Comunicar
Media Education Research Journal
E-ISSN: 1988-3293 | ISSN: 1134-3478
PREPRINT

Received: 2019-05-27
Reviewed: 2019-07-16
Accepted: 2019-07-31

ID: 110502
Preprint: 2019-11-15
Published: 2020-01-01

DOI: https://doi.org/10.3916/C62-2020-08

Self-perception about emerging digital skills in Higher Education students

Autopercepción sobre habilidades digitales emergentes en estudiantes de Educación Superior

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Abstract
The current labor market demands new qualities and knowledge from recent university graduates, including digital skills, and there is not enough research on the self-perception of students in this regard. The objective of this study was to measure student self-perception about their own 21st century digital skills related to the use of information and communication technologies (ICT) in Higher Education. A questionnaire was generated and applied to 356 students with the stratified random sampling technique. A principal component analysis was carried out, supported by adequate values of the Kaiser-Meyer-Olkin coefficient and the Bartlett sphericity test. The data indicate that students primarily use digital technology in academic projects and are quite skillful when using ICT for information management, to develop critical thinking and to solve problems, as well as to manage mobile devices. However, their self-perception in the use of ICT in teaching classes is low. The results suggest that the students do not believe that the use of ICT in the classroom is useful for developing this type of emerging digital skills. On the other hand, they think that carrying out academic projects does strengthen the acquisition and development of such skills in relation to the use of ICT.

Resumen
El mercado laboral actual exige nuevas cualidades y conocimientos a los recién egresados de las universidades, incluidas las habilidades digitales, no existiendo suficientes investigaciones sobre la autopercepción del estudiantado al respecto. El objetivo de esta investigación fue medir la percepción que el estudiantado tiene sobre sus propias habilidades digitales del siglo XXI, en relación con el uso de las tecnologías de la comunicación (TIC) en la Educación Superior. Se generó y aplicó un cuestionario a 356 estudiantes con la técnica de muestreo aleatorio estratificado. Se realizó un análisis de componentes principales avalado por valores adecuados del coeficiente Kaiser-Meyer-Olkin y de la prueba de esfericidad de Barlett. Los datos indican que el estudiantado usa la tecnología digital en proyectos académicos

primordialmente, y posee alta habilidad al usar las TIC para la gestión de información, para desarrollar pensamiento crítico y para resolver problemas, así como para manejar dispositivos móviles. Sin embargo, su autopercepción es baja respecto al uso de las TIC en la impartición de clases. Los resultados sugieren que el estudiantado no cree que el uso de las TIC en el aula sea útil para desarrollar este tipo de habilidades digitales emergentes. En cambio, indican que la realización de proyectos académicos sí fortalece la adquisición y desarrollo de tales habilidades en relación con el uso de las TIC.

Keywords / Palabras clave

Emerging digital skills, factorial analysis, principal component analysis, higher education, ICT, survey, self-perception.
Habilidades digitales emergentes, análisis factorial, análisis de componentes principales, educación superior, TIC, encuesta, autopercepción.

1. Introducción

1.1. 21st century skills and 21st century digital skills

Some years ago, university graduates only had skills that would not be considered enough to compete in today's knowledge economy. Nowadays, new arrivals on the labour market are required to have both "hard" and "soft" skills; the latter also being known as "21st century skills". The Organization for Economic Co-operation and Development (OECD) defines these as being necessary for young people to become effective workers in the present knowledge society (Ananiadou & Claro, 2009). The 21st century skills often mentioned in research studies, as in those by Wegerif & Mansour (2010), Fullan & Langworth (2013), Anderson (2010) and the World Economic Forum (Schwab, 2016) are the following: communication, critical thinking, creativity, collaboration, problem-solving and technological competencies.
In addition, the correct and efficient use of the information and communication technologies (ICT) requires new graduates to also possess an additional capacity, which consists of having the soft skills, but developed through the ICT which are known as the "21st century digital skills". These are necessary to be able to participate in the labour market, which is based on the knowledge economy, and to make these professionals responsible for their own learning, taking the most advantage of the ICT (Van-Laar, Van-Deursen, Van-Dijk, & de-Haan, 2017). Van-Laar and others (2017) specifically define "21st century digital skills" as: technical skill, information management, communication, collaboration, creativity, critical thinking and problem solving, all within the context of digital technologies.
Although the Higher Education institutions can collaborate in promoting the development of these skills in university students, there is still a gap between what is taught in Higher Education, and what the productive sector needs (Intel-Microsoft-Cisco Education Taskforce, 2009). Due to this, research on the skills forged at the universities and those required by the labour market is extremely important for educational research (Ramos, 2015). The above-mentioned gap is more pronounced in the developing countries, and at the same time, it holds back their preparation for full entry into the knowledge economy (Alfaki, 2016). In this way, the "21st century skills" is an emerging topic in educational research, so that they can be classified as emerging digital skills, since they represent the appearance of a construct supported by digital technology. Therefore, from now on we will use the term "Emerging digital skills" to refer to the "21st century digital skills".

