Psychometric properties of the Questionnaire for the evaluation of digital learning in higher education in Peruvian university students

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Evaluation, Learning, Virtual-environments, Feedforward, Feedback

ABSTRACT

This research presented the results of the process of creation and arrangement of the psychometric characteristics of the Questionnaire for the Evaluation of Digital Learning in Higher Education (QEDLHE). With a quantitative, predominantly instrumental approach, 379 students from different universities in Peru were considered for the validity and reliability stage. The reliability of instruments was assessed using the method of split halves with Pearson and Cronbach's Alpha ratified by the Guttman coefficient; in the exploratory factor analysis, the KMO (Kaiser-Meyer-Olkin) contrast and Bartlett's test were used, the rotation method for convergence with Varimax with Kaiser normalization; in the confirmatory factor analysis, the AMOS23 tool was used. Two models were used to compare the best fit indicators as a result. The conclusions show that the instrument has been operationalized theoretically by five dimensions composed of twenty-four items.

1. Introduction

COVID-19 brought about a radical change in universities. Models based on blended learning that combine classroom work and integration of technologies and complement face-to-face teaching were replaced by virtual modes. Consequently, the forms of evaluation adopt a rapid and forced transition to other forms of learning, especially online (Watermeyer et al., 2021), determined by physical separation. Currently, trends point to various lines of work such as the "development of personal learning environments, the use of intelligent agents or adaptive tutors and learning analytics" (Gros Salvat, 2018, p. 76).

The teaching-learning strategies traditionally contemplated as a process that is determined by a final evaluation through exams (Basogain-Urrutia, 2021) and that "do not guarantee the correct evaluation because they do not have supervision systems", which, in addition, are forced "to use monitoring systems only through videoconferencing" (2021, p. 9), must be overcome with a formative evaluation proposal that the *e-learning* system requires. The validity and importance of education with the incorporation of digital technologies (whether face-to-face or distance) also depend on health, economic and educational factors that require "profound methodological and organizational changes in the way of managing time, spaces, teaching professionalism, the content taught, learning activities, evaluation and ways of communicating with students" (Area Moreira, 2018, p.27).

The conceptualization of an educational modality must consider, above all, the consequences of the physical separation of the teacher/trainer and student/participant in space. This process involves the support of an organization/institution that produces materials, carries out monitoring and motivates communication and interaction, synchronous or asynchronous, between teacher/trainer and student (García Aretio, 2020).

Distance or non-face-to-face learning also brings some problems such as isolation (psychological effect) and low completion rates; it requires digital competencies, transformative learning, and new learning models (Blayone et al., 2017) that include as a substantial element, the evaluative process.

Assessment of learning in virtual environments

Evaluation is defined as any activity or process whose objective is to improve the conditions of teaching-learning, to know the state and, based on this, to make the appropriate decisions for its improvement. It should be developed as a continuous, permanent, integrated aspect (González and Martínez, 2018). It has people, processes and products as its central axis, and it involves planning, design, the ways in which they are developed, taught and maintained, as well as the materials that support the courses (Khan, 2005). In virtual environments, multiple didactic strategies are also required, hand in hand with the various digital tools that allow the evaluation through the interface of the skills and abilities established in each area of study. To achieve this, different dimensions are proposed:

Dimension 1: Initial or diagnostic assessment

It is a rigorous process carried out at the beginning of the semester or academic cycle with the objective of identifying the initial state of the students (Cizek, 2010). It is carried out through the use of instruments and digital tools with the purpose of making improvements to the planning and execution of learning that allow identifying the pace, style, talent, as well as the limitations of the student before the beginning of the school day. The diagnostic evaluation allows the teacher to use the results with assertiveness and creativity, allowing the programming of strategies that help to overcome deficiencies and develop their skills and competencies.

