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Delphi study for the design and validation of a questionnaire about digital competences in higher education

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Abstract

The study of digital competence remains an issue of interest for both the scientific community and the supranational political agenda. This study uses the Delphi method to validate the design of a questionnaire to determine the perceived importance of digital competence in higher education. The questionnaire was constructed from different framework documents in digital competence standards (NETS, ACLR, UNESCO). The triangulation of non-parametric techniques made it possible to consolidate the results obtained through the Delphi panel, the suitability of which was highlighted through the expert competence index (K). The resulting questionnaire emerges as a good tool for undertaking future national and international studies on digital competence in higher education.

Keywords: Digital competence, Higher education, Questionnaire, Standards

Introduction

Information and communication technologies (ICTs) have brought about major changes in the way learning is approached. This in turn has led digital competence to be considered as a means of achieving a degree of literacy suited to present-day society's needs. Thus, such digital competence has come to form part of the political agenda (European Commission, 2010; UN, 2010) and is currently the focus of attention in numerous and important general studies (Greene, Yu, & Copeland, 2014; Ilomäki, Paavola, Lakkala, & Kantosalo, 2014; Liyanagunawardena, Adams, Rassool, & Williams, 2014; Mohammadyari & Singh 2015; Ng, 2012; Pangrazio, 2014). The literature on digital competences in higher education is not extensive, though. The task carried out by ISTE (International Society for Technology in Education) through the NETS (National Education Technology Standards) program in the general context deserves to be highlighted. Furthermore, research initiatives have been undertaken for the purpose of analyzing the implementation of digital competences as well as their implications for teachers (Niederhauser, Lindstrom, & Strobel, 2007) or for the training of future teachers in such ICT standards (Klein & Weaver, 2010). Likewise, Jeffs and Banister (2006) examined how the NETS program influenced the professional development of undergraduate lecturers, and Ching (2009) studied the consequences of

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putting into practice NETS-based ICT competences in the educational context of the Philippines.

Voithofer (2005) analyzed the consequences that 'service-learning' had in relation to the short-term and long-term effects caused by ICT integration into classrooms characterized by their cultural diversity on the acquisition of technical skills and reflexive knowledge.

Along similar lines, NETS standards have inspired other studies (Kadijevich & Haapasalo, 2008; Masood, 2010; Naci & Ferhan, 2009; Rong & Ling 2008) and numerous proposals for standards and indicators of digital competence in an array of dimensions, including ILCS (Information Literacy Competency Standards for Higher Education; ACRL-Association of College and Research Libraries, 2000); SAILS (Standardized Assessments of Information Literacy Skills, SAILS, 2011); iSkills developed by the company Educational Testing Service; TRAILS, developed by the Kent State University Libraries; Information Skill Survey developed by the Council of Australian University Librarians (CAUL); the Australian and New Zealand Institute for Information Literacy (ANZIIL) standards; the French B2i framework of reference; the NETS-based INSA Colombian curriculum indications; or the European Commission's DIGCOMP project (Ferrari, 2012), which involved 90 experts from universities and research centers. Finally, the following stand out in the specific Spanish context: the proposal for information literacy or ALFIN (Area, 2008); computer and information competences in degree studies (CRUE-TIC, 2009); and the IL-HUMAS project (Pinto, 2010).

In short, broad references exist to the involvement of different organizations (UN, 2010; Organisation for Economic Co-operation and Development, 2005; UNESCO, 2008) and professional associations (ISTE, ALA, ACLR, AASL) aimed at raising awareness of the fact that citizens increasingly need to acquire digital competences. This acquisition of cross-disciplinary competences is closely linked to the university education stage (Hernández, 2010) and makes it easier for graduates to have a greater chance of success in the scientific and professional fields where they will develop their professional activity (Area, 2010).

In the light of all the above, the aim of this Delphi study is to design and validate a questionnaire constructed on the basis of various digital competence standards through which the perceived importance of the acquisition of digital competences in higher education can be specifically assessed by a panel of experts.