1.2. Use of ICT in Higher Education

In a previous qualitative study on ICT in Higher Education by two of the present authors (León-Pérez & Escudero-Nahón, 2017), three main constructs were defined: academic projects, the use of ICT

by teachers, and the use of ICT by students. The study method was based on analyzing the strategic planning of a leading Mexican university and semi-structured interviews with the heads of faculties in the same university. The information obtained was analyzed by thematic coding, a strategy based on constant comparison, which segments and categorizes the data by a reduction technique to capture the important concepts and is known as thematic analysis (Given, 2008: 867).
The results of the study indicated that the way in which teachers and students use ICT influences the development of their digital skills. They also found that teachers used ICT's didactic dimension only at a basic level, e.g. solely as a substitute for a blackboard and chalk, basically because many teachers find it difficult to adapt to new technologies and thus are reluctant to use them in class. It was also found that academic projects are an important transversal element as regards topics and participants (both students and teachers) from different branches of knowledge.
On the other hand, the present student community in Higher Education is composed of the so-called "digital natives", who are able to make complex and confident use of digital devices and technologies; in addition, the so-called "millennials" have little faith in organizations and are highly independent (Alvarez, Najarro, & Paredes, 2017; Pardue & Morgan, 2008). However, this does not mean that this generation makes correct use of the ICT in education. In fact, they often only use digital technology to look for, select and use quality information on the Internet at best, and at worst, they become confused by it. In any case, their confidence and ability to use the technology does not enable them to build knowledge autonomously.

1.3. Perception studies

Although observational studies are a good method of measuring skills, they are costly and time-consuming, which limits their application to large-scale data collection (Van-Deursen, Van-Dijk, & Peters, 2012), while "the measurement of perceptions, opinions, and attitudes of people do not replace events or behaviors measured in objective terms. However, it manages to capture information on issues and events of reality under investigation that could not be otherwise obtained." (Mazziotta & Pareto, 2012: 17). Some studies have used perceptions to reach important conclusions on the subject of education, such as that by Conchado, Carot & Bas (2015), who define the competencies required for knowledge management; or the one by Pérez-Mateo, Romero & Romeu-Fontanillas (2014), who analyze the acquisition of digital competencies; or the study by Cabero & Marín (2014), who aim to determine students' perception of social software and collaborative teamwork.
The aim of the present study was to measure students' self-perception of their emerging digital skills in relation to the use of ICT in Higher Education.

2. Materials and methods

2.1. Participants

The study population consisted of 4237 students from the Universidad Autónoma de Querétaro (UAQ) who had studied at least six semesters of their degree course at the City of Querétaro campus in Mexico.
The sample size was calculated for a 95% confidence level and 5% margin of error, giving a total of 356 observations, of which 59.5% were females and 40.5% males. The mean age of the participants was 22 years and 9 months, with a standard deviation of 2 years 3 months.
The sampling technique used was the simple stratified random sampling. Each of the university's 13 faculties was considered a stratum, and the number of observations per faculty was proportional to the number of students in each faculty. Randomness was ensured by drawing names from those in the different semesters until reaching the necessary sample number for each faculty.