Dimension 2: Virtual resources for evaluation

The evaluation of *online* learning requires the accompaniment of artificial intelligence in the different moments in which it is carried out, either through the use of *tablets*, *smartphones*, *laptops*, and the multiple resources or applications that they offer. The most widespread tool is *Kahoot*, which allows innovations in the evaluation model and produces a direct effect on the teaching-learning process, on training skills and academic performance that is measured through grades (Guardia et al., 2019), in addition, it incorporates recreational scenarios (gamification). Other similar tools are *Quizalize and Mentimeter, Gimkit, Socrative, Edpuzzle, Plickers, Playposit, Thatquiz, Classdojo, Yo teach*, which also develop recreational aspects and equally focus the evaluation on the opinion from surveys, *tests*, activities or questions asked by the student.

Gamification as a formative assessment tool provides first-order information about the learning processes of individuals, in addition, it observes the motivation or emotional traits of students (Orhan Göksün & Gürsoy, 2019). There is a series of tools called *Game-based student response system* (GSRS) used for the evaluation of teaching-learning based on student performance and participation. The feedback produced by these is immediate and the results are positive on learning performance, classroom dynamics and improved student attitude (Wang & Tahir, 2020), ease of use and response and metacognitive supports should be added.

Dimension 3. Feedback

Feedback is information provided by an agent (teacher, peer, book, parent, experience) regarding aspects of performance or understanding. It occurs after instruction that seeks to provide knowledge and skills or develop particular attitudes (Hattie & Timperley, 2007). *Feedback* allows recognizing the information received and leads to improve student learning if its aspects of summary, specificity, explanations, scope and affective language are considered, according to Nelson & Schunn (2009). Information becomes *feedback* only when students act on it to improve work or learning strategies (Carless & Boud, 2018). It is difficult to conceive of teaching without *feedback*, although much time and effort is sometimes spent on producing feedback on assessment, but conversely very little effort is made to examine its effectiveness on students (Price et al., 2010).

In academic circles *feedback* is an essential component in the learning cycle that allows for reflection and development. Alerting students to their strengths and weaknesses can provide the means by which their performance is evaluated (Weaver, 2006) and reduce levels of dissatisfaction. There are different modes of *feedback* such as *face-to-face* conversations, electronic annotations, handwritten comments, rubrics, and digital recordings (audio and video); these modes offer various benefits and challenges for students and educators (Ryan et al., 2019). The video *feedback* format, adopted in Wilkie and Liefeith's

(2020) study, is defined as "live synchronous video feedback" (LSVF), incorporates digital video recordings of student performance in real-time, synthesized, synchronous assessment activities. Another mode is *audio feedback*, which, according to the study by Rawle et al. (2018) is constructive, clearer, and easier to understand than *written feedback*. Lunt and Curran (2010) corroborate that electronic audio represents an improvement on *written feedback* in terms of efficiency (staff experience) and perceived quality (student learning and experience).

Dimension 4: Feedforward

Feedfoward refers to task information conveyed through instructions; instructors literally provide students with information prior exposure and prior practice with the assessment. This is prospective feedback. The most effective teaching strategies employed in a *feedforward* approach include the use of examples, explicit composition processes, self-assessment, and peer assessment (Baker & Zuvela, 2013). While *feedforward focuses* on future performance, it is important to note that it also reflects an important difference in the way we communicate.

Dimension 5. Cognitive, procedural and attitudinal assessment: formative

Many changes in learning focus only on academic development or knowledge, but there are many training contexts in which knowledge is only a part of the learning objectives; there are various approaches to its measurement, the most common being self-report provided by the learner (Schrader & Lawless, 2004) and which can occur in any circumstance.

Formative evaluation is defined as any evaluation activity or process that "aims to know the state of the teaching-learning process and make the appropriate decisions for its improvement" (Gonzáles & Martínez, 2018); it should be developed continuously, permanently and integrated in the teaching-learning process because its purpose is to direct the student towards improvement.

2. Methodology

This research was conducted with a quantitative and instrumental approach, the main purpose of this study was the design and analysis of the psychometric properties of an instrument (Montero & León, 2002). A total of 379 university students from different Peruvian public universities in Lima and the interior of the country participated in the present study.

The instrument called Questionnaire for the Evaluation of Digital Learning in Higher Education (QEDLHE) was applied to this population of students, with the purpose of performing the reliability through the split-half and internal consistency methods. Likewise, it was proposed to evaluate the validation of the instrument with the Exploratory and Confirmatory Factor Analysis method. For this purpose, a digital form was distributed among all the students. The 379 students who made up the study sample were those who responded voluntarily.

