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Analysis of predisposition in levels of individual digital competence among Spanish university students

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ABSTRACT

The objective of this study was to identify university student profiles with different levels of predisposition and usage of digital competences in social communication and collaborative learning (CSCCL) as well as technology use in information search and treatment (CSTI). The sample comprised 383 students from three state universities in Spain. The study employed a questionnaire called "basic digital competences 2.0 in university students" (COBADI). Chi-squared automatic interaction detection (CHAID) algorithm was used for data analysis due to its capability to handle both quantitative and qualitative variables, enabling profiling and the generation of predictive models with easily interpretable graphical representations (decision trees). The results revealed a high level of digital competence in socialization and execution of tasks online, managing digital tools for planning study time, and using resources for information searching and browsing. These findings align with previous works on collaborative writing on the Internet and digital competence. However, students demonstrated low digital competence in data analysis processes and image production using social software apps, which has been linked to task complexity and heavy workload in other studies. Interestingly, the students' sociodemographic characteristics (age, sex, and university attended) did not influence their predisposition towards the analyzed digital competences. In conclusion, enhancing effective digital teaching in higher education can be achieved by incorporating the teaching of critical analysis of information, addressing information overload, providing instruction on social software apps, and emphasizing collaborative learning. These strategies aim to help students acquire and apply knowledge relevant to the current job market.

Keywords: digital competence, university, collaborative learning, social communication, ICT, CHAID algorithm

INTRODUCTION

The universities of the 21st century and the academic and professional development associated with higher education institutions require students to be increasingly digitally competent. This enables them to learn anywhere and at any time, as well as becoming active creators of digital content, contributing to their

learning and career growth during their time at these institutions. Therefore, digital skills should be an integral part of the core competencies expected from all undergraduate students. By integrating digital competence into various subjects, students can better prepare for the evolving workplace. Analyzing the level of digital competence among university students and identifying areas for improvement can enhance the design of university courses and promote effective learning through a transversal approach to digital competences. Developing digital competence among university students is a crucial requirement in the socio-educational and employment landscape of the 21st century. Longitudinal studies encompassing diverse samples of university students across different age groups and educational levels are necessary to observe how they utilize fundamental digital skills in their socio-educational and digital environments. For this reason, the main objective of this study was to identify university student profiles with varying levels of predisposition and utilization of digital competences, identify areas requiring improvement and untapped potential, and examine possible differences related to sociodemographic variables such as age, gender, and the university attended.

University Students' Digital Competence

The definition of digital competence is multifaceted and evolves over time (Park et al., 2021), due to the rapid and dynamic changes accompanying the emergence of new digital resources and strategies (Tømte, 2015). A notable example of such transformative influence is the recent impact of ChatGPT and the integration of artificial intelligence in education (García-Peñalvo, 2023; Vázquez-Cano et al., 2021). These continuous technological advancements align with other factors that promote robust digital competence, including digital sustainability processes that guarantee the secure, ethical, and responsible utilization of technology. These processes enable individuals to grow and develop while respecting and engaging with their fellow citizens (Flores-Vivar & García-Peñalvo, 2023).

Digital competence can be defined as "the confident, critical and responsible use of technologies from the information society for work, entertainment and education" (European Commission, 2018, p. 9). This definition is specified in a preceding statement that outlines its scope as

> "the confident and critical use of information society technology for work, leisure, and communication. It is underpinned by basic skills in information and communication technology: the use of computers to retrieve, assess, store, produce, present, and exchange information; and to communicate and participate in collaborative networks via the Internet" (European Commission, 2018, p. 2018).

This competence, which enables a learner to use technological tools effectively to learn, work, and participate in society, is defined as digital competence (López-Meneses et al., 2020).

Recent studies have identified the main challenges associated with digital competence, including:

(1) Information overload: Students often struggle to manage and evaluate the vast amount of digital content available. This overload makes it difficult to find relevant and reliable sources. Gutiérrez-Ángel et al. (2022) emphasized the significance of information skills, such as evaluating online source credibility and critically analyzing information, to address this issue.

(2) Digital distractions: The proliferation of digital devices and online platforms can be both beneficial and distracting. While these tools provide access to numerous resources, they can also hinder student concentration and productivity. Kuznekoff and Titsworth (2013) identified the impact of digital distractions on students' ability to focus and engage in deep learning.

(3) Technological competence: Students may encounter difficulties in learning and mastering the necessary technological skills to effectively use digital tools for knowledge acquisition. This includes challenges in using specific software, online platforms, or information management systems. Kebritchi et al. (2017) underscored the need for training programs and support systems to enhance students' technical competencies.

Furthermore, there are fundamental digital skills and competencies that university students need to acquire, which include:

(1) Digital literacy: Digital literacy includes required to navigate, evaluate, and utilize digital tools for learning. It encompasses information literacy, media literacy, and digital communication skills. Siddiq

et al. (2017) highlighted the significance of developing digital skills to enhance students' capacity to search, analyze, and synthesize information from diverse digital sources.

(2) Collaboration skills: Digital competencies extend beyond individual skills and encompass the ability to collaborate effectively in an online environment. Students must develop skills such as online communication, teamwork, and digital citizenship to actively participate in co-curricular activities. Otto et al. (2023) emphasized the importance of fostering students' collaborative skills in the digital realm to facilitate knowledge sharing and co-construction.