2.2. Measures

Since questionnaires are the tools most frequently used to measure perceptions, a questionnaire was given to the Higher Education students on the subject of their emerging digital skills, and how they used the ICT. The questionnaire's underlying theoretical framework consisted of two blocks: the first contained the concepts of digital skills by Van-Laar and others (2017), and the second was a study of the use of ICT in Higher Education by (León-Pérez & Escudero-Nahón, 2017).
To define the indicators in the first block, a search was made for instruments that explicitly measured the emerging digital skills dealt with in this study without success, as the nearest approach involved only instruments for measuring digital competencies. However, there is a considerable number of instruments for measuring "21st century skills" that have been validated and published in scientific journals. The principles of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2010) were followed in order to choose from these instruments those that present a solid method and a well structured validity process. For the communication skill based on systematic revision (León-Pérez, Escudero-Nahón, & Bas, 2019), the instrument proposed by Wilkins, Bernstein & Bekki (2015) was chosen. The instruments that deal with collaboration skills (Van-de-Ven & Ferry, 2000), creativity (Kaufman, 2012), technical skill (Van-Deursen & al., 2012), information management (Van-Deursen & al., 2012), and critical thinking (Sosu, 2013) were selected in the same way. The chosen instruments were then adapted to generate indicators adapted to the theoretical framework. Problem solving was the only skill for which a suitable instrument could not be found, so that the items were based on the literal definition of the theoretical framework.
The definition of the items in the second block was also based exclusively on the theoretical framework.
The instrument was composed of 76 items: 4 of these requested descriptive data (faculty, degree course, age and sex) and 72 were indicators, and used a Likert scale with 5 options (ranging from "Very high" to "Very low"). The categories of the theoretical framework included in the instrument are given in Table 1.

Table 1. Categories of the theoretical framework included in the instrument

Category	Indicators (items)
Problem solving with ICT	1-2
Technical skill with mobile devices	3-7
Collaboration with ICT	8-9
Critical thinking aided by ICT	10-22
Creativity through ICT	23-34
Communication by ICT	35-48
Information management by ICT	49-54
Academic projects	55-58
Use of ICT by students	59-66
Use of ICT by teachers	67-72

The contents were validated by two procedures: 1) revision of the theoretical models on which the original instruments were based, and 2) evaluation by experts from the Universidad Autónoma de Querétaro and the Universitat de València, from both the area of the redaction and validation of instruments and from the area of ICT.
A pilot test was also carried out on 51 students from four faculties and was used to change the wording of items that were not easily comprehensible, to ensure inclusive language and determine the average response time (17 minutes). The Cronbach's alpha of the pilot test data was calculated

as 0.956, which reflected a high degree of internal consistency. Construct validity was by factorial analysis (described below), and its results are given in the corresponding Section.

2.3. Procedure

All the faculty heads consented to the application of the questionnaire by means of a face-to-face survey of 356 students to guarantee complete responses, since the voluntary support by an online application involved a risk of the non-participation of the students. The questionnaire was printed on both sides of two sheets of letter-size paper and was applied by the authors during a period of 45 days.

3. Analysis and results

Principal Component Analysis (PCA) can be used to obtain the minimum quantity of components that explain most of the total observed variability in a set of variables. The following values were calculated to determine whether it was possible to apply a factorial analysis to the data:

- The Kaiser-Meyer-Olkin coefficient (KMO), which compares the observed correlation coefficient values with the partial correlation coefficients, giving a result of 0.925.
- Anti-image correlation matrix, to determine whether the partial correlations were low and also the factors underlying the set of indicators. Almost 99% of the absolute matrix values of the anti-image were below 0.3, and the diagonal values (measures of sampling sufficiency of individual indicators) were all around 0.8.
- Bartlett's sphericity test, to check the hypothesis that the correlation matrix was an identity matrix, obtaining a significance level well below 0.05 and x^2=15339, which allowed the rejection of the null hypothesis that the variables were not correlated.

The results indicated that a factorial analysis could be carried out on the data. The principal component analysis started by defining the appropriate quantity of components, for which the drop contrast criterion or Castell's elbow test, which analyzes the sedimentation graph (Figure 1) and detects the point at which the component curve becomes almost horizontal, which was determined to be component 9. The vertical axis (self-value) indicates the quantity of variance explained by each factor on the horizontal axis. The first nine components (principal components) explain 56.36% of the total variance.