Instrument

The virtual questionnaire was applied to university students to provide information on the evaluative practice of teachers. Initially it had six components or dimensions with a total of 24 items in D1: Initial evaluation (2 items), D2: Virtual resources for evaluation (1 item), D3: Evaluation in the virtual process (3 items), D4: *feedback* (8 items), D5: *feedforward* (7 items) and D6: Evaluation of learning process (3 items); the items of dimension 1 and dimension 2 were worked with dichotomous scales YES, No, the four dimensions and all the other items with a rating scale of 1 to 7 points validated by expert judgment, item 3 with an alternative. The final model of the instrument establishes five components.

Procedure and data analysis

The first analysis performed was the Exploratory Factor Analysis. In order to contrast the model found, the Confirmatory Factor Analysis was developed using the AMOS26 program for SPSS. Multiple indicators were used to evaluate the model fit (Hu & Bentler, 1995). The Chi-square statistical test, the chi-square ratio over the degrees of freedom (CMIN/DF), change in chi-square of the alternative models, the comparative fit index (CFI), the global goodness-of-fit index (GFI) and the root mean square error of approximation (RMSEA) were used. The Chi-square indicates the absolute model fit, but is shown to be sensitive to sample size. Therefore, the Chi-square ratio over the degrees of freedom is also interpreted, and for a good fit it should take values less than 3. The CFI and GFI indices vary between 0 and 1, where 0 indicates no fit and 1 indicates optimal fit. Values of 0.95 or higher are considered excellent, and values above 0.90 suggest an acceptable fit of the model to the data. The RMSEA index is considered optimal for values below 0.05 and acceptable from 0.08 to 0.05 (Hu & Bentler, 1995). Three confirmatory analyses were performed in the study, one for the initial model and two to improve the model. In each situation, the CFA was determined to corroborate the relevance of each item to the components found in the exploratory factor analysis, which initially proposed six components.

3. Results and discussion

Reliability test of two halves

The total number of items of the instrument was divided into two parts and the results were then compared. The coefficients used were Pearson's correlation and Cronbach's alpha, the results are shown below:

Table 1. Reliability through the two-half test

Pearson's correlation in split halves		Sum of Pairs
Odd Sum	Pearson correlation	0,954**
	Sig. (bilateral)	0,000
	N	379

Note: **. Correlation is significant at the 0.01 level (bilateral).

Table 1, according to Pearson's correlation coefficient (0.954), indicates that the instrument has a very high reliability given that there is a high relationship between the sum of the even items versus the sum of the odd items.

Table 2. Reliability to split-half statistics with Guttman test

Statistical reliability of two halves			
Cronbach's alpha	Part 1	Value	0,845
		N of elements	12[a]
	Part 2	Value	0,972
		N of elements	12[b]
	Total N of elements		24
Correlation between forms			0,836
Spearman-Brown Coefficient	Equal length		0,911
	Uneven length		0,911
Guttman coefficient of two halves			0,875
a. The elements are: P01, P02, P03, P04, P05, P06, P07, P08, P09, P10, P11, P12.			
b. The elements are: P13, P14, P15, P16, P16, P17, P18, P19, P20, P21, P22, P23, P24.			

Table 2 shows the Cronbach's Alpha coefficients for the first part (0.845) indicating medium reliability, and for the second part (0.972) indicating high reliability of the instrument. In addition, there is a high correlation (0.836) between the parts, including a very high correlation (0.911) between equal and unequal length. Likewise, there is a high relationship in the Guttman coefficient (0.875). For the reliability of the instrument by means of the internal consistency mean, the Cronbach's alpha coefficient was applied considering all the items of the instrument, reaching a value of 0.958, indicating that it is a highly reliable instrument.