(3) Critical thinking: Digital literacy empowers students to think critically about the information they encounter online. This entails assessing source credibility, detecting bias, and analyzing complex information. Al-Husban (2020) underscored the significance of digital literacy in nurturing students' critical thinking abilities and their capacity to discern reliable information amidst the vast digital landscape.

The COVID-19 pandemic prompted a reflection on the level of digital competence in students and educators, and the need to find new ways to generate virtual cooperative learning spaces to enable users to learn beyond the screen for video conferencing on Teams or Zoom (Chang & Aytenew, 2021; Christopoulos & Sprangers, 2021; Scully et al., 2021; Sumardi et al., 2021). Undoubtedly, learning in ubiquitous contexts requires new didactics and self-learning strategies based on digital devices and resources to allow students to make the most of the potential of digital tools to improve their learning and socialization in virtual settings (Ariebowo, 2021; Soffer & Nachmias, 2018). OECD (2018) emphasized that digital competence in the current socio-technological environment was positive for personal, professional, and academic development and good mental health in citizens. UNESCO (2018, p. 2) stated that ICT can help students to improve their learning by using tools for searching, analyzing, and evaluating information, and for problem-solving and decision-making. This requires users to make creative and effective use of tools for production, to enable them to be communicators, collaborators, publishers, producers, and citizens who are informed, responsible, and capable of contributing to society.

University students' levels of digital competence have been widely analyzed in recent years (Cabero-Almenara et al., 2020; Ghomi & Redecker, 2019; Hämäläinen et al., 2021; Mehrvarz et al., 2021). For example, the meta-analysis by Sánchez-Caballé et al. (2020) revealed that despite living in a digitalized society, students lacked the necessary digital skills to meet the demands of the academic and professional environment (Cabezas González et al., 2017; Liesa Orús et al., 2016; Mesároš & Mesároš, 2010). Although students demonstrate proficiency in using devices and digital resources for leisure and social activities, such as social networks, videogaming, and entertainment apps (Gobel & Kano, 2013), being digitally competent requires them to manage a range of skills. These skills enable them to collaborate in groups, create audiovisual content, manage platforms, and learn effectively in a digital context, beyond mere consumption. Developing such competencies enhances their learning outcomes and prospects in the workforce (Gabarda Méndez et al., 2017; Ozdamar-Keskin et al., 2015). Digital competence extends beyond the academic realm and exerts socioeconomic influence, affecting functional diversity and shaping teaching strategies in pre-university education. The levels of digital competence acquired by students in earlier learning stages significantly impact their use and value of digital tools inside and outside the classroom (Barlow-Jones & van der Westhuizen, 2011; Kajee & Balfour, 2011).

Another important aspect is the potential influence of university students' level of digital competence on their academic performance. A recent study conducted by Cabero-Almenara et al. (2020, p. 1) established that

> "factors such as the number of digital resources utilized for the teaching-learning process, the previous preparation for managing their studies, as well as the level of education of the parents, mainly the father, significantly had an influence on both types of students".

Similarly, Ghomi and Redecker (2019) demonstrated that students who utilize more than five digital tools in classroom achieve higher levels of digital competence compared to those who use fewer tools. Other studies confirm that a broader use of digital tools sharpens digital skills and improves academic scores (Alderete & Formichella, 2016; Cox & Marshall, 2007; Csordás, 2020; Mehrvarz et al., 2021).

Sociodemographic aspects have been observed to influence the level of digital competence among university students, particularly age and sex. Numerous studies indicate that men exhibit higher levels of digital competence (Cebi & Reisoglu, 2020; Gnambs, 2021; Lucas et al., 2021; Wild & Schulze Heuling, 2020). However, several studies find no significant differences between men and women (Guillen-Gamez et al., 2020; Vázquez-Cano et al., 2017), while others suggest that women may be e more digitally competent than men (Siddiq & Scherer, 2019). Regarding age, older students tent to report lower levels of digital competence compared to their younger counterparts (Wild & Schulze Heuling, 2020). Nonetheless, some studies have found no significant differences in the development and application of digital competence across age groups in academic and professional contexts (Fraile et al., 2018; Vega-Gea et al., 2021).

METHOD

The data were collected using a questionnaire called "basic digital competences 2.0 in university students" (COBADI, registered trademark 2970648), developed and validated by researchers from the EDUINNOVAGOGiA® (HUM-971) research group recognized by the Andalusian Research, Development, and Innovation Plan and affiliated with the Universidad Pablo de Olavide, Seville (Spain). The questionnaire aimed to assess university students' proficiency in digital skills. It was administered in various countries, including those within the European higher education area, as well as Colombia and Mexico (Gómez-Galán et al., 2020; Pascual et al., 2017).

The questionnaire consisted of 24 items divided into two blocks. The first block focused on competencies related to ICT knowledge and usage for social communication and collaborative learning, comprising 13 items. The second block addressed competencies in utilizing ICT for information search and processing, comprising 11 items. Respondents rated each item on a 4-point Likert scale (ranging from 1=I feel totally incapable to 4=I feel totally in control). The questionnaire was distributed digitally to students from three universities in Spain (Universidad Rey Juan Carlos, Universidad Pablo de Olavide, and Universidad Nacional de Educación a Distancia) using non-probability convenience sampling. The final sample included a total of 383 students.