Method

The study was performed through a two-round Delphi iterative consultation process with experts (Keeney, Hasson, & McKenna, 2006). This technique is widely utilized in the research context (Peeraer & Van Petegem, 2015; Yeh & Cheng, 2015) and its validity for questionnaire development has already been described (Blasco, López, & Mengual, 2010).

Participants

The panel was made up of 27 researchers from 15 Spanish universities. Our selection criterion was that they had to be senior university lecturers or professors with a recognized academic career – in the areas of both teaching and research – relating to the study topic. Intentional sampling (Landeta, 2002) was used for those panelists who complied with the aforementioned criteria, who were contacted by e-mail. The

procedure specified in detail below began after their confirmation of participation had arrived. Furthermore, an analysis was carried out regarding their pertinence as experts through the calculation of the expert competence index (K) (López, 2008).
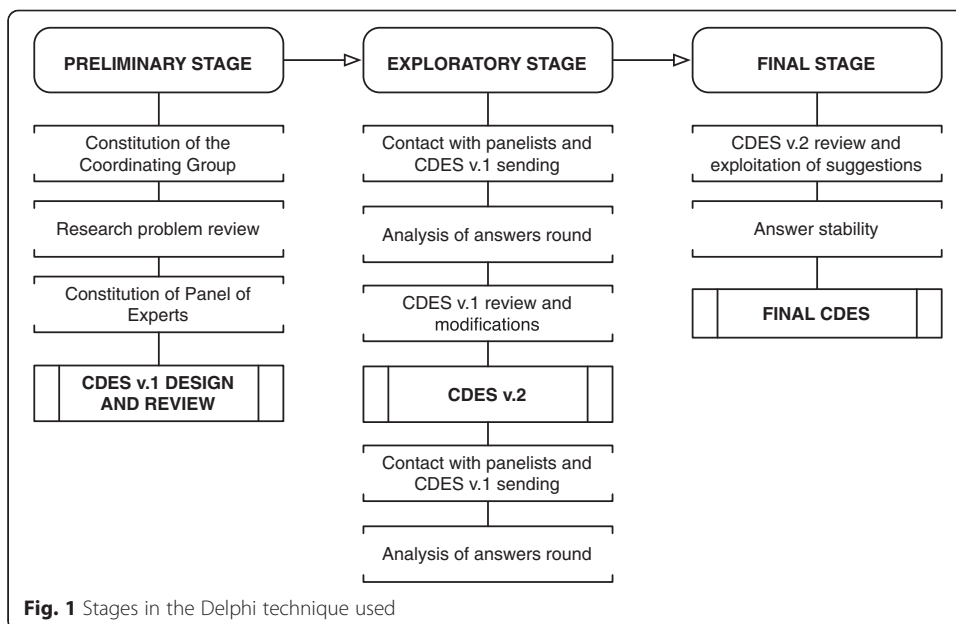
Procedure

The construction of the CDES[1] (*Cuestionario de Competencias Digitales en Educación Superior* [Questionnaire about Digital Competences in Higher Education]) took place in three distinct stages (Bravo & Arrieta, 2005) (Fig. 1).

A focus group formed by the members of the University of Alicante EDUTIC-ADEI research group was created during the first stage. The work undertaken in several sessions led to the first version of the questionnaire that would subsequently be submitted to the panelists. The LimeSurvey application was used both to contact panelists and to collect data. In successive rounds, our panelists received the complete questionnaire together with a scale on which they had to assess the degree of adequacy of the items and dimensions proposed (1 = not adequate; 2 = hardly adequate; 3 = adequate; 4 = quite adequate; 5 = totally adequate). The first round additionally included a scale that allowed the K coefficient to be determined. An analysis of answers was performed during the exploratory and final stages with the aim of modifying or adding items contained in this questionnaire.

