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Instrument for analysing digital entrepreneurship competence in higher education

Instrumento de análisis de la competencia de emprendimiento digital en educación superior
Instrumento para analisar a competência de empreendedorismo digital no ensino superior
高等教育数字创业能力的分析工具

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Abstract

Entrepreneurship and digital skills are key competences that students must acquire throughout their formal education. The EmDigital model was developed to assess digital entrepreneurship competence following a comparative analysis of these two competences. This model describes the competence of digital entrepreneurship in terms of four areas and 15 sub competences. The aim of the present study was to validate a quantitative instrument to measure digital entrepreneurship competence in university students. The following techniques were used: focus group, expert panel, cognitive interview and exploratory factor analysis. A pilot sample of 190 final year undergraduate students (60% were female with an average age of 24.97) was used. The instrument produced very good reliability indices. EFA outcomes indicated a 4-factor instrument that explained 43% of total variance. Based on the presented outcomes, the instrument was revised and a definitive questionnaire created. The final version of the questionnaire is presented in the present article. Data only revealed gender differences in relation to one of the dimensions of the instrument, namely, the identification of opportunities, in which men scored more highly.

Keywords: Digital Entrepreneurship; Competence; Higher Education; Questionnaire

Resumen

Entre las competencias clave que el alumnado debe adquirir podemos encontrar la digital y el emprendimiento. Del análisis comparativo de ambas surge el modelo EmDigital. Este modelo describe la competencia de emprendimiento digital a partir de cuatro áreas y 15 sub-competencias. El objetivo del estudio es validar un instrumento cuantitativo para medir la competencia de emprendimiento digital en universitarios. Para ello se han utilizado las siguientes técnicas: grupo focal, juicio de expertos, entrevistas cognitivas y Análisis Factorial Exploratorio. Se ha utilizado una muestra piloto compuesta por 190 estudiantes de último curso de Grado (60% eran mujeres con edad media de 24.97). La fiabilidad mostrada por el instrumento ha sido muy buena. Los resultados del AFE muestran 4 factores que explican el 43% de la varianza. A partir de los resultados se ha revisado el instrumento y creado la versión definitiva del mismo, que presentamos en el artículo. Los datos solo reflejan diferencias en función del género en una de las dimensiones del instrumento, concretamente en la identificación de oportunidades, donde los hombres puntúan más alto.

Palabras clave: Emprendimiento Digital; Competencia; Educación Superior; Cuestionario.

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Resumo

Entre as competências-chave que os estudantes devem adquirir estão as competências digitais e o empreendedorismo. O modelo EmDigital emerge de uma análise comparativa de ambas. Este modelo descreve a competência do empreendedorismo digital em termos de quatro áreas e 15 subcompetências. O objetivo do estudo é validar um instrumento quantitativo para medir a competência de empreendedorismo digital em universitários. Foram utilizadas as seguintes técnicas: grupo focal, parecer de especialistas, entrevistas cognitivas e Análise Factorial Exploratória. Foi utilizada uma amostra piloto composta por 190 estudantes do último ano do grau (60% eram mulheres com uma idade média de 24,97 anos). A fiabilidade demonstrada pelo instrumento foi muito boa. Os resultados da AFE mostram 4 fatores que explicam 43% da variância. Com base nos resultados, o instrumento foi revisto e foi criada uma versão final do instrumento, que apresentamos no artigo. Os dados refletem apenas diferenças de género numa das dimensões do instrumento, concretamente na identificação de oportunidades, em que os homens têm uma pontuação mais elevada.

Palavras-chave: Empreendedorismo digital; competência; ensino superior; questionário.

摘要

数字能力和创业能力是学生在高等教育阶段应该习得的重要能力。EmDigital 模型正是诞生于对这两种能力的对比分析中。该模型从 4 个领域 15 项次能力对数字创业能力进行描述。此项研究的目标是对测量大学生数字创业能力的定量工具进行验证。研究采用下列技术：焦点小组、专家判断、认知访谈和探索性因素分析。使用由 190 名本科应届毕业生（其中 60%为女生，平均年龄为 24.97 岁）组成的试点样本。该工具呈现出了良好的信度，同时探索性因素分析的结果显示 4 项因素解释了 43%的方差。在此结果上，我们对工具进行了检验并确定了工具的最终版本。根据学生性别的不同，数据只在工具的一个维度，具体来说是机会识别维度上反映出了差异，在这个维度上男生给出的评分比女生高。

关键词: 数字创业、能力、高等教育、问卷

Competency-based learning is one of the key concepts underpinning all educational models and proposals in recent years. Previous work (Prendes-Espinosa y García Tudela, 2020) has examined the roots of the concept of competence and highlighted its increasing value, as reflected in its inclusion in pedagogical proposals over the last decades of the 20th century. At the present time, competence-based education is already taking shape in models that specify the dimensions and indicators of the key competences of education in the 21st century. Such models include entrepreneurship skills and digital competence (European Commission, 2006; OECD, 2005; Kampylis et al., 2015). The European Commission proposes eight key competences that are considered necessary for society to move forward. These include entrepreneurial competence and digital competence.