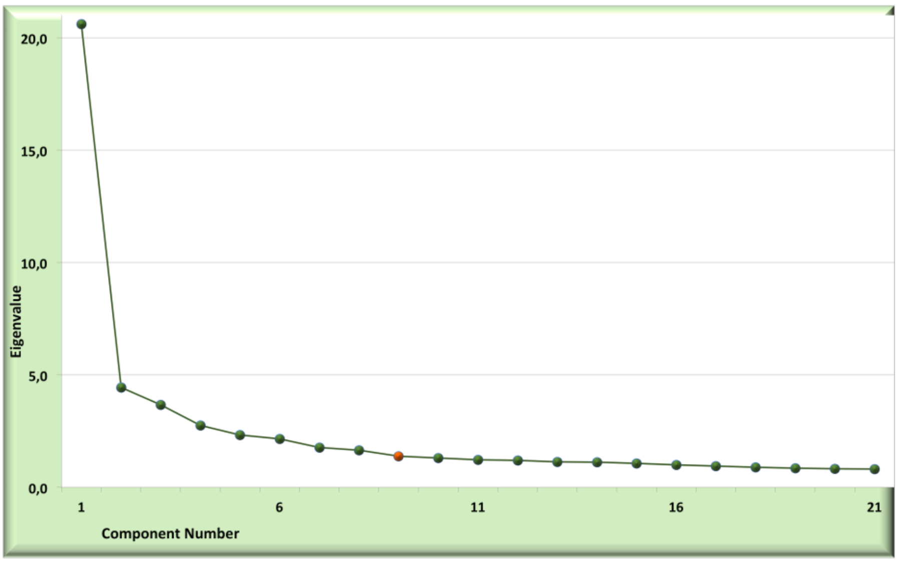

Figure 1. Sedimentation graph of the PCA application.

The rotation varimax method was chosen to generate the component matrix. This is an orthogonal rotation of the factorial axes to ensure that the correlation of all the variables is as close as possible to 1 with only one factor and almost null with the rest. This was used to delineate the groups of indicators corresponding to each principal component (factor), which were assigned a name according to the category of the theoretical framework from which the indicators proceeded (see Table 1). Since the emerging digital skills include the ICT by definition, the factors were named without explicitly mentioning them when this was possible. The factors identified by the PCA were: "Communication", "Critical thinking and problem solving", "Technical skills", "Use of ICT by teachers", "Information management", "General creativity", "Technical creativity", "Academic projects", "Use of ICT by students", about each of which information is given in Table 2.

Table 2. Resulting factors of Principal Component Analysis by varimax rotation

Factor	Indicators (items)	Percentage of explained variance	Cronbach's alpha
Communication	38-48	28,62%	0,932
Critical thinking and problem solving	1,2, 10-23	6,174%	0,902
Technical skill	3-9, 34	5,098%	0,843
Use of ICT by teachers	65-72	3,822%	0,550
Information management	36, 37, 49-54	3,243%	0,857
General creativity	24-30, 35	2,994%	0,854
Technical creativity	31, 32, 33	2,468%	0,795
Academic projects	55-58, 63	2,021%	0,753
Use of ICT by students	59-62, 64	1,927%	0,720

The nine factors identified were very similar to the constructs defined by the underlying theoretical framework. In fact, the only factor generated was "Technical creativity", which came from the "Creativity" construct (labelled here as "General creativity"), and the only non-resulting factor in the PCA as regards the underlying theoretical framework was "Collaboration with ICT", considered within "Technical creativity" (see Fig.2), i.e. students consider that their ICT skills (especially on mobile devices) include the capacity to establish collaboration processes with others, probably by means of the continuous and extensive use of social networks. The indicators for the constructs "Problem solving" and "Critical thinking" were grouped within a single component.

Communication is the factor that best explained most of the variance, while the use of ICT by students was the last factor selected and explains the smallest quantity of the variance. All the factors have a high Cronbach's alpha, except the use of ICT by teachers, which, represents acceptable internal consistency although it is the lowest. From the first results, an analysis was made of the indicator distribution of the diverse factors. This eliminated four items from the instrument, due to the content concept in the item not completely fitting in with the factor assigned by the PCA (items 35 and 36), probably due to ambiguous interpretation by the subjects of the survey (item 63) and to raise the Cronbach's alpha value (item 71). The items eliminated are given in Table 3.

Table 3. Items eliminated based on PCA results

Item	Indicator	Theoretical framework construct	Factor in which included by the PCA
35	Communication of information and ideas to multiple audiences	Communication by ICT	General creativity
63	Percentage use of ICT in academic activities	Use of ICT by students	Academic projects
65	Improvement in use of ICT during the degree course	Use of ICT by students	Use of ICT by teachers
71	Teachers' dependence on ICT	Use of ICT by teachers	Use of ICT by teachers

After eliminating the items, the Cronbach's alpha of each factor was again calculated to determine the impact produced. The "General creativity" component fell from 0.854 to 0.843; "Academic projects" fell from 0.753 to 0.741. For these components, variation was quite small and did not affect the good level of internal consistency. Finally, "Use of ICT by teachers" rose from 0.550 to 0.719. In fact, the elimination of item 71 was specifically designed to obtain this effect.
The distribution of the 68 items of the final version of the instrument in each of the factors identified is given in Figure 2. The number above the line is the number of items in the theoretical framework construct placed in the identified factors.