Questionnaire

The CDES (Mengual, 2011) consists of 5 dimensions: (1) Technological Literacy [15 items]; (2) Information Access and Use [8 items]; (3) Communication and Collaboration [8 items]; (4) Digital Citizenship [8 items]; and (5) Creativity and Innovation [13 items].

The dimensions and items were carefully examined from various proposals for digital competence standards. Mengual (2011) justifies these dimensions and items in his paper for their connection with the different framework documents utilized to construct the CDES (NETS, AASL, CI2, ACRL, ILCS, SAILS and OCT-CTS).

Fig. 1 Stages in the Delphi technique used

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Expert competence level analysis

The experts' competence was analyzed by means of the K coefficient, an index recently used in numerous works (García & Fernández, 2008; López, Stuart, & Granado, 2011; Llorente, 2013) and calculated in accordance with the actual experts' opinion of their respective levels of knowledge of the problem being solved.

These K analyses revealed that our panelists had proven competence and were suitable to form part of the panel. The value of K exceeded the average competence values in every case; 77 % ($n = 21$) of them obtained a high coefficient value, whereas 22 % ($n = 6$) showed a medium competence coefficient value.

Consensus definition

This paper followed the methodology previously adopted in several studies (Lee, Altschuld, & Hung, 2009; Williams, 2003; Zawacki-Richter, 2009). Data collection during the first consultation round and the determination of the K coefficient led to the establishment of consensus criteria among panelists (See Table 1).

Ancillary techniques

Our research work implemented strategies contained in Delphi studies through which it was possible to triangulate the data obtained from the panel of experts: a) Central tendency and dispersion measures; b) Analysis of consensus level between rounds (IQR, RIR, VCV); c) Reliability analysis (Cronbach's alpha); and d) Analysis of group stability in answers (median test and U Test).

Data analysis

Data analysis during R1 revealed that there was broad agreement on the five suggested dimensions. Seven items were proposed for a second round and two were discarded (Table 2).

After the second round (R2), a specification was made of the definitive item selection criteria through the interpretation of a contingency table with the consensus results (Table 2). The highly significant items responded to a unanimous consensus criterion in both rounds; the significant ones to the criteria R1 = N/A and R2 = N/A; and the non-significant items were discarded in each of the rounds.

Factor 1 included 11 of the 15 initially proposed items; the structure of the remaining factors was unaltered.

Analysis of consensus level and group stability in answers

A decision was made to calculate the acceptable degree of proximity and stability in the answers obtained during the rounds through the calculation of the interquartile

Table 1 Criteria underlying the consensus definition for the Delphi panel

Consensus	Parameters (Mdn: median; IQR: interquartile range)
Agreement(A)	Mdn ≥ 4, IQR ≤ 1.5
	Mdn ≥ 4, IQR ≤ 2, frequency [4–5] ≥ 70 %
Disagreement(D)	Mdn ≤ 3.5, IQR ≤ 1.5
	Mdn ≤ 3.5 IQR ≤ 2, frequency [1–3] ≥ 70 %
Neutral(N)	Mdn ≥ 3.5, IQR ≤ 2

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Table 2 Contingency table corresponding to the analysis of the results obtained during the Delphi rounds