Entrepreneurship competence includes skills such as innovation, creativity, risk-taking, and the ability to plan and manage projects, as well as personal qualities such as autonomy, decision-making, leadership, communication skills and civic responsibility (Bacigalupo, 2022; European Commission, 2006, 2014; Jones and Irelade, 2010). The European Framework for Entrepreneurial Competence (EntreComp) identifies three broad areas (ideas and opportunities, resources, taking action) comprising 15 sub-competences (Bacigalupo et al., 2016; McCallum et al., 2018). It is important to develop entrepreneurship competences by paying attention to all of its dimensions and indicators, as stated by several authors in recent years (Arranz et al., 2017; Bernal and Cárdenas, 2014, 2017; Contreras-Velásquez et al., 2017; Mesquita et al., 2016; Shaidullina et al., 2018; Testa and Francheri, 2015; Torres et al., 2014). This means a move away from the entrepreneurial approach that has traditionally been associated with entrepreneurship.

On the other hand, digital competence integrates the ability to search for, manage and store information, alongside communication and collaboration, the creation of digital content creation, uses and licences, problem solving and innovation, and, finally, data security and protection (Ala-Mutka, 2011; Carretero et al., 2017; European Commission, 2006, 2016; Ferrari, 2012, 2013; Ferrari et al., 2014; Kluzer and Pujol Priego, 2018; Lucas and Moreida, 2016; Vuorikar et al., 2016). Based on this construct, a multitude of proposals have emerged regarding digital skills training for students and teachers at all stages of the education system (González-Calatayud et al., 2018; Prendes et al., 2018).

From these two competences arises the competence of digital entrepreneurship, or what other authors call e-entrepreneurship, understood as the ability to plan, manage and develop innovative ideas through digital tools, with effects pertaining to the virtual world and being linked to the creation of value and sustainability (Allen, 2019; Kollmann, 2006, 2009; Lorenzo, 2012; Omar et al., 2019). Although the present study takes the European competence framework as a basis, literature on digital entrepreneurship presents other equally interesting models which were used in at the model design phase of the present research to conduct a preliminary analysis of indicators. A number of these models can be highlighted here, such as the model conceived by Carreón et al. (2014), which identifies five areas (basic digital and ICT market knowledge, digital business, access to finance and investment, digital skills and digital leadership, and entrepreneurial culture). Pérez et al. (2016) designed a model of digital entrepreneurship that is not competence-based but, instead, describes a sequence in which values, beliefs and perceptions constitute the basis on which people will develop their attitudes and knowledge to tackle entrepreneurial projects. Another example is provided by the model described by Cruz (2016), which, based on previous proposals, including that of Carreón, presents a model made up of four areas (digital agenda, teaching-learning, digital skills and employment). Figure 1 presents the indicators pertaining to each area. In previous work, Cruz (2015, p. 78) conducted a literature review and concluded that "studies on digital entrepreneurship show that perceptions of compatibility, usefulness and ease of use are essential to explain the process of adoption, acceptance and intensive use of technologies".

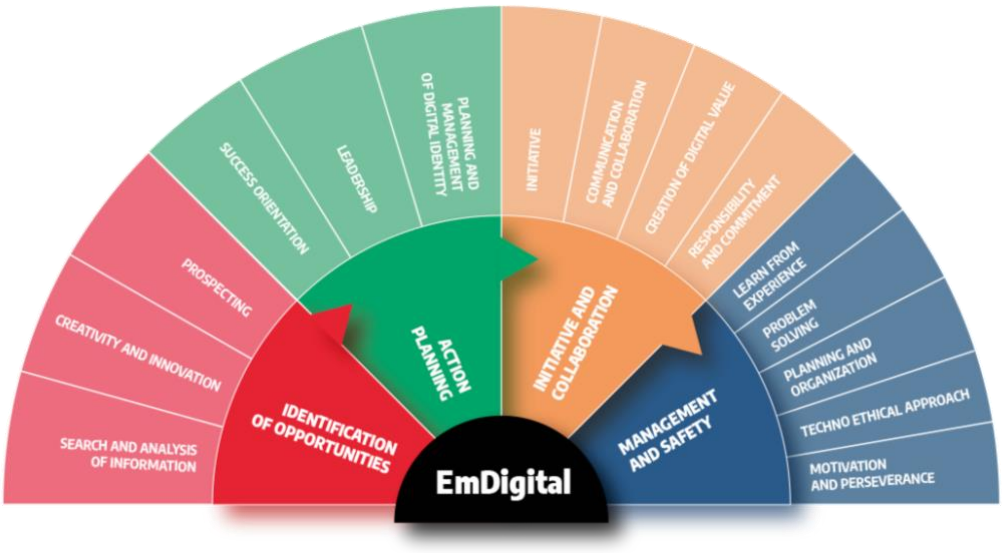
Figure 1. Cruz's digital entrepreneurship model (2016, p. 36).

Acknowledging the importance of digital entrepreneurship competence necessarily leads us to recognise the importance of training university students in all its dimensions

(López-Navarrete et al., 2019; Mababu, 2017; Moysidou and Hausberg, 2020; Ratten and Usmanji, 2020). According to McAdam et al. (2020), training in digital entrepreneurship will open up a multitude of possibilities for professional development and employment in the digital society and may even contribute to alleviating the effects of the gender gap in the entrepreneurship sector. Greater awareness of the current status of this competence may contribute towards improving the training on offer in the future and to equipping the public so that they are capable of adapting to the needs of present society.