Validity through Exploratory Factor Analysis

In compliance with the assumptions required for the test, such as normality of data, homoscedasticity (equality of variances) and multicollinearity (strong interrelation between items), the KMO (Kaiser-Meyer-Olkin) and Bartlett's test were used, which showed the following result:

Table 3. Test of sampling adequacy (KMO) and Bartlett's test of sphericity

Kaiser-Meyer-Olkin measure of sampling adequacy		0,961
Bartlett's test for sphericity	Approx. chi-square	8643,433
	Gl	276
	Sig.	0,000

Table 3 shows the KMO coefficient (0.961), a measure of sampling adequacy that indicates a very good fit value of the model, and Bartlett's test of sphericity showed statistical significance (0.000). These two analyses allow and guarantee the continuation of the Factor Analysis.

Table 4. Matrix of total variance explained

Total variance explained						
Component	Initial eigenvalues			Sums of loads squared by rotation		
	Total	% variance	Accumulated	Total	% variance	%Accumulated
1	3,549	56,453	56,453	8,535	35,561	35,561
2	,596	6,650	63,103	4,517	18,822	54,383
3	,279	5,329	68,432	2,838	11,826	66,209
4	,068	4,451	72,883	1,535	6,394	72,602
5	942	3,927	76,810	1,010	4,207	76,810
6	693	2,887	79,696			
7	613	2,556	82,253			
8	545	2,270	84,522			
9	502	2,091	86,614			
10	475	1,981	88,594			
11	328	1,366	89,961			
12	304	1,265	91,226			
13	296	1,232	92,457			
14	254	1,057	93,515			
15	238	,992	94,507			
16	209	,872	95,379			
17	181	,752	96,131			
18	166	,690	96,822			
19	153	,637	97,459			
20	148	,615	98,074			
21	132	,551	98,625			
22	127	,529	99,154			
23	104	,433	99,587			
24	099	,413	100,000			

Note: Extraction method: principal component analysis.

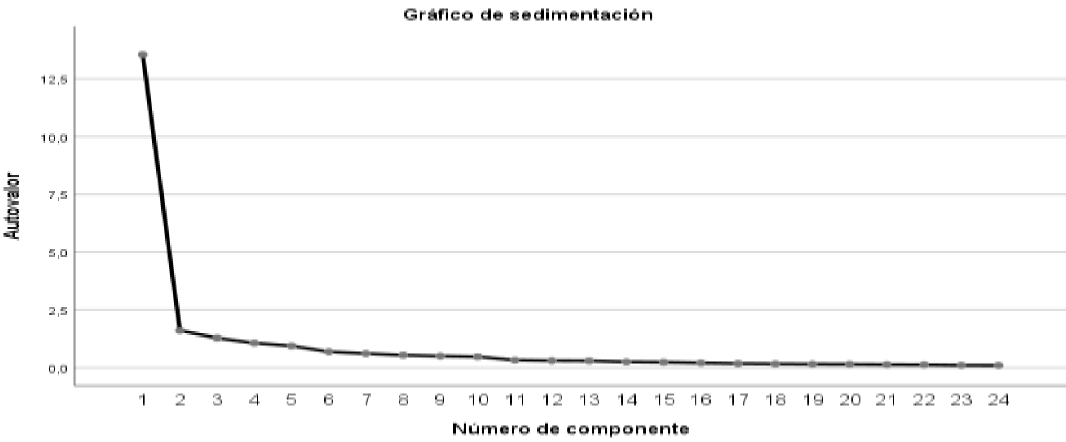
After this, the analysis of total variance explained for each of the 24 items was carried out and five components were found that describe up to 76.810% of the total variance, for which only eigenvalues greater than 1 were accepted in the extraction. Then, component 1 explains 35.561% of the variance, component 2 explains 18.822%, component 3 explains 11.826%, component 4 explains 6.394%, component 5 explains 4.207% of the variance, which can be seen in the sedimentation graph.

Fig. 1 shows the break point in the percentage of variance that occurs from component 2 onwards, with this value decreasing more and more.

In the same line, the values of the communalities were analyzed since they show the coefficient for a possible extraction (Table 5). All the items involved present coefficients greater than (0.7), not finding any candidate for extraction, since they all share more than 70% of the common variance with the other items.