The validation process of the questionnaire was conducted during the 2017/2018 academic year. It involved defining the objective of expert opinions for validation, selecting four relevant experts based on predetermined criteria related to their academic training and professional experience, evaluating the questionnaire indicators for relevance, clarity, and appropriateness, calculating the agreement among the experts, and drawing final conclusions based on the conducted psychometric analysis (Martínez-Heredia, 2020).

In accordance with the classification by George and Mallery (2010) and Hernàndez and Pascual Barrera (2018), the questionnaire demonstrated a high level of overall reliability (Cronbach's alpha (α Cronbach)=.89 (.85-.89), ω=.89). The subscale assessing competencies in the knowledge and use of ICT for social communication and collaborative learning exhibited acceptable reliability (α Cronbach=0.78 (.75-.79), ω=.77). Lastly, the subscale evaluating competencies in the use of ICT for information search and processing showed a high degree of reliability (α Cronbach=.85 (.85-.89), ω=.84).

The data were collected over two academic years (2019-2020 and 2020-2021). Participant anonymity was guaranteed in their responses to the questionnaire, and informed consent was obtained online. The analysis was conducted on the responses to the 24 items of block I, which assessed competences in the knowledge and use of ICT for social communication and collaborative learning (CSCCL) and block II, which evaluated competences in the use of ICT for searching and processing information (CSTI), both in the university context. Sociodemographic variables such as age, sex, and university attended were included to examine the student profiles and their propensity in developing digital competences (**Table 1**).

Given that the study was fundamentally of an exploratory nature, we employed Chi-squared automatic interaction detection (CHAID) technique for multivariate analysis to developed student profiles (Kass, 1980; Magidson, 1993). This technique requires a categorical or ordinal dependent variables and a set of independent variables or categorical predictors. By combining these variables, it becomes possible to identify distinct segments or divisions for the development of profiles (Byeon, 2017; Onoja et al., 2018). The choice of this analytical technique is based on methodological advantages outlined in previous scholarly works (Lizasoain et al., 2003), which are succinctly summarized below.

Table 1. Variables definitions

Type	Variable	Operationalization
Independent	Age	Level 1 (tercile 1)=18-21 years Level 2 (tercile 2)=22-23 years Level 3 (tercile 3)=24-40 years
	Gender	0=Woman, 1=Man
	University	1=URJC, 2=UNED, 3=UPO
	Indicate your level of effectiveness in each of following items (CSCCL)	Items measured in a Likert scale with 1-4 points, where 1="I feel completely ineffective" and 4="I feel that I completely master it"
	BI_1: I can communicate with others by e-mail	
	BI_2: I use Chat to interact with others	
	BI_3: I use instant messaging as a tool to communicate with others	
	BI_4: I can communicate with others by participating in social networks (Facebook, Hi5, Myspace, Ning, Twitter, Tuenti, ...)	
	BI_5: I am able to manage professional networks (LinkedIn, Xing, ...)	
	BI_6: I am able to participate in forums appropriately	
	BI_7: I feel able to participate in blogs	
	BI_8: I know how to design, create, modify blogs, and binnacles (Blogger, Wordpress, ...)	
	BI_9: I know how to use Wikis (Aulawiki21, Wikipedia, ...)	
	BI_10: I feel able to design, create, or modify Wikis (Nirewiki, PbWorks, Wikispace, ...)	
	BI_11: I use the syndication system (RSS)	
	BI_12: I know how to use social bookmarking, tagging, and social bookmarking (Blinklist, Delicious, ...)	
	BI_13: I am able to use educational platforms (Dokeos, Moodle, Online Campus, Intranet, WebCt, ...)	
	Indicate your level of effectiveness in each of the following items (CSTI)	
	BII_1: I can surf the Internet using different search engines (Explorer, Mozilla, Opera, ...)	
	BII_2: I can handle different search engines (research tools) (Google, Ixquick, Mashpedia, ...)	
	BII_3: I feel able to work with some digital mapping software to search for places (Google Earth, Google Maps, Tagzania, Vpike, ...)	
	BII_4: I know how to use programs to plan my study time (Google Calendar, ...)	
	BII_5: I work with documents on the Internet (Google Drive, Skydrive, ...)	
	BII_6: I am able to organize, analyze, and synthesize information using conceptual maps using some social software tools (Bubbl, Cmaptool, Mindomo, Text2mindmap, ...)	
	BII_7: I can use programs to broadcast interactive presentations on internet (Prezi, Scribd, SlideShare, ...)	
	BII_8: I feel competent to work with social software tools that help me analyze and/or browse content included in blogs (Tagxedo, Wordle, ...)	
	BII_9: I work with images by using tools and/or social software applications (Animoto, Gloster, Picmonkey, ...)	
	BII_10: I feel able to use podcasting and videocasts (Flicks, Odeo, Youtube, ...)	
	BII_11: I use QR codes to disseminate information	
Dependent	Measure of digital competence perceived level (MDCPL)	Level 1 or tercile 1=Low Level 2 or tercile 2=Medium Level 3 or tercile 3=High

Firstly, it accommodates both quantitative and qualitative variables, making it suitable for analyzing ordinal and nominal data commonly obtained through questionnaires (Blanco et al., 2017; López-Martín et al., 2018). Secondly, CHAID produces interpretable results in the form of a segmentation tree (Legohérel et al., 2015; Legohérel & Wong, 2006), facilitating profiling–the main objective of this research. Thirdly, CHAID enables the identification of interactions and the characterization of subpopulations. Lastly, it allows for the derivation of multivariate predictive models surpassing other techniques like discriminant analysis or logistic regression (Richard's et al., 2008). Notably, unlike multiple linear regression, CHAID eliminates the need to meet assumptions of homoscedasticity, normality, multicollinearity, and independence, making it a valuable exploratory tool that guides the design of more refined models and subsequent parametric analysis.