Interest of the present study to investigate digital entrepreneurship competence stems from scientific interest and the desire to unmask current approaches to training digital entrepreneurship competence. The main aim of the Emdigital project, funded by the Seneca Foundation, is to learn about and improve the training of university students in digital entrepreneurship skills based on real data on the issue in the Spanish context. This is the foundation of the EmDigital project, for which the EntreComp model (Bacigalupo et al., 2016) and the DigComp model (Vuorikari et al., 2016; Carretero et al., 2017) provide conceptual references. The EntreComp model defines 3 areas comprising 15 competences, while the DigComp model defines 5 areas pertaining to 21 competences. Following an in-depth review of the dimensions and competence indicators of both models, a new construct of digital entrepreneurship was developed with its corresponding model of competence areas and indicators. This model was analysed through a long and rigorous qualitative research process employing document analysis, expert panel and focus group techniques. The full process is described in detail in Prendes-Espinosa & García-Tudela (2020) and Prendes-Espinosa et al. (2021). The resulting model (EmDigital) presents four areas comprising 15 competences (see Figure 2).

Figure 2. EmDigital model of digital entrepreneurship competence



Method

Based on the EmDigital model described above, an analysis of the needs of students attending public universities in the region of Murcia in terms of digital entrepreneurship was carried out. Subsequently, resultant findings will be used to design and implement a training plan to improve the digital entrepreneurship skills of these university students. To this end, the aim of the present work was to design and validate an ad hoc questionnaire conceived to provide the aforementioned information. The

present article presents the process used to validate this instrument and assess its capability for uncovering the level of development of digital entrepreneurship competence and the training received by university students to this end. For this purpose, a quantitative methodology was chosen which employed an instrumental and non-experimental research design. According to Ato et al. (2013), this type of research is suitable for analysing the psychometric properties of an instrument.

Validation procedure

Based on the theoretical model of digital entrepreneurship (EmDigital) forming the foundation of the research framework (Figure 2), a preliminary version of the questionnaire consisting of 84 items was designed.

Expert panel. This first version was subjected to a content validation process by expert panel in accordance with that outline by authors such as Einhorn (1974), Escobar-Pérez and Cuervo-Martínez (2008) and Barroso-Osuna and Cabero-Almenara (2013). To this end, a total of eight experts in the field of educational technology and entrepreneurship were consulted. This validation process made it possible to refine the instrument, reducing it to 70 items.

Cognitive interviews. Subsequently, a second content validation procedure was carried out. Cognitive interviews enable the identification and correction of issues arising from responses to items by understanding the reason behind participant responses. In the case of the present study, 19 cognitive interviews were conducted with students with a similar profile to the target population (Dillman, 2019; Morrison et al, 2010; Willis, 2015). This led to the reformulation of eight items. These two validation procedures resulted in an instrument consisting of 70 items, four of which were socio-demographic in nature (gender, age, university and field of knowledge). The remaining 67 items were organised into four dimensions and 15 sub-competencies, corresponding to those that make up the theoretical entrepreneurship model (Figure 2). The formulation of indicators for each of the sub-competences, as detailed in Prendes-Espinosa et al. (2021) was key to this process of item definition.

Factor analysis. Following development of this preliminary instrument through the two aforementioned validation procedures, reliability was analysed, followed by construct validity. In terms of the latter, exploratory factor analysis (EFA) was carried out. On the one hand, this technique enables the exploration of collected data, whilst, on the other, confirming the dimensions defined deductively in the EmDigital model. Indeed, as stated by Pérez-Gil et al. (2000, p. 443), "at present, even though CFA (confirmatory factor analysis) procedures are highly developed (there is powerful software on the market to carry out CFA), EFA is still being used for confirmatory purposes".

Instrument (initial version)

Following completion of the two phases described in the previous section, the questionnaire was structured as shown in table 1 and was finally administered in a pilot test in the last phase of the validation process.

Table 1. Questionnaire structure

DIMENSIONS	SUBCOMPETENCES	ITEMS

Identifying opportunities	Information search and analysis	1 to 7
	Creativity and innovation	8 to 9
	Seeking behaviour	10 to 11
Action planning	Achievement orientation	12 to 19
	Leadership	20 to 24
	Digital identity planning and management	25 to 28
Initiative and collaboration	Initiative	29 to 31
	Communication and collaboration	32 to 37
	Digital value creation	38 to 40
	Responsibility and commitment	41 to 44
Management and security	Learning from experience	45 to 49
	Troubleshooting	50 to 56
	Planning and organisation	57 to 60
	Techno-ethical vision	61 to 66
	Motivation and perseverance	67 to 70

La escala empleada en todos los ítems de las dimensiones del cuestionario es de carácter ordinal de cinco valores, acorde con una escala tipo Likert de acuerdo-desacuerdo. Para su selección nos hemos basado en las conclusiones aportadas por el estudio bibliométrico realizado por Matas (2018, p. 45), que apunta que una de las recomendaciones, a la luz de los estudios consultados es "usar escalas de cinco alternativas con una opción de `No tengo opinión´, `No opino´, o `Sin opinión´". En este sentido, apoyándonos también en los argumentos dados por Schuman y Presser (1981), hemos decidido incluir una categoría de respuesta de "No contesta".

