The digital gender gap among undergraduate students in several Spanish universities

La brecha digital de género en los estudiantes de grado en varias universidades españolas

Josué Artiles-Rodríguez - *Universidad de Las Palmas de Gran Canaria, ULPGC (Spain)*
María Victoria Aguiar-Perera - *Universidad de Las Palmas de Gran Canaria, ULPGC (Spain)*
Vanessa Esteve-González - *Universidad Rovira i Virgili, URV (Spain)*
Vanessa Serrano-Molinero - *Universidad Rovira i Virgili, URV (Spain)*

ABSTRACT

A student's level of digital competence affects aspects of their academic life such as progress and performance or access to degrees. This research is based on a descriptive and inferential quantitative methodology, with a survey design aimed at collecting information on an initial group of 909 participants, from different educational levels, of which the responses of 725 undergraduate students were finally analysed. The results show that women are the group with the highest mean scores, although more than half of the respondents of both genders have a high mean score. No significant differences were found when analysing the different regions of Spain based on gender. Nor were differences found when contrasting degree subject area and gender, or when grouping degrees according to whether they are included in the STEM subject block or not. Differences were appreciated in certain digital competence literacies when gender and average grade are taken into account. These results may represent an indication of a change in the digital divide identified over the past few years by various authors. The findings indicate that, while there is a need to strengthen equity in digital competence training between genders, there may be more factors influencing students' perceptions of their level of competence.

Keywords: digital competence; gender gap; undergraduate students.

RESUMEN

La competencia digital del alumnado afecta a aspectos de su vida académica, como el progreso y rendimiento o el acceso a titulaciones. La presente investigación se basa en una metodología cuantitativa de corte descriptivo e inferencial, con un diseño de encuesta con el objetivo de recabar información sobre un grupo inicial de 909 participantes, de diferentes niveles educativos, de los que finalmente se han analizado las respuestas de 725 estudiantes de grado. Los resultados muestran que las mujeres son el grupo que obtiene las calificaciones medias más altas, aunque más de la mitad de los encuestados de ambos géneros se sitúa en una calificación media alta. No se encontraron diferencias significativas en cuanto al análisis de las CC.AA. en función del género. Tampoco se encontraron diferencias cuando se contrastaba el área de conocimiento de la titulación y el género, ni cuando se agrupan las titulaciones según se incluyan en el bloque de materias STEM o no. Aparecen diferencias en algunas de las alfabetizaciones de la competencia digital cuando se tiene en cuenta el género y la nota media. Estos resultados pueden representar un indicio de cambio en la brecha digital identificada a lo largo de los últimos años por diversos autores. Las conclusiones indican que, aunque es necesario reforzar la equidad en la formación de la competencia digital entre géneros, pueden existir más factores que influyan en la percepción que tiene el alumnado sobre su nivel de competencia.

Palabras clave: competencia digital; brecha de género; estudiantes de grado.

How to cite: Artiles-Rodríguez, J., Aguiar-Perera, M. V., Esteve-González, V., & Serrano-Molinero, V. (2025). The digital gender gap among undergraduate students in several Spanish universities. [La brecha digital de género en los estudiantes de grado en varias universidades españolas]. *RIED-Revista Iberoamericana de Educación a Distancia, 28*(1). https://doi.org/10.5944/ried.28.1.41536

INTRODUCTION

STEM (Science, Technology, Engineering and Mathematics) degrees are of great importance for socio-economic development. However, there is a low representation of women accessing and studying these degrees, which is subsequently reflected in the low presence of women in leadership or innovation positions (Anaya et al., 2022; Card & Payne, 2021; Lapan & Smith, 2023).

The underrepresentation of women is a phenomenon influenced by various factors (Beroíza & Salas, 2024). Some of the factors that influence this underrepresentation are social, such as the early use of digital resources, whereby men are exposed to technology through video games and/or online games, which may generate a different perception of self-efficacy than women (Yates & Plagnol, 2022). Thus, late exposure to technology could condition women's later access to careers such as computer science (Smith & Lapan, 2021). In terms of self-perception, gender differences can be found in STEM degrees, with higher self-perception among men (Getenet et al., 2024; Niño-Cortes et al., 2023) and, despite women having similar qualifications, a lower entry rate into STEM degrees is found in comparison to men (Card & Payne, 2021). On the other hand, aspects that may also play a role include gender stereotypes (Blaney, 2021); educational factors, such as the role of teachers (De las Cuevas et al., 2022) and peers (Yates & Plagnol, 2022); women's social interests when choosing studies (Beyer, 2014); job expectations and remuneration (Stoet & Geary, 2022), or family conditioning factors (Anaya et al., 2022). These factors influence women's decisions and expectations in the STEM field and can lead to inequalities that limit their professional development, so there is a need to encourage female STEM programmes and role models (Kurti et al., 2024).