Data segmentation in this study involved classifying survey participants based on their sociodemographic characteristics and the levels and types of digital competences they possessed. CHAID algorithm in IBM© SPSS statistics v.28 software was used to perform the segmentation analysis on the nominal dependent variables. The main objective of this study was to identify segments of university students with different levels of predisposition and utilization of their digital competences. To this end, as **Table 1** shows, the independent predictor variables included individual sociodemographic profile characteristics (age, sex, university attended) and the self-reported efficacy levels for each competence item (CSCCL and CSTI). A dependent variable (MDCPL) was also used, which represented the total measure of digital competence level derived from the sum of the competence levels in CSCCL and CSTI. The MDCPL variable was transformed into a dummy variable using two cut-off points (three terciles: 1, 2, and 3). Furthermore, an analysis was conducted using each student's total digital competence level, which ranged from a minimum of 26 to a maximum of 96.

RESULTS

Results of the Descriptive Study

The descriptive analysis of the data revealed that the university with the largest student representation in the sample was URJC (57.4%), followed by UNED (27.7%), and UPO (14.9%). The sample consisted of 89.6% women, which was significantly higher than the number of men (10.4%). This segmentation pattern was consistent among the surveyed undergraduate students, from the Social Sciences and Humanities degree programs, where most students were women. In terms of age, most participants fell within 18-21 years range (55.4%), followed by 22-23 years range (39.2%), and 24-40 years range (5.5%). Women were also the majority at all three universities: 94.5% at URJC, 81.8% at UNED, and 86% at UPO. Regarding digital competence, 35% of men reported having a high level of digital competence compared to 27.7% of women. Among different age ranges, students between 18-21 years had the highest levels of competence (35.8%), while the medium level of competence (38.1%) was most prevalent across all ages. Analysis of competence levels by university indicated that UNED (44.3%) had the highest percentage of students with a high level of digital competence, whereas URJC (41.4%) had the highest percentage of students with a low level of digital competence.

Results of Decision Trees

In this section, we will provide an explanation of each decision trees, or classification derived from CHAID analysis for every analyzed model. Additionally, we will present the variables and categories with the highest level of discrimination, along with the frequency tables for each node, the number of cases, and the relative and absolute value for each category of the dependent variable. The category with the highest value in each node will be clearly indicated. The most significant findings for each model are presented below.

Tree model implemented by item

To explore student profiles with greater or lesser propensity in the development of their digital competences, the results of the first model showed that only six of the 27 independent predictor variables considered were incorporated in the model. These corresponded to the following survey questions: BII_4: I know how to use programs to plan my study time (Google Calendar, ...); BII_9: I work with images using social software tools and/or apps (Animoto, Gloster, Picmonkey, ...); BII_2: I know how to use a range of search engines (Google, Ixquick, ...); BI_8: I know how to design, create and modify blogs and binnacles (Blogger, Wordpress, ...); BI_10: I consider myself competent to design, create and modify a wiki (Nirewiki, PbWorks, Wikispace, ...). This indicates that, a priori, the rest of the predictor variables considered seemed to have no significant influence on the student's level of digital competence; such elements include age, sex, university attended, and the rest of the items in the questionnaire.

Figure 1 illustrates that 38.1% of the sampled students declared a medium level of digital competence, 28.5% indicated a high level, and 33.4% reported a low level (node 0). The most influential predictor of students' digital competence level was associated with variable BII_4, which pertains to the use of programs for planning study time (Google Calendar, ...), χ^2=225.600 (df=6; padj<.001). This variable further splits into four segments (nodes 1, 2, 3 and 4). These segments allow us to propose the classification of four profiles comprising the following nodes: the first profile consists of nodes 0, 1, 5, 6, 14, and 15; the second profile