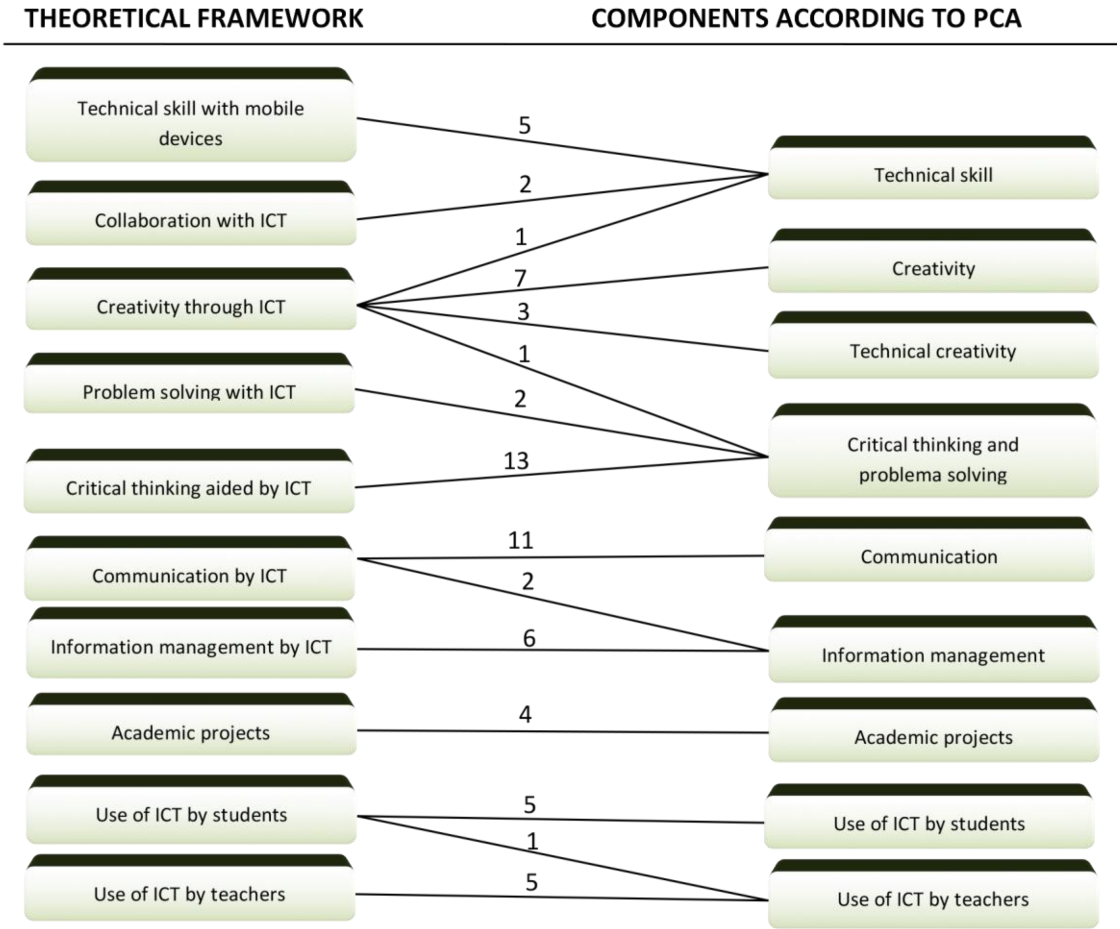

Figure 2. Relationship of items between the categories of the theoretical framework and PCA results.

Total Cronbach's alpha was calculated, giving a value of 0.944, indicating high internal consistency. Finally, the descriptive statistics were calculated of the data obtained in the items in the final version of the instrument (see Table 4).

Table 4. Descriptive statistics obtained

Factor	Mean	Standard deviation
Academic projects	4.059	0.970
Technical skill	3.863	0.891
Information management	3.818	0.858
Communication	3.643	0.854
Critical thinking and problem solving	3.625	0.834

General creativity	3.277	1.049
Use of ICT by teachers	3.249	1.015
Use of ICT by students	2.537	1.170
Technical creativity	2,.34	1.164

The results given in Table 4 show a clear and efficient perception of the use of ICT for academic projects. There is also good self-perception of the technical skill in the use of the ICT, being noteworthy that the PCA found that this skill included collaboration by means of ICT. On the other hand, as regards the use of ICT by teachers, the perception is that it does not have a large impact on the teaching-learning process, while the perceptions of creativity and the use of the ICT by students are also low.
The standard deviation (SD) of each of the factors shows an interesting pattern. The set of factors with an SD lower than 1 is composed of those most highly considered by the students, while the set of factors with an SD higher than 1 are those least valued. This correspondence indicates a more homogeneous perception of the digital skills of critical thinking and problem solving, communication, information management, technical skill and recognition of ICT in academic projects. Students and teachers' use of ICT and creativity shows a higher degree of variation, which appears to indicate a less clear perception by students of ICT use in the university and of its usefulness in creative processes, and this could be the reason for the students' low self-perception of these factors.

