Factor Analysis: An Application of the Digital Competencies Questionnaire in Students of the Business Administration Career of the Instituto Tecnológico Superior España (ISTE)

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The purpose of this research was to perform an exploratory factorial analysis of the digital competencies questionnaire in students. A cross-sectional observational design was applied to 322 students of the Tecnológico Superior Universitario España from the 4th and 5th cycles of the Business Administration career. It was obtained that the basic assumption of the factor analysis of the Kaiser-Meyer-Olkin Measure was 0.778 and Bartlett's sphericity test had a significant value $p<0.000$. On the other hand, the variance of the first component was 28%, component 2 had a percentage of almost 12% as explained variance, and finally the third component had a variance percentage representation of 10%. This means that the percentage of accumulated variance of the three components was 50.5%.

Keywords: factor analysis, higher education, digital competencies questionnaire, business administration, technological institutes

INTRODUCTION

The 21st century focuses on the digital society, which is an extension of the industrial society development that expanded throughout the 20th century. The Internet and digital technology is the main communication channel in people's daily lives. The number of Internet users worldwide has tripled in a ten-year period (2005-2015) from 1.024 billion to 3.174 billion users (TECHATAWEEWAN & PRASERTSIN, 2018) . In addition, the rise of digital technology has changed the way people communicate,

collaborate, create work, solve problems, make decisions and consume information (VAN DEURSEN et al., 2016).

Technology has also changed the learning paradigm for students, encouraging them to harness the power of digital technologies for successful study (ECHEVERRÍA & MARTÍNEZ, 2018). The current education must move from traditional methods of teaching and learning based on printed materials to digital formats. In addition, by increasing the quantity of learning resources on websites, the Internet offers a wide range of disciplines and learning opportunities (TECHATAWEEWAN & PRASERTSIN, 2018).

Access to computers and other digital devices and the Internet has grown very fast in modern societies. In addition to access, citizens around the world were often expected to demonstrate digital skills, as they promote economic growth, help people find jobs and perform more efficiently. The access to and competencies in the use of digital devices also open up opportunities for individuals and groups in a variety of areas.

Several studies have challenged that these skills often correspond only to leisure and socialization activities and do not transfer to academic and work contexts (SÁNCHEZ et al., 2020)ç; regardless of whether students in higher education really have such competencies. There is a consensus across a variety of disciplines and institutions that all citizens today must have a certain level of generic digital competencies to thrive in society (HERNÁNDEZ et al., 2018). LÓPEZ & SEVILLANO (2020) argue that, in these times of digital transformation, digital literacy is an essential condition. ICT can play an important role in the personal and professional development of students. Although higher education institutions can collaborate in promoting the development of these competencies in students, there is still a gap between what is taught in Higher Education and what the productive sector needs. Therefore, research on the digital competencies that are being developed in universities and those required by the labor market is of utmost importance for educational research.

The aforementioned gap is more prominent in developing countries and, at the same time, slows down their preparation for full entry into the knowledge economy (LEÓN et al., 2020). Thus, the competencies of the 21st century are an emerging topic in educational research. So it is necessary to have optimal questionnaires for their evaluation. In this sense, the purpose of this study is to conduct an exploratory factor analysis of Garcia's Digital Competencies questionnaire in university students to know the internal components of the construct.

Digital Competencies

In the last two decades, the term competence has gained special relevance in the field of education. Although it is not a new concept, we can say that it has been redefined since its relevance has been issued by relating it directly to the essential knowledge that education must offer to all individuals. On the other hand, competencies are the cognitive, affective, socioemotional and physical capacities that a person is capable of mobilizing in an integrated manner that allows him/her to act effectively in the face of the demands of each context (MIRETE et al., 2020).

It is important to describe competence as a behavioral characteristic that is obtained from knowledge and skill and that is demonstrated through a particular action with a level of proficiency. These illustrated secondary factors are known as mental characteristics that can help shape the success and speed of the Internet search action along with knowledge and skill. (SUWANROJ et al., 2019)

Digital competence is a behavior formed by the cognitive (knowledge) and psychomotor (skill) domains of latent learning in individuals. The competencies help these individuals to successfully operate information and communication technology (ICT) (REYNA et al., 2019) and information technology tasks. The cognitive proficiency refers to the knowledge, news and understanding of general and specific issues that an individual acquired, provided that it can be further used in real life practices. Psychomotor proficiency refers to the ability to perform tasks that require fair experience, training or practice (LEVANO et al., 2019).