Table 5. Rotated component matrix with extraction method

	Rotated component				
	1	2	3	4	5
P21	,858	,171	,257	,219	
P19	,834	,170	,234	,248	
P18	,829	,201	,273	,196	
P20	,799	,216	,252	,240	
P16	,798	,269	,212	,252	
P15	,786	,276	,255	,182	
P17	,776	,294	,248	,284	
P14	,731	,516	,145		
P13	,707	,561	,131		
P10	,682	,522	,200		
P12	,658	,499	,120		
P08	,360	,700	,238	,236	
P09	,320	,685	,246	,276	
P07	,223	,680	,340	,140	
P11	,552	,618	,133	,188	
P04	,285	,197	,792	,170	
P05	,389	,193	,775	,146	
P06	,216	,282	,744		
P03		,104	,691		
P22	,560	,328	,228	,622	
P24	,574	,315	,265	,589	
P23	,238			,574	
P01					,863
P02					,859



Subsequently, the next analysis performed were the values in the rotated component matrix through the extraction method of principal component analysis and the rotation method as Varimax with Kaiser normalization. All this indicates that convergence was found in 11 iterations in this matrix discriminating all coefficients with absolute value less than 0.30 to obtain a better composition. Likewise, items that were found in more than one component were eliminated, as long as they presented a difference of less than 0.05 between the factor loadings of each one. The final result (Table 6) is shown below:

Table 6. Matrix of components or final dimensions of the questionnaire for the evaluation of online

learning in higher education

Grouped components of 5 components of the questionnaire					
	1	2	3	4	5
P21	0,858				
P19	0,834				
P18	0,829				
P20	0,799				
P16	0,798				
P15	0,786				
P17	0,776				
P14	0,731				
P13	0,707				
P10	0,682				
P12	0,658				
P08		0,700			
P09		0,685			
P07		0,680			
P11		0,618			
P04			0,792		
P05			0,775		
P06			0,744		
P03			0,691		
P22				0,622	
P24				0,589	
P23				0,574	
P01					0,863
P02					0,859

Table 6 allows us to conclude that the final instrument would be made up of 5 components

D1: Initial evaluation (2 items), D2: Evaluation in the virtual process (4 items), D3: Feedback (8 items), D4: Feedforward (7 items) and D5: Evaluation of the learning process (3 items) the items of dimension 1 with categories YES, NO and the four dimensions with polytomous scale 1 to 7 points validated by expert judgment. It should be noted that item 3 has seven alternatives on virtual resources for evaluation.

Therefore, with the Exploratory Factor Analysis it is concluded that the instrument is made up of the following components with their respective items: Component 1: Feedforward: P10, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, component 2: Feedback: P07, P08, P09, P11; component 3: Virtual resources for assessment: P03, P04, P05, P06; component 4: Assessment of skills development: P22, P23, P24; component 5: Initial assessment: P01, P02. Then, with the AMOS tool of the SPSS, we proceeded to perform the Confirmatory Analysis of this last proposal, obtaining the following graphic model.

Validity of the instrument by confirmatory factor analysis.

At this stage, the AMOS26 tool of the SPSS software was used to model the results obtained in the exploratory factor analysis. The first model analyzed (Fig. 2) is as follows:

Table 7. Comparison of parameters in the adjustment of online learning assessment models in higher education

Models	Absolute adjustment measures		Incremental adjustment measures			Parsimony adjustment measures			
Model	Chi-square	RMSEA	IFC	TLI	NFI	PRATIO	PCFI	PNFI	AIC
Model 1	0.000	0.091	0.919	0.909	0.897	0.883	0.812	0.792	987.123
Model 2	0.000	0.085	0.921	0.911	0.951	0.895	0.824	0.801	682.699

In the results of the model fit, the p-value (0.000) was found for the Chi-square test, which indicates the equality of the model obtained with the estimated model, but the p-value is very susceptible to the sample size which could be the present case since it has 379 cases and many items.

Another analysis performed took the CFI comparative fit index (0. 919). This indicates that the model has a good fit; it is also shown in the TLI index (0.909) which expresses the proportion of the variance explained by the factorial model, indicating that the model could be improved with components considered. The root mean square approximation index RMSEA (0.091) was also found to be much higher than 0.05 which also calls for an improvement in the model. Another index to pay attention to is the information criterion index, AIC, which is used to compare models and states that the best model is the one with the lowest value.