All items pertaining to all questionnaire dimensions were responded to along an ordinal five-point scale, through which participants indicated their agreement-disagreement with various statements. This scale type was chosen based on the conclusions of a literature review carried out by Matas (2018, p. 45). Following consultation of a number of studies, this review urged the use of "scales of five alternatives with an option of 'I have no opinion', 'I will not give my opinion', or 'no opinion'". In this sense and also in consideration of arguments presented by Schuman and Presser (1981), it was decided to include a response category of "no answer".

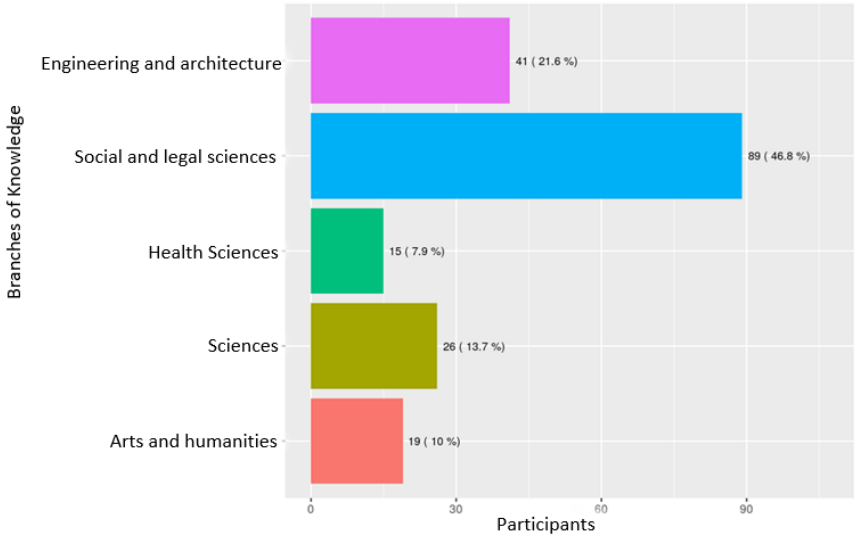
Sample

Sampling was carried out in consideration of recommendations made by various authors regarding the minimum number of participants required to conduct a pilot test. In this sense, authors such as Nunnally (1978) and Morales (2012 and 2013) highlight that the sample size of a pilot study must be conditioned by the number of items on the questionnaire. Other authors such as Boomsma (1985) define a concrete minimum sample size of between 100 or 200 individuals. However, the present study is in line with that recommended by Wolf et al. (2015), who argue that sample size determination requires careful evaluation and must consider the specific characteristics of the model under examination. Thus, the take home message from all of the aforementioned studies is that, in cases in which a model with multiple indicators is proposed, as in the present case, a very large sample size is not necessary.

In light of this consideration, the incidental sample for the pilot test conducted as part of the present study was made up of 190 final year undergraduate students from 11 Spanish public universities. Participating students covered the full spectrum of the 5 knowledge branches and came from different geographical regions. 40 % (n=76) of the data-producing sample were men and 60% were women (n=114). With regards to knowledge branch, 10% (n=19) were undertaking Arts and Humanities, 13.7% (n=26) were undertaking Sciences, 7.9% (n=15) were undertaking Health Sciences, 46.8% (n=89) were undertaking Social and Legal Sciences, and 21.6% (n=41) were

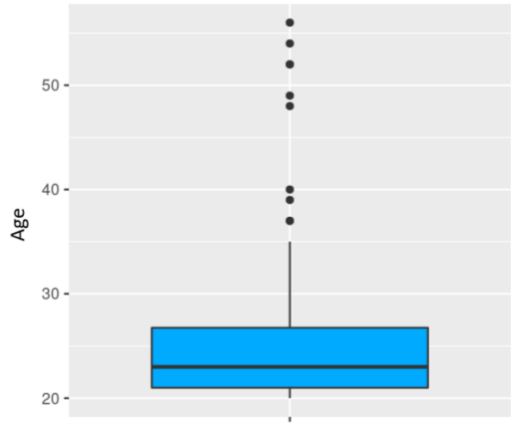
enrolled on Engineering and Architecture (Figure 3).

Figure 3. Student sample according to knowledge field



With regards to age, the average age of the sample was 24.97 years with a standard deviation of 6.27, with the minimum age being 20 years and the maximum age being 56 years. Median age was 23 years. Age distribution of the sample is reflected in the boxplot shown in figure 4.

Figura 4. Boxplot showing the age distribution of the sample



Data collection and analytical procedure

The questionnaire was designed using the "surveys" platform of the University of Murcia due to its functionality, reliability and capacity to collect an unlimited number of questionnaires. An e-mail was sent to lecturers involved in the teaching of final year undergraduate degrees at different Spanish universities and in different knowledge branches requesting their collaboration in distributing the questionnaire to their students. The first page of the questionnaire informed that responses would be completely anonymous and to be used exclusively for research purposes.

The R program, version 4.0.3 (R Core Team 2020), was used to perform data analysis. The questionnaire structure was examined by means of factor analysis to assess its construct validity. However, before exploratory factor analysis was conducted, the following indices were scrutinised: 1) Correlation matrix indices; 2) Bartlett test statistics; 3) Kaiser-Meyer-Olkin Coefficient (KMO) for each block; and 4) the determinant of the correlation matrix for each block. A correlation matrix was constructed to check whether all variables were highly but not perfectly correlated, i.e., whether values no lower than 0.3 and no higher than 0.9 were obtained. Bartlett's test was performed to ensure that the constructed correlation matrix is not equal to an identity matrix, which would be indicated by a significant p-value. The KMO coefficient was examined in order to check the

appropriateness of factor analysis to the empirical data and, in this way, confirm that different dimensions are not being measuring for each battery of items. EFA was carried out using the principal components method with varimax rotation. Given that the questionnaire allowed participants to provide a "no answer" response, cases in which no response was provided were eliminated.