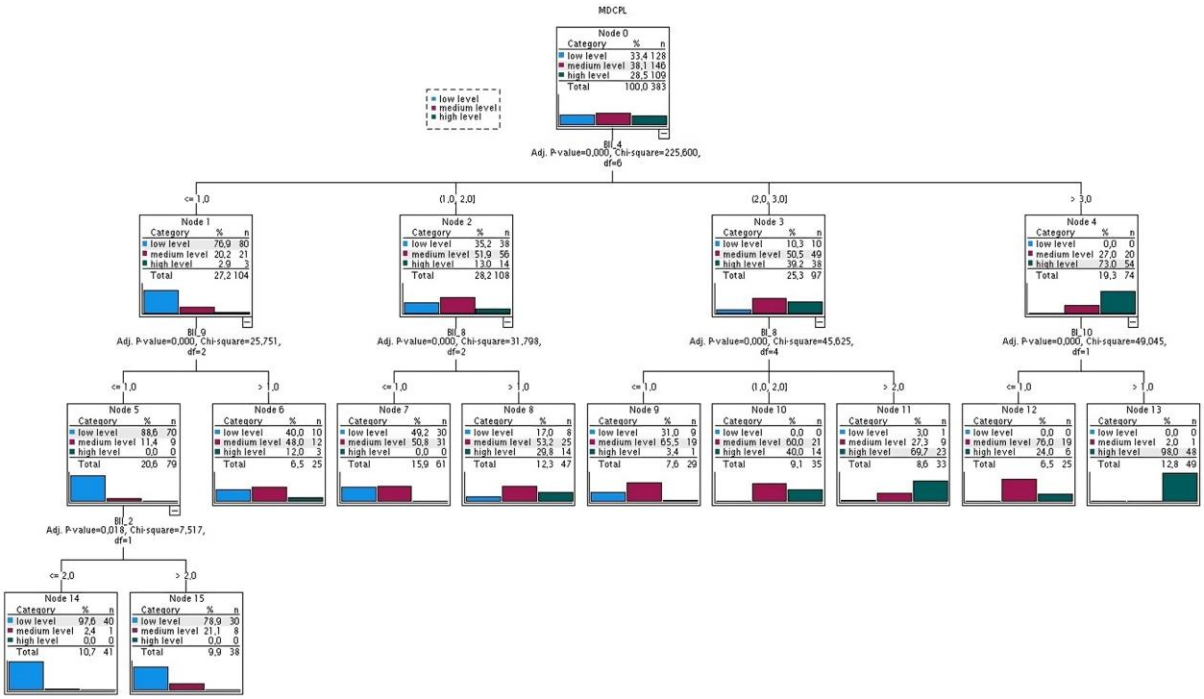

Figure 1. Tree model inferred by items (Source: Authors)

comprises 0, 2, 7, and 8; the third profile incorporates 3, 9, 10, and 11; and the fourth profile encompasses nodes 0, 4, 12, and 13.

The main findings for each profile are as follows. In the first profile, which corresponds to the segment of students who felt completely incompetent in using programs to plan their study time (Google Calendar, ...), 76.9% of students showed a greater inclination towards a low level of digital competence (node 1). Within this segment, when examining the split based on the second predictor variable BII_9, I work with images using social software tools and/or apps (Animoto, Gloster, Picmonkey, ...), χ^2=25.751 (df=2; padj<.001), 88.6% of students who considered themselves completely incompetent in this aspect were more likely to have low levels of digital competence (node 5). Similarly, within this segment, considering the split based on the third predictor variable, BII_2, I know how to use a range of search engines (Google, Ixquick, ...), χ^2=7.517 (df=1; padj=.018), 97.6% of students who considered themselves completely incompetent in using different platforms exhibited a stronger inclination towards a low level of digital competence (node 14). Likewise, 78.9% of the students who felt somewhat or completely competent in using various search engines showed a greater inclination towards a low level of competence (node 15). In this sense, only 21% of those who felt somewhat or totally competent in the use of different search engines had greater disposition towards a medium level of competence (node 15). Furthermore, in this profile, within the second split in node 1, which pertains to students who felt somewhat competent in using different search engines (Google, Ixquick, ...), 48% of these students were more likely to have a medium level of digital competence, and 40% a low level (node 6).

In the second profile, within the segment of students who felt somewhat or completely incompetent in using programs to plan their study time (based on the second split of variable BII_4), 51.9% of students were more likely to declare a medium level of digital competence, while 35.2% reported a low level (node 2). Within this segment, considering the split by the second predictor variable BII_8, which pertains to feeling competent in working with social software tools that aid in analyzing and/or searching for content in blogs (Tagxedo, Wordle, ...), χ^2=31.798 (df=2; padj<.001), 53.2% of the students who did not feel completely incompetent when using such tools were more likely to have a medium level of digital competence (node 8). Similarly, 50.8% of those who felt completely incompetent in working with social software tools for analyzing and/or searching for content in blogs exhibited a stronger inclination towards a medium level of digital competence (node 7).

In the third profile, based on the third split of variable BII_4, which consists of the segment of students who were somewhat competent in using programs for planning their study time (Google Calendar, ...), 50.5% of these students declared a greater likelihood of possessing a medium level of digital competence, and 39.2%

Table 2. Classification by items

Observed	Predicted			
	Low level	Medium level	High level	Percent correct
Low level	**70**	57	1	54.7%
Medium level	9	**127**	10	87.0%
High level	0	38	**71**	65.1%
Overall percentage	20.6%	58.0%	21.4%	**70.0%**

Note. Growing method: CHAID & dependent variable: MDCPL

with a high level (node 3). Furthermore, within this segment, considering the split by the second predictor variable, BI_8, which pertains to knowing how to design, create, and modify blogs and binnacles (e.g., Blogger, Wordpress, ...), χ^2=45.625 (df=4; padj<.001), 69.7% of the students who stated they were somewhat, or totally competent in these actions exhibited a stronger inclination towards a high level of digital competence (node 11). Conversely, 65.5% of those who stated they were totally incompetent in designing, creating, and modifying blogs and binnacles, and 60% who had minimal ability to do so, displayed a greater disposition towards a medium level of digital competence (nodes 9 and 10).

In the fourth profile, our study findings indicate that 73% of the students who considered themselves somewhat competent in using programs to plan their study time exhibited a greater inclination towards a high level of digital competence (node 4). Within this segment, the variable BI_10, which pertains to considering oneself competent in designing, creating, and modifying a wiki (Nirewiki, PbWorks, Wikispace, ...), χ^2= 49.045 (df=1; padj<.001). Notably, 98% of the students who did not consider themselves totally incompetent in these tasks displayed a stronger predisposition towards a high level of competence (node 13). Conversely, 76.0% of those who considered themselves totally incompetent in performing these tasks were more likely to have a medium level of digital competence (node 12).