The digital competence components include: a) Digital literacy; b) Accessing digital information; c) Using digital information; d) Creating digital information and media; e) Communicating digital

information; f) Managing digital information; and g) Evaluating digital information (SUWANROJ et al., 2019).

The digital competencies questionnaire of GARCÍA (2016), has a structure of 12 questions, of which 3 are focused on the demographic aspects of the population> The questionnaire has gender with categories of female and male It also analyzes whether the population has work experience with a level of none, little. and much experience, and also includes the academic attainment level. It is the last question about the general data of the population, an aspect that has several categories such as elementary school, middle school, high school, vocational training, languages, adult education.

The questionnaire has four dimensions directed to digital competencies according to his author GARCÍA (2016), which are detailed below with the respective questions, which have a free expression response option.

User Profile

- Microsoft defines 3 user profiles according to your competence. What do you consider as your profile? Please select only one answer.
- Do you think your ability to work with ICT is related to the above profile? Please select only one answer.
- Do you have work experience? Please select one of the options.

Cell Phones and Video Games

- Do you consider that it is important for your work to expand your profile to an advanced or administrator level? Please select only one answer.

Web 2.0

- Do you work with online apps? Please select only one answer.
- Online apps represent a current way of generating shared knowledge and collaborative work. Please select only one answer.
- To use Web 2.0 tools you must have a minimum profile of advanced user. Please select only one answer.
- The current digital competence is closely related to the use of Web 2.0 tools. Please select only one answer.

Composition of a Digital Competence

- Having your files online or in the cloud (as is the case with Google Docs, Dropbox...) available at any time is: (Select one answer).
- Having a current digital competence is essential for working in modern society. Please select only one answer.

METHODOLOGY

This research had a cross-sectional observational design of students who belong to the Business Administration career of fourth and fifth cycles. This population follows a pattern of sequence in the study and adaptation to the management of the technological infrastructure that the institution has. They are students who are in the final part of their graduation and therefore have already developed digital competencies, allowing them to be fully adapted to the online study system that the institution has in its academic offerings. The study was conducted during the academic period, February-June 2022. The study population comes from the list of students enrolled in the aforementioned period. From this population, 322 people were selected based on a non-probabilistic sampling technique using the systematic consecutive technique.

The questionnaire was self-administered using the Surveymonkey digital platform. To this end, the researchers were responsible for explaining the content and purpose of the questionnaire beforehand, ensuring that the students understood the purpose of the research.

In the exploratory factor analysis, we based factor solutions on the number of factors with eigenvalues exceeding 1.0, on the variance percentage explained by the factors, and on the cohesion of the ability items within the identified factors. We used varimax rotation because we knew from previous research that digital skills are related and, therefore, we expected ambiguity in the positioning of some of the items that might cause them to load on more than one factor.

The information gathering was carried out under the strategies applied by the researchers, under this premise, to obtain the information from the students there was a contact via telephone with the student representatives, with the purpose of attracting the students, therefore, regarding the application, a meeting was held through the zoom app for the explanation of the questionnaire and its purpose, specifying the parameters of registration in which they were asked to respond thinking and reflecting from the realities of each of the students.

Factor Analysis

The exploratory factor analysis was applied in order to study the reality of the questionnaire in the Ecuadorian context, using 10 questions. In this regard, the aim was to find those factors that explained the maximum variability and that were structured with variables (items) specific to the factor. There are a series of assumptions that must be fulfilled in order to apply factor analysis, the most important of which are specified below.

- The variables were measured with continuous quantitative parameters, in this study both interval and ratio categories were applied.
- In the application, it was necessary to have ordinal or Likert scale type variables.
- The sample size was in context to the study variables.
- The study did not establish independent or dependent variables, because it is necessary that all the study variables occupy the same role.
- The observations were independent.
- The common factors were metric, continuous, unbounded variables and lacked measurement error.
- Data were distributed with mean 0 and variance 1.
- The errors were random and independent, both from each other and from the factors. Furthermore, they are assumed to be normally distributed with zero mean and constant variance (homoscedasticity).