	R1				R2				Consensus
	M	SD	Me	IQR	M	SD	Me	IQR	
Factor 1									
It1	3.61	1.09	3.5	2	4.22	.83	4	1.5	A
It2	4.33	.97	5	1.25	4.56	.88	5	1	A
It3	3.56	.98	4	1	3.67	1	4	1.5	A
It4	3.5	.85	3.5	1	3.67	.86	4	1	A^2
It5	4.22	.64	4	1	4	.70	4	1	A
It6	3.72	1.12	4	2	3.22	.83	3	1.5	D
It7	3.5	.78	4	1	3.56	.72	3	1	D
It8	3.94	.99	4	2	4.44	.72	5	1	A
It9	4	.84	4	1.25	4	.70	4	1	A
It10	4	.84	4	1.25	4.44	.72	5	1	A
It11	3.83	.78	4	1.25	3.89	.78	4	1.5	A
It12	3.83	1.04	4	2	3.44	.72	4	1	A^2
It13	4.11	.83	4	1	4.22	.44	4	0.5	A
It14	3.22	.88	3	1.25	3.78	1.09	4	2	A^2
It15	2.89	.9	3	2	3.11	.78	3	1.5	D
Factor 2									
It1	3.94	1.05	4	1	4	.70	4	1	A
It2	4	1.08	4	2	4.33	.70	4	1	A
It3	4.44	.61	4.5	1	4.11	.92	4	2	A^n
It4	4.33	.84	5	1.25	4.11	.78	4	1.5	A
It5	4.33	.76	4.5	1	4.44	.72	5	1	A
It6	4.28	.89	4.5	1	4.33	.70	4	1	A
It7	4.06	.80	4	2	4.22	.44	4	0.5	A
It8	3.89	1.02	4	2	4	.86	4	2	A^n
Factor 3									
It1	4.39	.60	4	1	4.33	.70	4	1	A
It2	4.22	.94	4.5	1.25	4.33	.70	4	1	A
It3	4.67	.48	5	1	4.22	.83	4	1.5	A
It4	3.89	.96	4	2	4	.70	4	1	A
It5	4.22	.64	4	1	4.11	.78	4	1.5	A
It6	4.06	.72	4	1.25	4.33	.5	4	1	A
It7	4.44	.61	4.5	1	4	.70	4	1	A
It8	4.06	.99	4	2	4.22	.83	4	1.5	A
Factor 4									
It1	4.22	.80	4	1.25	4.22	.97	5	2	A^n
It2	4.17	.85	4	2	4.22	.83	4	1.5	A
It3	4.22	.73	4	1	4.56	.52	5	1	A
It4	4.17	.85	4	1	4.11	.92	4	2	N
It5	3.56	1.09	3.5	1.25	3.89	.78	4	1.5	A^2
It6	3.94	1.16	4	2	3.78	1.09	4	2	N
It7	3.94	.87	4	2	4.22	.83	4	1.5	A^2

Table 2 Contingency table corresponding to the analysis of the results obtained during the Delphi rounds *(Continued)*

It8	4.06	.93	4	2	3.78	.83	4	1.5	A
Factor 5									
It1	4.28	.75	4	1	4.22	.83	4	1.5	A
It2	4.67	.48	5	1	4.33	1	5	1	A
It3	4.06	.80	4	2	4	1.22	4	2	A
It4	4.33	.68	4	1	4.44	.72	5	1	A
It5	4.39	.77	5	1	4.22	.83	4	1.5	A
It6	3.89	.96	3.5	2	3.78	1.09	4	2	A^2
It7	3.83	.92	4	2	3.78	.83	4	1.5	A^2
It8	3.94	.80	4	0.5	3.56	1.01	3	1.5	A^n
It9	4.22	.64	4	1	4.11	.78	4	1.5	A
It10	4.17	.85	4	2	3.89	.33	4		A
It11	4	1.13	4	2	4.22	.97	5	2	A^n
It12	4.28	.82	4	1	4.44	.72	5	1	A
It13	4.11	.96	4	2	3.78	1.09	4	2	A^2

M: Mean; *SD*: Standard deviation; *Me*: Median; *IQR*: Relative interquartile range; *A*: Accepted in R1 and R2; A^2 Neutral in R1 and accepted in R2; A^n: Accepted in R1 and neutral in R2; *D*: Discarded

range (IQR) and the variation in the coefficient of variation (VCV). The analysis of the consensus reached between panelists' opinions revealed an acceptable degree of proximity and stability (IQR < .5) (Ortega, 2008).