Two indicators were considered to assess the model's goodness of fit. Firstly, the risk was estimated at 0.300 with a corresponding standard error of 0. 023. Secondly, the percentage of correct predictions by the model was 70.0%. **Table 2** presents the number of students with different levels of digital competence and the corresponding predictions made by the model based on the presence or absence of the three indicators considered in this model, as indicated in the diagonal of the concordances obtained. The model demonstrated a prediction rate of 87% for students with a medium level of digital competence, while the accuracy was slightly lower for students with a high level of digital competence at 65.1%, and only 54.7% for those with a low level of digital competence.

Tree model implemented by dimensions

The most significant findings for this second model are represented in the decision tree in **Figure 2**, which illustrates the survey questions that influenced students' digital competence based on the presence or absence of these indicators in the decision tree. This model analyzed the potential influence of independent variables, such as age, sex, university attended, competences in knowledge, and use of ICT in social communication and collaborative learning (CSCCL), and competences for ICT use in searching for, and treatment of information (CSTI) on the dependent variable (MDCPL), related to students' digital competence.

The results for this model indicate that out of the five independent predictor variables considered, only two variables, CSCCL and CSTI, were incorporated into the model. Variables relating to age, sex and university attended do not appear to have significantly influenced their levels of digital competence. **Figure 2** illustrates the presence of the two predictive variables, CSTI and CSCCL, included in the model, ranked in order of importance. Additionally, **Figure 2** reveals that 38.1% of students exhibited a medium level of digital competence, 28.5% had a high level, and 33.4% had a low level of digital competence (node 0). The CSTI variable emerged as the strongest predictor of students' level of digital competence, exhibiting significant association with competence in ICT use for information search and processing (χ^2=428.399, df=4, padj<.001). This variable was further divided into three segments (nodes 1, 2, and 3), enabling the classification of three distinct profiles. The first profile comprised nodes 0, 1, 4, and 5, while the second profile formed of nodes 0, 2, 6, 7, and 8. Lastly, the third profile comprised nodes 0, 3, 9, and 10.

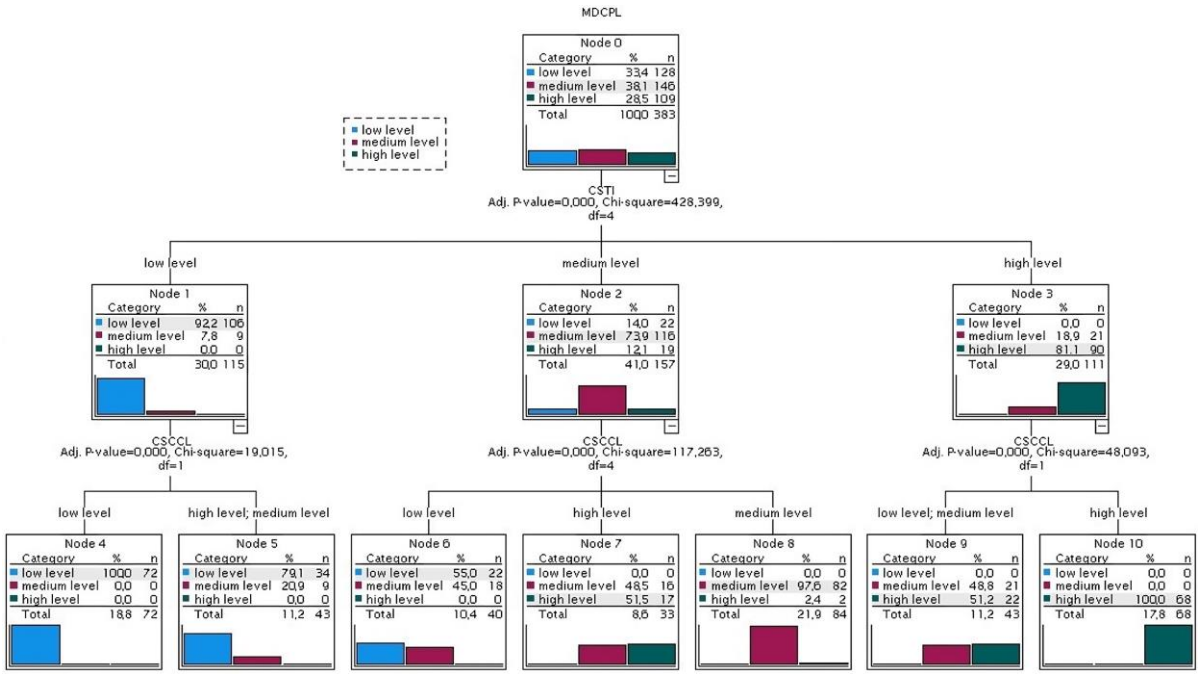

Figure 2. Tree model inferred by dimensions (Source: Authors)

The findings for each of these profiles indicate that the results for classification in the first profile, based on the initial split of the CSTI variable, comprised the segment of students who reported a low level of competence in ICT use for searching and processing information. Among these students, 92.2% exhibited a stronger inclination towards a low level of digital competence (MDCPL) (node 1) χ^2=19.015 (df=1; padj<.001). This segment reveals a division between two groups of students concerning their competence in ICT knowledge and use in social communication and collaborative learning (CSCCL). This segmentation was derived from the analysis of the split of the second predictor variable, CSCCL, which consisted of students who reported being competent in ICT knowledge and use in social communication and collaborative learning. Two student groups were identified in the analysis. The first group (node 4) showed 100% inclination towards a low level of digital competence (MDCLP). The second group (node 5) had a 79.1% predisposition towards a low level of the same competence (MDCPL).

