimensions proposed in the DigCom (Resolution of May 4th 2022, from the General Bureau of Territory Evaluation and Cooperation, 2022; Saidi et al., 2023; Segura et al., 2023) were included. The use of equipment and devices was added as a dimension, since this is linked to the other five (Vitezić & Perić, 2024). After this review and the operationalization of the variable and its dimensions, a 15-item questionnaire was designed.

The quantitative content validity was performed through the experts' judgment technique with the calculation of Lawshe's Content Validity Index (CVI) from the Content Validity Ratio (CVR') and the adjustment of minimum values for greater credibility of the evidence. The analysis was made with a constant minimum value of CVR' and CVI = .5823 (Tristán-López, 2008). The experts were six experimented researchers in the field of digital competence that accepted to assess the instrument anonymously. Their expertise was proved through their registered

publications in high impact journals indexed in Scopus database and their h index.

Subsequently, the resulting formal questionnaire was sent through Google Forms to 120 researchers for a pilot test aiming to assess the questionnaire reliability and construct validity. The former was established through, the Cronbach's alpha coefficient. The latter was confirmed with the Exploratory Factor Analysis (EFA) (Osborne, 2014), following Watkins' (2018) recommendations for reliable results with the EFA. After those tests and analyses, we expected to get the final version of the instrument.

3. Results

3.1 Content validation

The initial version of the questionnaire contained 15 items in a five-options Likert scale ranging from totally disagree to totally agree. The six experts were provided with the questionnaire, the operationalization table and the format for content validity assessment.

The results showed high content validity index (CVI= .98). All items, except items two and seven obtained CVR'= 1.00; none was considered 'non-indispensable' (see Table 1).

Table 1 - Results of quantitative validation.
Source: own elaboration .

CONTENT VALIDITY INDEX: CVI

Item	Essential	Useful/non-essential	Not important	N judges /2	Include	CVR'
1	6	0	0	3	Yes	1.00
2	5	1	0	3	Yes	.90
3	6	0	0	3	Yes	1.00
4	6	0	0	3	Yes	1.00
5	6	0	0	3	Yes	1.00
6	6	0	0	3	Yes	1.00
7	5	1	0	3	Yes	.90
8	6	0	0	3	Yes	1.00
9	6	0	0	3	Yes	1.00
10	6	0	0	3	Yes	1.00
11	6	0	0	3	Yes	1.00
12	6	0	0	3	Yes	1.00
13	6	0	0	3	Yes	1.00
14	6	0	0	3	Yes	1.00
15	6	0	0	3	Yes	1.00
					CVI	**0.98**

Results in Table 1 evidence robust quantitative validity of the items according to the experts, considering that the minimum value of the CVI for this test is .5823. Also, when they were asked about the need of adding more items, they claimed the completeness of the instrument.

3.2 Construct validity and reliability

The questionnaire was sent to 120 researchers from different universities and research centers. The response rate was 79.6 % (n= 96). Then, a sample of 96 researchers (52 male and 44 female) answered the questionnaire. Their average age was 44.7 years (Min 25 – Max 67; SD: 9.7). A database was created in Microsoft Excel© and processed with IBM-SPSS (version 27.0) to calculate construct validity and reliability.

The authors used the EFA to assess the construct validity of this questionnaire. Before conducting the EFA, the authors confirmed the suitability of data for such assessment. The Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy resulted in 0.830 and the Bartlett's sphericity test proved to be statistically significant (p= .000). The anti-image matrix showed high values except for the first item that did not reach the critical threshold in the communality's values; so, it was removed.

After proving data adequacy, the EFA was conducted for the six fixed factors using the Varimax method. The main component analysis was the extraction method with rotation, converging in nine iterations. Results are shown in Table 2.

Nine out of 14 items showed factor loading > 0.7. The lowest value was found for item 9 (0.507); however, it was inside the acceptable results to be included. All the values obtained are high enough to evidence the consistency of all the items because they are over the critical threshold (0.5). Then, reliability was calculated with Cronbach's alpha coefficient. This analysis showed high reliability (α=.874).

3.3 Resulting data-gathering instrument

The authors recalculated the IVC of the final version by eliminating the evaluation to the excluded item and calculating averages of experts' evaluation for the remaining 14 items. The, IVC for the final questionnaire did not suffer any change. In few words, the tested instrument showed strong validity (CVI= .98), solid construct validity in the EFA, and high reliability (α= .874).

The final version was a six-factor questionnaire with 14 items in Likert scale with the following options: Totally disagree (TD), partially disagree (PD), neutral position (NP), Partially agree (PA), and totally agree (TA) (see Table 3).