Group stability is understood to exist if the variation in the relative interquartile range (RIR) between rounds is lower than .30. Similarly, consensus is understood to exist if the variation in the coefficient of variation (CV) is below 40 % in most items. Figure 2 shows that the VRIR between rounds is lower than .30 in each and every item, thus describing group stability in answers. The consensus between panelists is thus illustrated by the VCV data (Fig. 3).
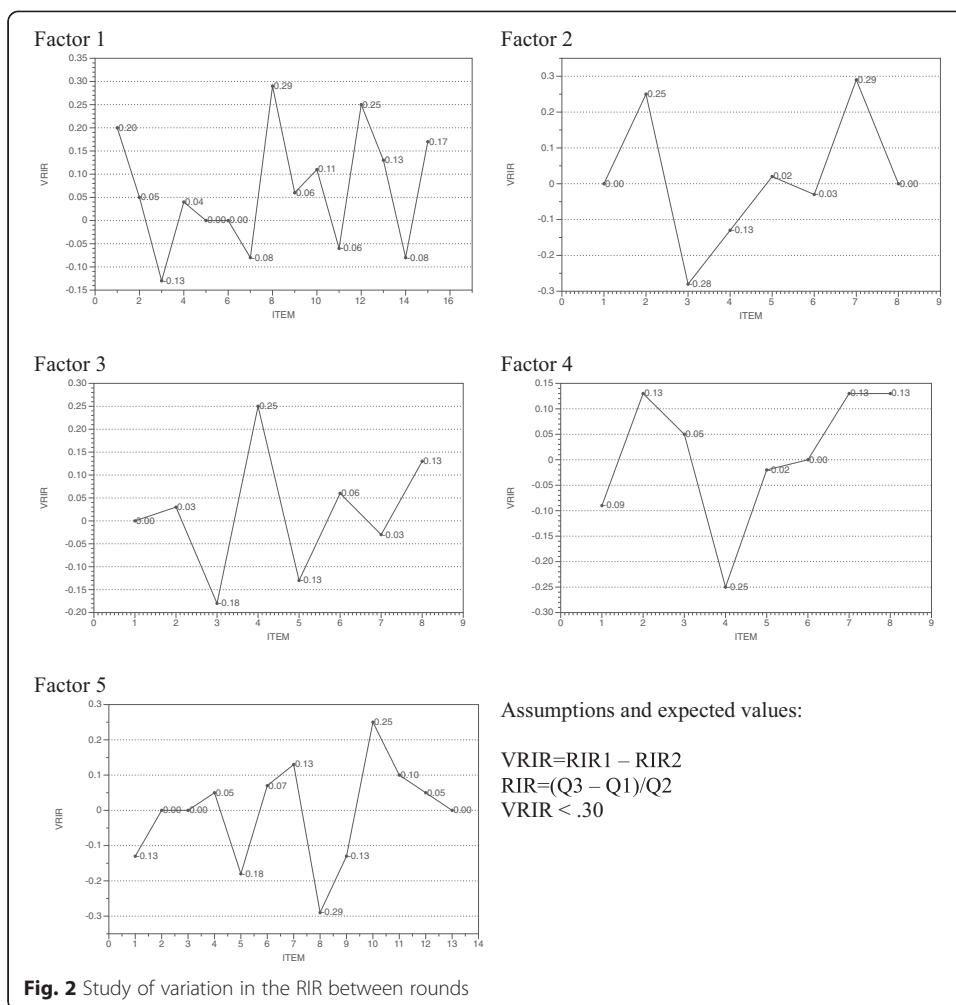
The Delphi process is considered complete when consensus and stability levels have been defined, since the application of another round would not provide significant variations in results.

Multivariate analysis

The previous analyses were supported by non-parametric means difference tests. The results obtained with Mann-Whitney's *U* test did not reveal statistically significant differences in the scores corresponding to CDES factors between consultation rounds at a $p \le .05$ level [Factor 1 ($z = -.438$, $p = .661$), Factor 2 ($z = -.052$, p = .959), Factor 3 ($z = -.181$, $p = .856$), Factor 4 ($z = -.206$, $p = .837$), Factor 5 ($z = -.489$, $p = .625$)]. Nor were significant differences described in the item scores at a $p \le .05$ level.