In order to examine empirical validity, homogeneity and normality of the sample was first analysed. This confirmed that criteria for conducting parametric tests were not met. Instead, the Mann-Whitney test for bivariate data and the Kruskal-Wallis test for multivariate data were used (significance 0.05).

Results

Reliability analysis

Reliability analysis revealed highly acceptable indices for the questionnaire, with a Cronbach's alpha 0.956 (Table 2).

Given that data was collected using an ordinal scale, composite reliability was also examined for each of the dimensions as an alternative to Cronbach's alpha. This was appropriate give that, unlike Cronbach's alpha, the value obtained does not depend on the number of attributes associated with each concept. For an instrument to be considered reliable, it must produce a minimum value of .70 (Hair, 2009). Likewise, the validity of the scale is also estimated in terms of extracted variance or AVE (average variance extracted) which reflects the total amount of variance explained by the indicators pertaining to the construct under study. In this case, Hair (2009) recommends that the AVE value should not exceed .50. Outcomes revealed a composite reliability index of .957 and AVE value of .271 (Table 3).

Likewise, estimation of reliability according to the Omega coefficient, also known as Jöreskog's Rho, pointed to high reliability with a value of .967 (n= 190). This is similar to results obtained regarding the aforementioned coefficients. This coefficient is recommended by authors, such as Ventura-León (2017), due to the fact that the value obtained is not affected by the number of items, number of response options or the proportion of variance pertaining to the instrument (Table 4).

Tabla 2. Cronbach's alpha for each block

Dimension	Alpha
1	.7881
2	.7966
3	.8837
4	.9163

Tabla 3. Composite reliability and AVE for each block

Dimension	Composite reliability	AVE
1	.7894	.285
2	.7769	.2286
3	.8839	.3547
4	.9193	.3424

Tabla 4. Omega coefficient for each block

Dimension	Omega
1	.7967
2	.8195
3	.8909
4	.9245

Construct validity

In order to analyse construct validity of the instrument, exploratory factor analysis (EFA) was carried out. Prior to this analysis, a series of checks were carried out to determine its suitability. Specifically, a correlation matrix was constructed, and KMO and Bartlett sphericity statistics were calculated. The correlation matrix showed a good relationship between all items, will all inter-item correlation coefficients being above 0.3 and below 0.9. As shown in Table 5, the Bartlett's test produced a significant value and KMO value was acceptable. This indicated that EFA was an appropriate approach.

Table 5. KMO and Bartlett sphericity test outcomes

Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)		.71
Bartlett's test of sphericity	Approximate chi-square	5439.344
	df.	2415
	Sig.	<.05

The consistency of item responses was analysed according to each dimension set out by the model. Dimension 1 obtained a KMO of .74, dimension 2 was .77, dimension 3 was .85 and dimension 4 was .83. Tables 6, 7, 8 and 9, presented below, show the correlation matrix pertaining to all items according to the dimension and sub-competence of the model. Average individual communalities (h2) below or close to .3 indicate items that need to be revised. The table reveals that this was the case for a number of items in the present model.

Produced outcomes led to the revision of a total of 6 items pertaining to dimension 1 in order to determine whether they needed to be deleted or modified.

Table 6. Correlation matrix pertaining to dimension 1 items

		PA	h2	u2
Block 1	Item 1	-0.03	0	1
	Item 2	.47	.22	.78
	Item 3	.65	.42	.58
	Item 4	.76	.58	.42
	Item 5	.51	.26	.74
	Item 6	.40	.16	.84
	Item 7	.34	.12	.88
Block 2	Item 8	.80	.64	.36
	Item 9	.69	.47	.53
	Item 10	.48	.24	.76
	Item 11	.66	.44	.56

With regards to the second dimension, a total of 9 items were reviewed which, as shown in the table provided above, obtained h2 values lower than 0.3. A borderline value was obtained for item 18 and so this was not considered for revision.

With regards to dimension 3, it was decided to revise a total of 4 items. Three of these were revised due to producing h2 values below 0.3, whilst one obtained a value highly similar to 0.3 (item 44).