The second profile, based on the second split of the CSTI variable, comprised students who declared themselves competent in ICT use in searching and processing information. Among these students, 73.9% were more likely to have a medium level of digital competence (MDCPL) (node 2) χ^2=117.263 (df=4; padj<.001). This segment was further divided by the second predictor variable, CSCCL, which represented students competent in ICT knowledge and use for social communication and collaborative learning. The students were classified into three groups based on their level of efficacy in CSCCL competence: the first group, with 55.0% more likely to have a low level (node 6); the second, with 51.5% more likely to have a high level (node 7); and a third group, with 97.6% more likely to have a medium level of digital competence (MDCPL) (node 8).

The third profile, based on the third split of variable CSTI, consisted of students who declared themselves competent in ICT use for searching and processing information. Among these students, 81.1% stated that they had a high level of digital competence (MDCPL) (node 3) χ^2=48.093 (df=1; padj<.001). There were two groups of students within this segment, based on their degree of competence in ICT knowledge and use in social communication and collaborative learning (CSCCL). The first group comprised 51.2% of students more likely to have a high level of digital competence (MDCPL) (node 9), and the second group consisted of 100.0% who had greater predisposition to a high level in this digital competence (MDCPL) (node 10).

Two indicators were considered for the model's goodness of fit; firstly, the risk estimated at 0.172 and associated with a standard error of 0.019, and secondly, the percentage of correct predictions made by the model, which in this case was 82.8%. **Table 3** displays the number of students observed at different levels of digital competence in the analysis, as well as those predicted by the model based on the presence or absence of the three indicators considered. These results demonstrate that the model effectively classified students

Table 3. Classification by dimensions

Observed	Predicted			
	Low level	Medium level	High level	Percent correct
Low level	**128**	0	0	100.0%
Medium level	27	**82**	37	56.2%
High level	0	2	**107**	98.2%
Overall percentage	40.5%	21.9%	37.6%	**82.8%**

Note. Growing method: CHAID & dependent variable: MDCPL

at both ends of the competence scale (high and low), achieving prediction scores of 100.0% and 98.2%, respectively. However, the medium level of digital competence category was less accurately predicted, with a rate of 56.2%.

DISCUSSION

This study identified student profiles with varying degrees of propensity in developing their digital competences. The study analyzed the discriminatory nature of digital competences associated with ICT use in social communication and collaborative learning, and information search and treatment. It also explored the relationship between these competences and the individual level of digital competence acquired by the students.

One key finding is that among students who achieved a high level of digital competence in information and search treatment (CSTI)–which accounted for 29.0% of the total sample–81.1% also obtained a high level of overall individual digital competences (MDCPL), while 18.9% acquired a medium level of MDCPL. Interestingly, this was regardless of their level of control over digital competences associated with ICT use in social communication and collaborative learning (CSCCL). These scores could potentially be higher, as other studies have identified higher levels of digital competence among students enrolled in courses involving significant digital production (Brodahl et al., 2011), and among those in their final year who have taken subjects with a specific emphasis on digital competence (Liyanagunawardena et al., 2014). In this sense, the digital competences associated with ICT use in social communication and collaborative learning need to be fostered to enhance students' skills in managing specific software, online platforms, or information management systems (Kebritchi et al., 2017).

A similar trend was observed among students who achieved a low level in CSTI (30.0% of the sample). Among them, 92.2% maintained a low level of overall individual digital competences (MDCPL), while 7.8% attained a medium level of MDCPL. Notably, these outcomes, where independent of the level achieved in CSCCL. Previous studies have associated these low levels with task complexity, which significantly diminishes the perception of digital competence (Gutiérrez Porlán & Serrano Sánchez, 2016). To enhance the utilization of ICT in information search and processing, it is crucial to minimize information overload, including the difficulty of finding relevant and reliable sources (Gutiérrez-Ángel et al., 2022). In the same vein, a study conducted by Sparks et al. (2016) revealed that students often face challenges in digital information literacy, including the ability to critically evaluate online sources.

It is important to note that among the items (questions) with a greater discriminatory range in determining the total individual level of competence (MDCPL), certain aspects were particularly relevant. Firstly, the fourth question of block II (BII_4) associated with CSTI showed a wider range of discrimination. This highlights that among the students who expressed complete incompetence in using programs for planning their study time (27.2% of the sample), 76.9% acquired a low level of total individual digital competences (MDCPL). The ability to plan study routines using digital tools is an area identified in the literature as lacking among university students. Several studies link this difficulty to the accessibility and usability of digital tools, resources, and educational platforms required for academic work in certain subjects (Alkinani & Alzahrani, 2021). Additionally, some studies suggest that first-year university students are less inclined to manage their time effectively and utilize digital tools and resources, leading to a decline in digital competence and an increased perception of heavy workload (Kyndt et al., 2014). In our study, among the students who reported felling completely in control when using programs to plan study time (19.3% of the sample), the majority (73.0%)

achieved a high level in MDCPL. This high level also persisted in 98% of these students even if they also expressed not felling completely incompetent in using podcasting and videocasts.