In parallel, the median test complemented the preceding hypotheses. The analysis of scores did not confirm the existence of differences between rounds, neither in dimension scores [Factor 1 ($\chi^2 = 3.8000$, $p = .695$), Factor 2 ($\chi^2 = 4.1250$, $p = 1.000$), Factor 3 ($\chi^2 = 4.2500$, $p = .406$), Factor 4 ($\chi^2 = 4.1250$, $p = 1.000$), Factor 5 ($\chi^2 = 4.2308$, $p = .695$)] nor in item scores; $p \ge .05$ values were obtained in all cases.

Median test values confirm those yielded by the *U* test, thus allowing us to state that panelists' scores present stability. These analyses highlight the suitability of

Fig. 2 Study of variation in the RIR between rounds

Assumptions and expected values:

$$VRIR = RIR1 - RIR2$$
$$RIR = (Q3 - Q1)/Q2$$
$$VRIR < .30$$

the technique used for item discrimination and of the statistics utilized for the consensus definition.

Questionnaire validity and reliability analysis

The resulting questionnaire was finally administered to a random sample of students enrolled in the Faculty of Education at the University of Alicante ($n = 100$) in the course of a pilot test, observing all ethical issues during the process (Mesía Maraví, 2007). Cronbach's alpha test results were .962. The individual scores for each of the dimensions were above .8 [F1 = .86; F2 = .89; F3 = .89; F4 = .87; F5 = .92], resulting in high and suitable reliability indices.

As for the item-total correlation analysis, its results described an optimum inter-item correlation range, and the deletion of several items did not result in an improvement in the reliability coefficient of either the dimensions or the questionnaire.

Discussion and conclusions

The CDES that we designed is based on a series of referents and models specified in the introduction to this paper. This does not mean that its importance should be minimized, since it constitutes one of the few existing models for the determination of

Fig. 3 Study of VCV between rounds
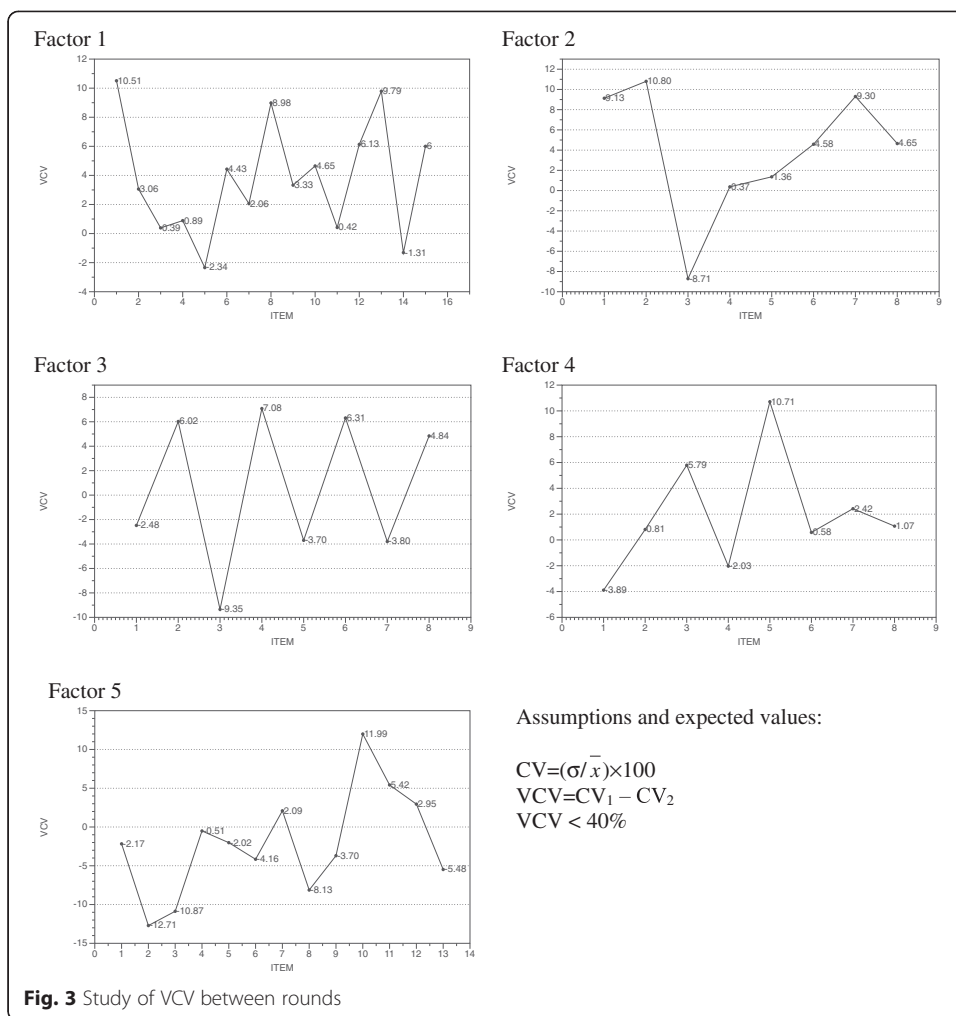
generic digital competences within the higher education study framework. In this respect, our study complements other proposals made from different perspectives. By way of example, it is worth mentioning models that determine the importance of digital competences in higher education lecturers (Jeffs & Banister, 2006; Masood, 2010; Naci & Ferhan, 2009; Rong & Ling, 2008), to which it is necessary to add those studies describing the importance of standards related to digital competences in the training of higher education students (Alan & Pitt, 2010; Hong & Jung, 2010; Kadijevich & Haapasalo, 2008; Kaminski, Switzer, & Gloeckner, 2009; Li-Ping & Jill, 2009; Niederhauser, Lindstrom, & Strobel, 2007; Voithofer, 2005).