Table 7. Correlation matrix pertaining to dimension 2 items

		PA	h2	u2
Block 3	Item 12	.12	.01	.99
	Item 13	.70	.49	.51
	Item 14	.20	.04	.96
	Item 15	.78	.60	.40
	Item 16	.85	.72	.28
	Item 17	-.07	.01	.99
	Item 18	.56	.31	.69
	Item 19	.75	.56	.44
Block 4	Item 20	.33	.11	.89
	Item 21	.58	.34	.66
	Item 22	.70	.50	.50
	Item 23	.39	.15	.85
	Item 24	.36	.13	.87
Block 5	Item 25	.48	.23	.77
	Item 26	.77	.60	.40
	Item 27	.62	.39	.61
	Item 28	.31	.10	.90

Table 8. Correlation matrix pertaining to dimension 3 items

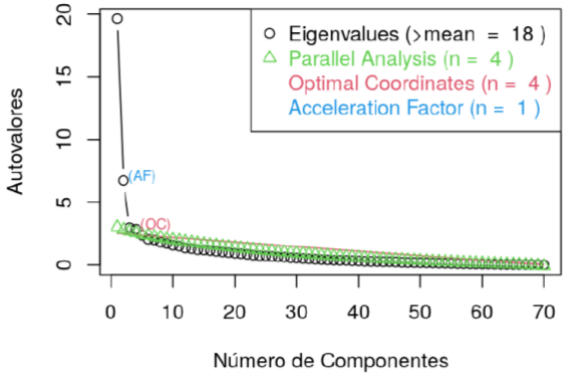
		PA	h2	u2
Block 6	Item 29	-.10	.01	.99
	Item 30	.52	.27	.73
	Item 31	.66	.43	.57
	Item 32	.65	.42	.58
	Item 33	.63	.40	.60
	Item 34	.73	.53	.47
	Item 35	.86	.74	.26
	Item 36	.63	.40	.60
	Item 37	.45	.20	.80
Block 7	Item 38	.76	.57	.43
	Item 39	.86	.74	.26
	Item 40	.59	.35	.65
Block 8	Item 41	.40	.16	.84
	Item 42	.72	.52	.48
	Item 43	.64	.41	.59
	Item 44	.56	.31	.69

Table 9. Correlation matrix pertaining to dimension 4 items

		PA	h2	u2
Block 9	Item 45	.82	.68	.32
	Item 46	.85	.72	.28
	Item 47	.67	.45	.55
	Item 48	-.03	0	1
	Item 49	.52	.27	.73
Block 10	Item 50	-.15	.02	.98
	Item 51	.54	.29	.71
	Item 52	.80	.64	.36
	Item 53	.85	.73	.27
	Item 54	.68	.47	.53
	Item 55	.26	.07	.93
	Item 56	.47	.22	.78
Block 11	Item 57	.14	.02	.98
	Item 58	.66	.44	.56
	Item 59	.96	.92	.08
	Item 60	.71	.50	.50
Block 12	Item 61	.48	.23	.77
	Item 62	.75	.57	.43
	Item 63	.75	.57	.43
	Item 64	.58	.34	.66
	Item 65	.45	.20	.80
	Item 66	.61	.38	.62
Block 13	Item 67	.70	.49	.51
	Item 68	.70	.49	.51
	Item 69	.79	.62	.38
	Item 70	.66	.43	.57

Before proceeding with EFA, the theoretically optimal number of factors was deduced, resulting in a total number of 4 factors (Figure 5).

Figure 5. Eigenvalue solution to determine the number of factors or components



As shown in table 10, examination of the optimal factor structure through principal component analysis with varimax rotation supported the inclusion of 4 factors (GFI= .95, RMSR= .07), which explained 43% of the variance shown in questionnaire data. Factors were attributed a name based on their characteristics in order to assist understanding of the produced groupings. Factor 1 was named *Ideate, Create and Drive* and explained 15% of variance. Factor 2, explaining 13% of variance was named *Process and Team Management*. Factor 3, denominated *Keys to Success* explained 12% of variance and factor 4, denominated *Challenges and Difficulties* explained 3% of variance. Table 10, presented below, reveals the factors on which items loaded.

Table 10. Exploratory factor analysis

Ítem	F1	F2	F3	F4
3. I consider myself capable of undertaking a network project based on self-identified needs.	.47			
4. I know how I can contribute with my ideas to promote entrepreneurial initiatives in networks.	.61			
8. I can come up with innovative ideas that have a practical application.	.53			
9. I have innovative ideas that could be turned into digital entrepreneurship projects in the future.	.74			
12. I am familiar with digital tools to evaluate possible business ideas I may have.	.52			
14. I am willing to start new projects, despite the risk of making mistakes.	.54			
17. I consider myself capable of estimating the economic budget to carry out real digital entrepreneurship proposals.	.53			
21. When I have an idea, I use all the material and personal resources at my disposal to turn it into a final product that can reach potential customers.	.61			
24. I believe it is unnecessary to communicate the progress of the work process to users interested in the project.	.28			
28. Once you have identified the potential clients of a project, it is possible to design an ICT-supported communication plan.	.61			
30. I am determined to create a digital entrepreneurship project in the future.	.68			
31. I am able to involve others in my innovative ideas.	.47			
40. I collaborate with others to create, integrate and rework digital resources and content.	.45			
43. I make appropriate use of open resource licences (creative commons or similar).	.38			
49. I am able to define strategies that evaluate the performance of a digital entrepreneurship project.	.55			
51. I would be able to easily identify any problems during the development of a venture proposal.	.45			