4. Discussion and Conclusions

The development of digital skills is a must for researchers to face and overcome challenges in a technology-mediated world (Kuzminska et al., 2021, 2023). Digital skills help researchers to access and manage information efficiently. They also facilitate collaborative work, innovation and high-quality knowledge production (Subaveerapandiyan et al., 2024). Researchers with advanced digital skills are better equipped to adapt to emerging technologies, optimize their research processes and contribute significantly to scientific progress. In that sense, fostering digital competencies through appropriate training programs and institutional policies is a central strategic investment for scientific and technological progress in academia. However, it is necessary to conduct research to assess those skills to identify strengths and weaknesses for proper planning.

The authors of the present study aimed to systematize the design and validation of an instrument for the measurement of digital skills in researchers. The instrument showed high reliability (α=.874). In addition, this questionnaire presented high content validity (IVC= .98 for a threshold of .58) and showed solid construct validity, as seen in the EFA. The result of this study was a valid and reliable instrument to assess digital skills in the field of research.

Table 2 - Rotated component matrix for the Exploratory Factor Analysis (EFA) .

Note. UDS: Use of devices and software. IL: Information Literacy. DC: Digital Communication. CC: Content Creation. DS: Digital Security. PS: Problem solving.

	Component / Factor					
	1 UDS	**2 IL**	**3 DC**	**4 CC**	**5 DS**	**6 PS**
1	0.796					
2	0.768					
3	0.701					
4		0.590				
5		0.766				
6			0.729			
7			0.786			
8			0.663			
9				0.507		
10				0.786		
11					0.665	
12					0.863	
13						0.797
14						0.589

Table 3 - Questionnaire to assess digital skills for research.

Item	TD	PD	NP	PA	TA
UDS: Use of devices and software					
I use digital devices (e.g., phone and tablet) to carry out scientific research.					
I feel comfortable using specific programs for scientific research (e.g., software for data analysis).					
I efficiently use digital tools to manage scientific literature and generate citations and references.					
IL: Information Literacy.					
I frequently search for scientific literature in academic databases.					
I evaluate the epistemological quality and relevance of scientific articles found online.					
DC: Digital Communication.					
I use email and online instant messaging applications to communicate with fellow researchers.					
I use of online collaborative tools for joint work on research projects.					
I easily participate in webinars and other scientific events in virtual mode to communicate the results of my research and listen to those of other researchers.					
CC: Content Creation.					
I comfortably use digital tools to write and edit research proposals and scientific manuscripts.					
I am skilled at using software to create and edit graphs and tables for data visualization in my research.					
DS: Digital Security.					
I troubleshoot technical issues with the software used for my research project.					
I troubleshoot technical issues with the hardware used for my research project.					
PS: Problem solving					
I troubleshoot technical issues with the software used in my research without external help.					
I troubleshoot technical issues with the hardware used in my research without external help.					

The limitation of the present study was the sample size which might be considered small to perform Confirmatory Factorial Analysis (CFA). The next step in research should be assessing the internal consistency of factors with a larger sample.

This questionnaire fills the gap of a tool to measure digital competencies in researchers. The present study provides evidence supporting its quality to be recommended for use in future research. This is a contribution for institutions aiming to explore the digital skills of their researchers. This questionnaire differs from the instruments analyzed by González-Rodríguez & Urbina-Ramírez (2020), which only measure digital competencies in teachers or students

for teaching and learning purposes. It also differs from the versions of the TPACK (Alemán et al., 2023; Barajas et al., 2023; Paidican & Arredondo, 2022) and TPACK questionnaires applied to artificial intelligence (Ning et al., 2024; Saz-Pérez et al., 2024).

The six dimensions measured with this questionnaire are consistent with the European Framework for Digital Skills (Mattar et al., 2020) and with previous proposals for the study of digital skills in teaching and learning contexts (Saidi et al., 2023; Segura et al., 2023). Also, they match important theories that can explain digital skills usefulness in research (Bandura, 1997; Davis, 1989; Falloon, 2020; Kuhlthau, 2004). Hence, the authors recommend using it.

Some of the indicators considered in this instrument are similar to those analyzed by Peinado (2023) in his study on digital competences in university students. However, unlike Peinado (2023), in the present study, the evidence of the respective validations is provided and readers are offered the instrument in its entirety so that it can be used when studying these skills in researchers and researcher trainees. We suggest to conduct further research using this questionnaire with undergraduate students and the teaching staff to evidence their weaknesses and potential in terms of digital skills for research.

In conclusion, the results obtained in this study validate this questionnaire as an accurate and reliable tool for assessing digital competencies of researchers. This instrument might be useful in the initial phases of policy planning aiming to strengthen scientific production and to close gaps in digital competencies in faculties and students conducting or aiming to conduct research.

With the application of this questionnaire, institutional policy makers can have an evidence-based baseline to reinforce the aspects that need to be strengthened, directing resources appropriately. Likewise, with the application of this questionnaire, decisions can be made for the formation of research groups and mentoring programs. It makes it easier to form teams with people that complement each other and designate mentors according to their potential and needs.

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