In relation to our model, and concerning the taxonomy of dimensions and indicators proposed, it can be said that emphasis is not placed on the importance of the teacher or student role, but rather on those aspects from which the teaching-learning model should be approached. That is why the questionnaire represents a good framework document that can serve as a referent to undertake future research initiatives, as well as to analyze the study of digital competence from this point of view, to examine its usage in other contexts, to establish connections between different groups or to subject the questionnaire to a review, adaptation or change process.

Criteria should be set to recognize the specific competences that teachers and students possess so that the teaching-learning models can be adjusted accordingly. Our approach in this regard coincides with that of Rong and Ling (2008), who state that the proposals for ICT competence and literacy models and elements based on standards and derived from consultation processes with experts or Delphi techniques provide the dimensions and competences that need to be included therein. The utilization of the Delphi technique during this process "has great impacts on improving information literacy competence and the willingness of applying information technology on teaching" (Rong & Ling, 2008, p.796).

The results of this study must be interpreted in accordance with the limitations that, in our opinion, it has faced. In this sense, it is worth saying that, even though the Delphi technique is very popular and widely accepted within the scientific community, it would be particularly interesting to undertake the validation of this work using other multivariate analysis modalities. This approach would make it possible to give validity to the questionnaire and to describe its suitability for use in diverse contexts. It is for this reason that our recommendations for future research works include the collection of a significant university student sample (both national and international) for the purpose of suggesting an evaluation of the questionnaire through a content validity index (CVI) and a factor analysis.

Our stance coincides with that of Tello and Aguaded (2009), according to whom it is necessary to utilize reliable and valid instruments in research processes. Our intention was thus to suggest a measurement instrument of proven reliability and validity on the perceived importance associated with the inclusion of digital competence within the university environment. This becomes a must when shaping the 21st-century citizen, and even more so in the light of the importance that technology is gradually acquiring within this context.

Endnotes

[1]Versions of the CDES in Spanish and Italian available at http://www.edutic.ua.es/cdes.

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