58. I have the knowledge to use ICT for data management.	.48			
59. I would be able to deal effectively with unforeseen events in the development of a digital entrepreneurship project.	.69			
60. I consider myself capable of managing the development of an entrepreneurial project.	.75			
62. I can propose improvement strategies to keep future digital entrepreneurship projects up to date.	.54			
64. I would know how to use ICT to ensure security and data protection in entrepreneurship projects.	.60			
65. I am aware of current legislation on confidentiality when working online.	.39			
67. I am consistent and persistent when I start working on an entrepreneurial project.	.53			
68. I consider myself capable of proposing ICT solutions to problems that arise in a project.	.60			
69. When I have ideas, I am sure they will come to fruition.	.79			
5. I am able to use digital technologies to search for business opportunities.		.39		
22. I can influence the decisions of the working group in order to achieve a final product.		.34		
23. I can use digital technologies to communicate the latest developments in a work process.		.55		
25. I differentiate my personal profile in different social networks (professional, family, etc.).		.33		
26. Information dissemination is easier when there is a strong digital identity.		.54		
32. ICT helps me to manage my personal network of professional contacts in the virtual world.		.51		
33. ICTs are used to discuss aspects related to the work we are carrying out.		.45		
34. I am able to create private groups in social networks to manage the development of an innovative proposal.		.46		
35. I am able to use ICTs to share the content of my entrepreneurial project.		.52		
36. I am aware of strategies for using different social networks to improve my online visibility.		.72		
37. I know the basic rules of online behaviour (netiquette)		.57		
38. I can use digital resources that contribute to the development of an idea.		.75		
39. I use tools for the creation of digital resources and content (videos, audios, presentations, etc.).		.62		
45. ICT helps me to detect any errors during my work process.		.49		
46. ICT helps me to find new opportunities during the development of my entrepreneurial project.		.52		
47. I use problems encountered in a project as a learning opportunity.		.50		
52. I use various digital resources at my disposal to find solutions with my work team.		.53		
53. I am aware of strategies for mediating and solving communication and organisation problems in the work group.		.61		
54. I am able to anticipate possible errors and their solutions in the development of work.		.47		
55. I prefer to start working and solve problems as they arise.		.33		
56. I devise problem-solving solutions to different situations.		.39		
63. I use real online identities that are always linked to a person or entity (e.g., project name, traceable and clear company).		.55		
2. To search for information on the internet, I use different strategies to help me find what I am looking for (keywords, search filters, etc.).			.48	
6. I consider it important to assess the risks involved in an entrepreneurial initiative before taking it on.			.40	
7. I believe that the use of technologies enhances opportunities for entrepreneurship.			.64	
10. It is important to clearly define what can be achieved with a new project.			.70	
11. I am able to determine whether the ideas I have are feasible for development and implementation in the immediate future.			.42	
13. It is important to have a working team to deal with entrepreneurship projects.			.67	
15. ICT can help in the design of entrepreneurship projects.			.76	
16. A well-functioning team is important for the success of a networked entrepreneurial project.			.77	
18. The design of inclusive projects is a key factor for their success (projects that take into account disadvantaged groups, economic or social inequality, functional diversity, etc.).			.46	
19. A key to the success of entrepreneurial projects is to respect the environment with a vision for the future (sustainability).			.62	
20. It is important to use online communication spaces so that employees can share their innovative ideas.			.61	
27. It is important to have a strong digital identity to approach digital entrepreneurship projects.			.34	
29. I consider myself incapable of putting innovative ideas into practice and implementing them.			.24	
41. In the elaboration and development of innovative projects I am able to take ownership and responsibility for the process.			.54	
44. When communicating online, I always act in a respectful manner.			.58	
57. I consider it essential to meet deadlines for the tasks of an entrepreneurial project.			.65	
61. It is important to assess the environmental impact that my proposals may have.			.41	
66. I am aware of the importance of ensuring the protection of personal participant data in the entrepreneurship proposals in which I will be involved in the future.			.50	
70. I am motivated to use ICT in the development of my innovative ideas.			.42	
1. It takes me a long time to find information on the internet that is useful.				.28
42. I always acknowledge authorship of the digital content I use.				.47
48. I get stuck when unforeseen situations arise in the development of my projects.				.47
50. I have difficulties in solving technical problems with the computer, internet, etc.				.53

In consideration of the statistical values obtained for each item and the outcomes presented here, the instrument was reformulated. Items 1, 6, 7, 12, 14, 14, 17, 20, 24, 24, 28, 29, 48, 50, 55, 61 and 65 were eliminated from the final questionnaire, which can be found in [https://digitum.um.es/digitum/handle/10201/110187]. Most of these items presented low correlations with respect to the rest of the items in the dimension, whilst also producing low regression weights in the final model. Some items with low regression weights were retained due to the fact that no other items described certain indicators in the model and, therefore, they were considered necessary at a research level.

Empirical validity

First, descriptive statistics pertaining to the four main dimensions making up the digital entrepreneurship model are presented (Table 11).

Tabla 11. Descriptive statistics pertaining to the four dimensions

	N	Minimum	Maximum	Average	Standard deviation
Identifying opportunities	190	18	55	38.82	6.406
Action planning	190	19	72	52.24	10.279
Implementation and collaboration	190	24	85	60.09	9.751
Management and security	190	35	130	88.20	16.558

The Mann-Whitney test was used to analyse differences as a function of gender. Table 12, presented below, reveals that gender differences only emerged in relation to dimension 1, where men reported higher average scores than women.