Given that the analysis of the first model still did not find adequate values for the indicators, we moved on to the search stage of the improved model by analyzing the values of the factor loadings in the new model. One step is to look for lower estimation values. For the improved model, one or more analyses were again carried out in search of better values with respect to the first model. In model 2, better parameters or measures were found. This is how the final model of the instrument Table 7 and Figure 3 was established.

Discussion

The instrument *Questionnaire for the evaluation of digital learning in higher education* manages to be a suitable option to be applied as a diagnostic test of knowledge about competence in higher education students. The main result of this research is related to the confirmatory validity, in this sense, the reliability and validity of the instrument allow generating scientific knowledge with a level of precision and valid evidence for the improvement of educational quality in the university. The digitalization of societies has taken an accelerated course (Cena, 2022) and different countries have built new educational policies that include the use of ICT in the teaching-learning process (Sanchez, 2020).

These results are consistent with research linked to the design and validation processes of questionnaires to measure digital learning Cabero. Almenara et al. (2020) validated a digital competence questionnaire for university students of education in Spain, using structural equations, establishing a model aligned with the main competence frameworks in their different dimensions and levels of digital learning. Mejía Corredor et al., (2023) adapted a questionnaire to measure the levels of digital competence of higher education students in Colombia, the results of the statistical validation presented positive indicators for its evaluated dimensions. Casildo-Bedón et al., (2023) analyzed the psychometric properties of a questionnaire of digital competencies in Peruvian university students, the original structure was respected with 42 items distributed in 5 latent factors, reporting acceptable goodness-of-fit and internal consistency indexes.

The findings of this research show the structure formed by 5 components, similar results were found by Orosco et al. (2020) where in a sample of Peruvian university students they found the conformation of 5 dimensions in digital competencies. Silva-Quiroz et al. (2022) designed and validated an evaluation instrument of digital competencies in pedagogy, in a context of three Chilean public universities, also finding 5 dimensions. These results are different from those reported by Acosta-Aguilera et al. (2019) who developed an instrument with 3 dimensions applied to high school students and Barragán-Sánchez et al. (2020) who reported a single-factor model that measures self-perceived teaching digital competencies in relation to the eco-responsible use of technologies.

Regarding the internal structure, the instrument in its totality of items through Cronbach's alpha statistic reached a value of 0.958, characteristic of a highly reliable questionnaire. Similar results were found Luna Serrano and Hernández Villafaña (2020) through the internal consistency (ordinal alpha) of the questionnaire registered an index of 0.998. Likewise, del Carpio Ramos et al. (2021) in their study show a Cronbach's alpha coefficient, initial and final, greater than 0.8 and a Pearson correlation coefficient different from zero.

The results corroborated the theoretical foundation of the instrument with acceptable measures of validity and reliability, it becomes an instrument designed to measure the digital learning of university students in the Peruvian educational context. The above invites to reflect on the concept of evaluation as those activities developed by students, individually or collectively, in a digital environment, in search of obtaining meaningful learning that is linked to the teaching process (Cabero, 2014).

The study has some limitations. By using a cross-sectional design, it is impossible to evaluate the temporal stability of the instrument. It is important to mention that the perception of digital learning assessment can be influenced by cultural and social factors in different regions. Therefore, future research should take these aspects into account. It is important to mention that, despite having a large sample of different university students in Peru, the data were taken virtually, which does not guarantee obtaining accurate information in the research.

4. Conclusion and future scope

The first conclusion is that the instrument has been operationalized theoretically by six components or dimensions composed of twenty-four items. From the analysis of rotated components with extraction method, the number of items is maintained; however, when the exploratory analysis of the items was carried out, it was constituted in five dimensions. First, feedforward constituted by eleven items; second, feedback with four items; third, virtual resources for evaluation with four items; fourth, evaluation of the development of skills with three items; and fifth, initial evaluation with two items.

A second conclusion points out that the validity of instruments and reliability of the items, in the first place, went through the content validity through expert judgment. For reliability, the method of split halves was used with Pearson's correlation (0.954), Cronbach's Alpha considering all the items of the instrument, reaching a value of 0.958, which indicates that it is a highly reliable instrument. Finally, it is ratified by the Guttman coefficient (0.875).

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