STAGES OF FACTOR ANALYSIS

Basic Assumption of Factor Analysis

A correlation matrix was issued, because it expresses a pattern of relationships between variables that can be decoded. In conjunction with the generation of the correlation matrix, a series of statistical tests were obtained to indicate whether it is pertinent to carry out the factor analysis with the available information:

- Kaiser-Meyer-Olkin Coefficient (KMO): measure of the comparison between observed correlation coefficients and partial correlation coefficients. It assumed values between 0 and 1. The decision rule was, that it is adequate when the KMO coefficient is greater than 0.5.
- Bartlett's sphericity test: this test evaluates the null hypothesis that the variables are uncorrelated, that is, it assesses whether the correlation matrix is not an identity matrix, in which there is no relationship between the variables. It is accepted as valid if the significance level is less than 5% ($p < 0.05$).

Factor Extraction

A component analysis was obtained, since this method creates as many factors as variables. It looked first for the factor that explains the greatest amount of variance within the correlation matrix, which is subtracted from the original matrix and looks for a second linear combination, which explains the maximum proportion of the remaining variance and so on. This means that factors whose variance is greater than 1 must be incorporated, otherwise it would explain less variance than an original variable. It is important to establish that the extracted factors do not correlate with each other.

Calculation of Communalities

This calculation was presented because it measures the variance percentage in a variable explained by all the factors together and can be interpreted as the reliability of the indicator. It was calculated through the squared coefficient of multiple determination and takes values between 0 and 1. If a factor has a low eigenvalue, then it is contributing little to the explanation of the variance of the variables.

Determining the Number of Factors

Several criteria have been defined: 1) Kaiser criterion, that is, to retain those factors with an eigenvalue greater than 1; 2) *a priori* definition of the number of factors to be retained; 3) *a priori* definition of the variance percentage; 4) graphically, from a sedimentation graph showing the way in which the eigenvalues decrease, selecting the number of factors corresponding to the point where the graph curve becomes horizontal; 5) to retain factors whose eigenvalues are equal to or greater than the average of all the eigenvalues.

Factor Rotation

The sum of the eigenvalues is not affected by rotation, but rotation will alter the eigenvalues and the variance percentage explained. With the rotated factors, each of the variables will have a correlation close to 1 with one of the factors and close to 0 with the rest of the factors, the varimax method was included. A matrix of rotated components was obtained, which indicated the correlation between each variable and its corresponding factor, known as saturations, which take values between -1 and +1.

Finally, the resulting factors were interpreted by assigning them names considering the original variables included in each factor. SPSS 24 statistical software was used for data analysis.

RESULTS

The study sample was made up of 322 students, most of them female, with a representation of 75.8%, while 24.2% corresponded to the male gender. Of the respondents, 36.9% maintained their secondary education in a public institution and 3.1% in a private institution. Taking work experience into account, 59.6% had little experience, 34.5% had no experience at all, and only 5.9% had extensive experience.

The questionnaire score establishes the extraction of the mean and standard deviations for each question belonging to the questionnaire. The question showing the lowest score was question No. 9, while the highest score was for question No. 5 (see Table 1).

TABLE 1
QUESTIONNAIRE SCORES (DATA EXTRACTION)

Descriptive statistics			
	Mean	Dev. Deviation	No. of analysis
1. Do you have work experience? Please select one of the options.	,71	,568	322
2. Microsoft defines 3 user profiles according to your competence. What do you consider as your profile? Please select only one answer	1,39	,581	322
3. Do you think your ability to work with ICT is related to the above profile? Please select only one answer.	2,59	,983	322
4. Do you consider that it is important for your work to expand your profile to an advanced or administrator level? Please select only one answer.	2,70	1,122	322
5. Do you work with online apps? Please select only one answer.	1,89	1,190	322
6. Online apps represent a current way of generating shared knowledge and collaborative work. Please select only one answer.	2,84	,741	322
7. To use Web 2.0 tools you must have a minimum profile of advanced user. Please select only one answer.	2,29	,886	322
8. The current digital competence is closely related to the use of Web 2.0 tools. Please select only one answer.	2,54	,893	322
9. Having your files online or in the cloud (as is the case with Google Docs, Dropbox...) available at any time is: (Select one answer).	1,20	,473	322
10. Having a current digital competence is essential for working in modern society. Please select only one answer.	2,77	,884	322

Source: Prepared by the authors

As shown in Table 2, the basic assumption of the factor analysis of the Kaiser-Meyer-Olkin Measure was 0,778 and Bartlett's sphericity test had a significant value p<0,000, which demonstrates and affirms that the factor analysis is adequate in this questionnaire.