Table 12. Mann-Whitney U test outcomes analysing sex-related differences

	Sex	N	Average range	Sum of ranks	U	PS_{est}
Identifying opportunities	Male	76	106.40	8086.50	3505.5*	0.40
	Female	114	88.23	10058.50		
Action planning	Male	76	97.18	7385.50	4204.5	0.49
	Female	114	94.38	10759.50		
Implementation and collaboration	Male	76	97.86	7437.00	4153	0.48
	Female	114	93.93	10708.00		
Management and security	Male	76	101.65	7725.50	3864.5	0.45
	Female	114	91.40	10419.50		

Note: *significance level >0.05

Discussion and conclusions

The development of entrepreneurial (European Commission, 2006, 2014; Jones and Irelade, 2010) and digital (European Commission, 2006, 2016; Ferrari et al., 2014) skills by future citizens is essential. The combination of the two competencies is considered by the EmDigital model (Prendes-Espinosa et al., 2021). Based on this model, a series of indicators related to the dimensions and sub-competences that comprise this competence have been developed. In order to measure this model and its indicators, a questionnaire with a total of 84 items was developed. As a first step in the validation of the instrument, an expert panel and a series of cognitive interviews were carried out, resulting in a preliminary questionnaire composed of a total of 70 items.

In a subsequent validation phase, the questionnaire was administered to a pilot sample of 190 final-year undergraduate students from various Spanish universities undertaking courses in all knowledge branches. The reliability analysis carried out produced high values. Turning attention to the specific

dimensions, outcomes also pointed to good or very good reliability. Subsequently, EFA was performed, which established a 4-factor structure. Outcomes revealed the need to revise certain items as some items were found not to correlate adequately with the rest.

Following analysis of item data, both in terms of reliability and construct validity, the questionnaire was restructured. Specifically, 15 items were eliminated for not correlating adequately with the other items, whilst other items were reformulated to aid understanding. This improved the validity and reliability of the instrument (Lloret-Segura, 2014; Méndez-Martínez et al., 2012) as a tool for measuring digital entrepreneurship competence in university students [https://digitum.um.es/digitum/handle/10201/110187].

Exploratory factor analysis of the instrument resulted in four overall factors which explained 43% of variance in the empirical data. Factor 1, called *Ideate, Create and Drive*, consisted of a total of 25 items. Factor 2, called *Process and Team Management*, consisted of a total of 22 items. Factor 3, called *Keys to Success*, consisted of 19 items and, finally, factor 4, denominated *Challenges and Difficulties*, consisted of four items. The model comprised four dimensions, namely, identification of opportunities, action planning, initiative and collaboration, and management and security. Factor 1 pertained to the dimension of action planning, factor 2 to the dimension of management and security, factor 3 to the dimension of opportunity identification and factor 4 to initiative and collaboration.

With regards to previously described models of digital entrepreneurship, the questionnaire conceived in the present study can be considered to adequately encapsulate the digital knowledge and entrepreneurial culture of the model proposed by Carreón et al. However, the Pérez et al. (2016) model contributes the importance of including, not only items relating to knowledge but, also, axiological questions and personal perceptions, whilst the EmDigital model also appears to be useful in contributing the idea of a sequential basic model. Finally, Cruz's model (2016) indicates that the competence of interest could be distributed according to 4 areas, which is consistent with the number of factors identified in the present model. This being said, Cruz presents areas of action within these areas, whereas, in the present case, indicators were established for the development of the digital entrepreneurship competence.

Bearing in mind that the original model has also been validated, findings pertaining to both the original and new models present an advancement in knowledge on the topic. Indeed, the questionnaire produced by the present study is currently being used to collect data from a representative sample on which confirmatory factor analysis will be able to be performed to test the research hypotheses established for the present project.

This questionnaire is the result of a complex and lengthy design and validation process, with successive techniques being employed to guarantee its validity and reliability for use by the research community interested in the subject. The indicators obtained can be used together or separately, according to the factors obtained via EFA, as long as the participating sample is made up of university students. It can also serve as a basis on which a questionnaire may be adapted for use with secondary school students or, even, professionals, companies and organisations interested in analysing digital entrepreneurship competence. Given the total absence of digital entrepreneurship questionnaires based on the European framework or other revised models, we consider the present instrument to address an area of research that is of great interest for the social sciences.

With regards to the limitations of the present study, a more in-depth analysis with representative and randomly selected samples is required in order to eliminate potential sampling biases. For this reason, the questionnaire developed in the present work is currently being retested with a similar sample of individuals. Based on the data obtained,

reliability and validity of the instrument will be analysed in depth using confirmatory factor analysis (CFA). The aim of the present study is to use the findings obtained to develop specific training for students that targets the identified shortcomings.

Finally, the acquisition of digital entrepreneurship skills by students represents a challenge that universities must tackle without delay (López-Navarrete et al., 2019; Mababu, 2017; Moysidou and Hausberg, 2020; Ratten and Usmanji, 2020). In this sense, the instrument presented here provides a tool that can be used by other institutions to understand the situation of their students and improve the training on offer. The competence under study has enormous potential for professional development in an increasingly digital society and, as McAdam et al. (2020) and Román-García and González-Calatayud (2022) point out, may help to reduce the gender gap that exists in relation to entrepreneurship. It is, therefore, necessary to assess the digital entrepreneurship competence of future university graduates in order to identify whether they see themselves as capable of starting a digital project that could open up new employment or business opportunities. This type of analysis provides valuable information about the state of the issue from which specific training can be designed to help improve the acquisition of digital competence, as evidenced by previous approaches to developing digital competence (González et al., 2018; Prendes-Espinosa et al., 2018).

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