Medium level MDCPL was achieved in 48.0% of these students if they also expressed themselves to be somewhat or totally competent when working with images using social software tools and/or apps. The positive influence of social software and social networks on students' academic performance has been identified in other studies, particularly when combined with didactic strategies based on the flipped classroom (Chen Hsieh et al., 2017; Thai et al., 2017).

Among the students who demonstrated an intermediate level of competence in using programs to plan study time (25.3% of the sample), 50.5% obtained a medium level of MDCPL. This percentage would increase to a high level if 69.7% of these students also considered themselves somewhat or totally competent in designing, creating, and modifying blogs and binnacles. Knowing how to design and create blogs for learning, as well as accessing them, has been recognized in the literature as highly effective digital competences (Hamid et al., 2015; J. Lee & Bonk, 2016; L. Lee, 2017; Venkatesh et al., 2016). The importance of digital competence associated with blogging has also been emphasized in other studies (Alt, 2017; Dikilitas & Yayli, 2018) as fundamental to self-regulated development and progress, aligning with the constructivist perspective of learning and enhancing students' digital competence at both individual and social levels. The lack of digital competence in effectively planning study time with digital tools can be attributed to several factors. Research conducted by Zhao et al. (2021) suggests that students may lack the necessary skills to navigate and utilize digital calendars, task management apps, and other planning tools efficiently. Additionally, the study carried out by Wolters and Brady (2021) indicates that students may struggle with time management and self-regulation, which in turn hinders their ability to effectively utilize digital tools for study planning.

Finally, another important finding of our study was that the students' sociodemographic characteristics (age, sex, and university attended) did not influence their predisposition to the analyzed level of digital competences. The lack of gender influence on students' digital competence, as observed in this study, aligns with other research findings (Galindo-Domínguez & Bezanilla, 2021; Gil-Juarez et al., 2011). However, it is worth noting that some studies have reported significant differences (Cózar & Roblizo, 2014; Rodríguez-Muñiz et al., 2021). Specifically, certain studies have indicated a higher level of digital competence among men compared to women (Cabezas González et al., 2017; López-Martín et al., 2018), while others have observed the opposite trend (Moreno et al., 2019).

CONCLUSIONS AND FUTURE WORK

The findings of our research have revealed challenges that academic institutions and professors must confront to enhance the digital competencies of university students. Firstly, it is essential to teach critical analysis of information and source credibility to mitigate students' information overload experienced in the online environment. Secondly, there is a need to provide instruction on the utilization of social software apps for image production. Lastly, promoting collaborative learning should be emphasized.

If technology is to drive collaborative learning, it is essential that the design of study courses and the types of tools used are capable of generating new relationships. To achieve this, formal and informal learning environments should mutually benefit from each other, considering the abundance of digital resources students already employ outside the classroom, that have the potential to be effectively incorporated into formal educational contexts. University instructors must integrate students' ICT experiences into the design of learning environments that promote interactive spaces. Additionally, leveraging artificial intelligence resources for tailored automated responses to students' queries can greatly enhance the creative and innovative aspects the of the teaching-learning process, improving it. Furthermore, the development of effective workplace skills necessitates practical applications, where students learn to create and disseminate content and collaborate in teams. For this reason, greater emphasis should be placed on training teachers in technologies to enhance pedagogy and facilitate better learning outcomes in higher education. This would enable students to practice with a diverse range of resources that facilitate situated learning.

This study contributes to the existing literature on collaborative learning and digital competences by highlighting the importance of institutional interventions and educational support in improving the digital

literacy of university students in the aforementioned areas. These enhancements are highly advantageous for their future integration into the labor market.

Among the notable limitations found in the present study, the following should be highlighted: Firstly, the sample size. Van Middelkoop et al. (2003) recommended a sample size of approximately 200 observations per predictor variable for a CHAID-based algorithm. While this recommendation was followed for the second model (by dimensions), it was not met for the first model (by items) due to the sample size being less than 500. Considering that this analysis involved more than five predictor variables, the recommended size should have been greater than 1,100. Despite this limitation, the study's sample still resulted in a significant albeit limited partition. To address this concern, both models were validated through tree cross-validation on 10 subsamples before generating the tree models, which provided an acceptable assessment of the tree structure's goodness when generalized to a larger population. Moreover, other studies have successfully conducted CHAID analysis using samples of limited size (Busby & Huang, 2012; Chen Hsieh et al., 2017; Kim et al., 2011). However, for future studies utilizing CHAID technique, we recommend enlarging the sample size and conducting a more detailed partition, which would generate additional results for comparison and contribute value to the scientific community. Secondly, the sample used in this study consisted of a non-probabilistic selection of students from three universities in Spain. Therefore, caution should be exercised when comparing the results of the applied didactic instrument to broader samples or to degree programs at universities outside Spain. Thirdly, although this study explores student profiles based on their digital competencies and the relationship between different digital skills, it does not provide a sociodemographic classification or consider variations across different types of universities or degrees. It is recommended that future research in this context incorporate these factors to enhance understanding in the field.

In conclusion, the study has identified important limitations related to sample size, sample representativeness, and the scope of analysis. Addressing these limitations and considering sociodemographic factors and variations across different institutions will contribute to a more comprehensive understanding of student digital competencies and their development.

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