TABLE 2
BASIC ASSUMPTION OF FACTOR ANALYSIS

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		,778
Bartlett's sphericity test	Chi-square Approximation	419,659
	gl	45
	Sig.	,000

Source: Prepared by the authors

Table 3 shows the calculation of the communalities as a means of interpreting the reliability for each indicator. Considering the eigenvalue, it is understood that questions 5 and 3 are not contributing.

TABLE 3
COMMUNALITIES CALCULATION

Communalities		
	Initial	Extraction
1. Do you have work experience? Please select one of the options.	1,000	,510
2. Microsoft defines 3 user profiles according to your competence. What do you consider as your profile? Please select only one answer	1,000	,586
3. Do you think your ability to work with ICT is related to the above profile? Please select only one answer.	1,000	,319
4. Do you consider that it is important for your work to expand your profile to an advanced or administrator level? Please select only one answer.	1,000	,471
5. Do you work with online apps? Please select only one answer.	1,000	,385
6. Online apps represent a current way of generating shared knowledge and collaborative work. Please select only one answer.	1,000	,570
7. To use Web 2.0 tools you must have a minimum profile of advanced user. Please select only one answer.	1,000	,611
8. The current digital competence is closely related to the use of Web 2.0 tools. Please select only one answer.	1,000	,623
9. Having your files online or in the cloud (as is the case with Google Docs, Dropbox...) available at any time is: (Select one answer).	1,000	,426
10. Having a current digital competence is essential for working in modern society. Please select only one answer.	1,000	,554
Extraction method: principal component analysis.		

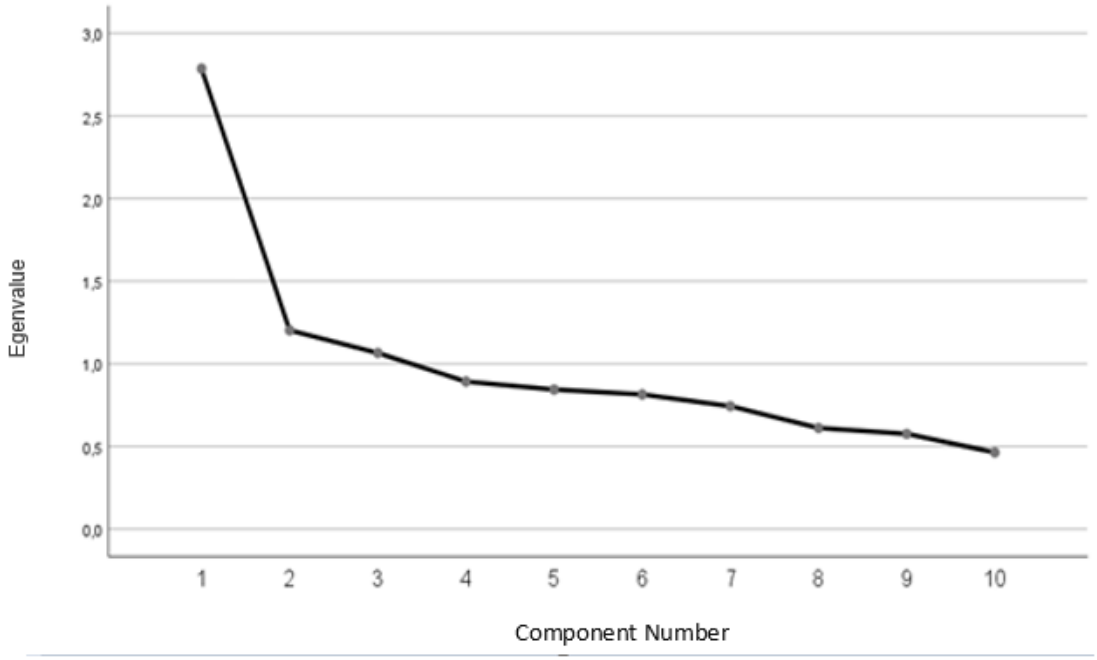
Source: Prepared by the authors

Table 4 shows the components, specifying the eigenvalue of each one and the percentage representation of variance, both explained and accumulated. According to the processed data, only 3 factors were stopped, because only three components showed a value higher than 1 (eigenvalue). The eigenvalue of the first component was 2,9 with a variance of 28% (percentage value explained). Component 2 had an eigenvalue of 1,2 with a percentage of almost 12% (variance explained) and finally the eigenvalue of the third component was 1,1 with a percentage representation of the variance of 10%. This means that the percentage of accumulated variance of the three components was 50,5% (see graph 1).