4. Discussion and conclusions

The results of this study confirm the close relationship between critical thinking and problem solving, concepts which a number of studies have found to have a strong semantic association. For example, the World Bank Institute (WBI Development Studies, 2007) considered that the critical thinking inherent in problem solving should be stimulated. Fullan & Langworthy (2013) combine them into a single skill for deep learning, and the World Economic Forum defines critical thinking as “the capacity to identify, analyze and evaluate situations, ideas and information in order to solve problems” (World Economic Forum, 2015: 3). Vásquez & Findikoglu (2011) define both as cognitive competencies, together with reading, writing and arithmetic.
One interesting finding was the identification of factors that refer to creativity: both “creativity in general” and “creativity in technical activities”. A high percentage of studies on creativity in the fields of education and technology measure it in specific contexts, such as in classrooms (Souza, Leão, Carmona, Ruas, Carneiro-da-Cunha, & Nassif, 2018; Stana, 2017) in developing software engineering (Mohanani, Ram, Lasisi, Ralph, & Turhan, 2017), in technological and engineering education (Yasin & Yunus, 2014) and in collaborative design in workshops (Landoni & Diaz, 2015). However, in the present study, ICT-aided creativity clearly distinguished between one factor that defines creativity in technical activities with ICT (technical creativity) and another in which ICT only provide support to creative development (general creativity).
The good perception of the use of ICT in academic projects coincides with the findings of previous studies that gave a high value to projects as a means of learning and acquiring skills, as in the case of Cisco, who when defining the characteristics of 21st century students (Cisco Systems Inc., 2009) emphasized the use of project-based interdisciplinary tasks. It also agrees with recent studies on the good results of research on project development in diverse areas (Hadinugrahaningsih, Rahmawati, & Ridwan, 2017; Menkhoff, Tan, Ning, Hup, & Pan, 2018; Milbourne & Bennett, 2017) because projects involve interdisciplinary activities that require capacities for administration, collaboration, problem solving and use of ICT, among others.
In fact, closely connected to the technical skill dealt with in this paper, studies have been carried out on how to acquire digital competencies through projects (Pérez-Mateo, Romero, & Romeu-Fontanillas, 2014) and define projects as a fertile means of using and taking advantage of ICT when the students have the ability to do so. The good self-perception as regards technical skills

corresponds with studies that even suggest that mobile phones should be introduced into Higher Education (Champagne, 2013; Simonova & Poulova, 2016; Yong, 2016).
The results on the use of ICT by teachers define a scenario in which students perceive themselves to be well able to achieve solutions, but do not attribute this to the use of ICT in the educational institutions. This could correspond to the concept that what the present students require from Higher Education institutions does not coincide with what they are actually offered (Oblinger, 2003).
The low perception of creativity and both teachers' and students' use of ICT are in line with the DMGT model (Gagne, 2012), which indicates that the university environment can be used as a catalyst for the way in which creativity can be expressed in a variety of dominions and also, indicates that these influences include classroom instructors, as Miller & Dumford (2015) found in their empirical study. It is thus reasonable to believe that the teachers' influence on the use of ICT corresponds to the students' self-perception of its creative properties.
The results obtained in this study can be used to design and build study and curriculum plans in Higher Education institutions, including the transversal use of the ICT, with a view to the development of the emerging digital skills.
In terms of the disadvantages encountered when carrying out this work, it should be mentioned that perception studies always involve a risk of the non-uniform interpretation of the tool by the subjects involved in the survey, an effect to which this study was not exempt, in spite of the considerable effort made to validate the contents.
One of the study's limitations is that the results reflect the context of only a single country. Also, even though the tool is powerful and robust, and covered a student population from different fields of study, it was applied to a sample from a single Higher Education institution. However, it can be used as the basis for application to other institutions in other geographical areas, which will help to validate the results, improve the tool designed and obtain new findings.

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