TABLE 4
DETERMINATION OF COMPONENTS

Total explained variance									
	Initial eigenvalues			Sums of squared extraction loads			Sums of squared rotational loads		
Component	Total	Variance %	Accumulated %	Total	Variance %	Accumulated %	Total	Variance %	Accumulated %
1	2,786	27,861	27,861	2,786	27,861	27,861	2,189	21,885	21,885
2	1,202	12,025	39,886	1,202	12,025	39,886	1,695	16,949	38,834
3	1,066	10,658	50,543	1,066	10,658	50,543	1,171	11,709	50,543
4	,892	8,924	59,467						
5	,844	8,441	67,908						
6	,815	8,146	76,055						
7	,744	7,436	83,491						
8	,612	6,117	89,608						
9	,576	5,760	95,368						
10	,463	4,632	100,000						
Extraction method: principal component analysis.									

FIGURE 1
SEDIMENTATION



The post-rotation component matrix establishes that component 1 covers questions 8, 7 and 4 in which the component is the use of Web 2.0. Component 2 includes questions 6, 9 and 5, questions directed to the composition of a digital competence. As a final aspect, component 3 is analyzed in which questions 2 and 1 belonging to the user profile are found; however, questions 3 and 10 were discriminated among the lowest scores; nevertheless, based on their value, they are incorporated into component 1 (Web 2.0).

TABLE 5
ROTATION OF FACTORS

Rotated component matrix[a]			
	Component		
	1	2	3
8. Current digital competence is closely related to the use of Web 2.0 tools. Please select only one answer.	,780	,108	,055
7. To use Web 2.0 tools you must have a minimum profile of advanced user. Please select only one answer.	,761	-,037	,176
4. Do you consider that it is important for your work to expand your profile to an advanced or administrator level? Please select only one answer.	,614	,254	-,174
3. Do you think your ability to work with ICT is related to the above profile? Please select only one answer.	,520	,180	,129
10. Having a current digital competence is essential for working in modern society. Please select only one answer.	,519	,486	-,220
6. Online apps represent a current way of generating shared knowledge and collaborative work. Please select only one answer.	,182	,731	,055

9. Having your files online or in the cloud (as is the case with Google Docs, Dropbox...) available at any time is: (Select one answer).	,115	,639	,059
Rotated component matrix[a]			
	Component		
5. Do you work with online apps? Please select only one answer.	,057	,605	,127
2. Microsoft defines 3 user profiles according to your competence. What do you consider as your profile? Please select only one answer	-,071	,200	,735
Do you have work experience? Please select one of the options.	,176	-,006	,692
Extraction method: principal component analysis. Rotation method: Varimax with Kaiser normalization. [a]			
(a) The rotation has converged in 4 iterations.			

DISCUSSION

The study revealed the presence of three components, which maintain a percentage representation of 50% of the total variance of the analysis. In comparison to the original data issued by GARCÍA (2016), four internal components were established which were Web 2.0, composition of a digital competence, user profile and cell phones and video games.

Component 1 identified was the one representing the use of Web 2.0, with a variance value representation of 28%, changing its internal structure from 4 to 5 questions. This component was the most representative despite the fact that the adjustment of the analysis cannot be defined as perfect, in contrast to what was established by GARCÍA (2016), it was necessary to eliminate the original component of cell phones and video games because it was not representative, however, the composition value did not allow its elimination and it was regrouped.

Now, when analyzing the questions in reference to their distribution, it was similar to the components of GARCÍA (2016) supporting this statement since the items did not have a significant rotation to the original, it is inferred that these analyses were issued in a similar context in the validation of the Spanish population of students, in addition to not finding evidence and statistical support from other research both in populations with similar or different characteristics to those of this study.

CONCLUSIONS

The 10-question questionnaire showed a representative correlation between the questions involved in an internal distribution considered to be solid; however, it has not been possible to establish whether there is similarity in other populations with similar contexts to that of the ISTE students in Ecuador. Despite of the above, and in response to the exploratory factor analysis of the digital competencies questionnaire in students of the Institute, it is concluded that it has an internal distribution with three components, which does not exclude that in other different populations there are other results diverse to those established in this research.

It is important to mention that for a better adjustment the questionnaire should be submitted to a confirmatory factor analysis in a future projection based on the models already applied in this research. With this research as a model and guide for future research, it is intended to demonstrate the relevance of implementing new evaluation instruments aimed at digital competencies in students in higher education and the contribution that a multivariate analysis can provide in the internal distribution of a questionnaire.

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