Self-perception of STEM subjects differs by gender, with females tending to show a lower academic self-concept and having more difficulty taking an interest in subjects in which they may feel insecure (Lewis, 2022). Men, on the other hand, tend to have a more positive appraisal of themselves and show higher self-esteem in terms of self-assessment or self-efficacy than women (Cabezas et al., 2017; Wild & Schulze, 2020). This perception conditions STEM degree choices, as expectations and possibilities are reflected upon based on an understanding of perceived performance in a social order (Stearns et al., 2020). Specifically, in mathematics, gender differences in performance, and self-perceived levels of mathematical ability during childhood, could be key factors explaining this under-representation of women in comparison to men (Anaya et al., 2022). Similarly, in computer science, females self-assess their ability lower than their male counterpart with similar qualifications, which may lead to a negative view of the field (Beyer, 2014; Hunt et al., 2022).

Classroom climate has also been studied with respect to gender differences in STEM subjects. In computer science subjects, a self-directed learning approach is observed, where there is a competitive atmosphere and females are often not supported by their male peers or teachers (Yates & Plagnol, 2022). Female students make fewer positive judgements about their competence compared to their male peers and may receive more disrespect from male peers or teachers linked to their competence (Hunt et al., 2022). Female students' interaction with their professors plays a critical role in STEM degrees (Tandrayen-Ragoobur, & Gokulsing, 2022; Hunt et al., 2022), and female students often perceive their learning style as individualistic, detached from peers and professors (Pantic & Clarke-Midura, 2022). Mentoring and coaching by

teachers plays a significant predictive role in students' positive self-perceptions of leadership (Blaney, 2021).

The experience of internships is a further reason for gender analysis of STEM subjects. In computer science they influence professional development, and gender identity can be a relevant factor, whereby female students are motivated to continue their careers in computer science after this period, especially when they have the possibility to work on challenging projects and create useful products for others (Lapan & Smith, 2023). In any case, female students have fewer opportunities to develop their skills and receive positive feedback during their internships. Some students even report that their internships may make them reconsider their career choice (McChesney et al., 2022).

Students' family background may also influence their future choice of STEM degrees (Verdugo et al., 2022). Female students are more likely to choose a STEM degree than male students if they have parental support (Tandrayen-Ragoobur & Gokulsing, 2022). There appears to be a link between academic performance in mathematical activities when students have an immediate family member in a STEM-related occupation. However, this does not mean that they have a self-concept of mathematical literacy commensurate with that level of performance (Anaya et al., 2022).

Perceived digital competence (DC) is an important factor that can influence the choice of STEM subjects, and there are gender differences, with men perceiving themselves as more competent (He & Zhu, 2017). While men tend to be overconfident in their skills and competences, women tend to underestimate and doubt themselves (Yates & Plagnol, 2022). DC, at university level, is seen as the integration of four literacies: information literacy, technological literacy, multimedia literacy and communicative literacy. Together, they form a holistic DC adapted to the demands of the 21st century (Larraz, 2013). This DC construct has been taken as a reference in various research projects and, in particular, in the development of the INCOTIC instrument, which measures how university students perceive themselves in terms of their DC (González et al., 2018). These authors describe the different literacies as follows:

Information Literacy (IL) is related to the search for, evaluation and management of information. Although there is currently a tendency to perceive students as digital natives, due to their use of technology and being born with access to the internet (Prensky, 2001), this does not mean that students end up conforming to the conceptualisation of digital natives in terms of competence (Casillas et al., 2017). The majority of students opt for printed paper and internet access only to consult information, which reveals conventional preferences. Compared to men, women use a greater diversity of resources to search for information. Women's information creation process is more complex, and aspects such as respecting intellectual property, citing sources, reviewing drafts and consulting with others are taken into account, making use of more advanced tools and formats than men. However, it is men who are more sceptical when selecting information (López Vicent et al., 2017). Both genders perceive that they have an adequate level of competence in the use of podcasts, web browsers or information search engines (Vázquez-Cano et al., 2017).

Technological Literacy (TL) is, perhaps, the most technical literacy of those that make up the competence, linked to the processing of information in the management of software and hardware. Thus, it receives a low level of self-perception by students who value this type of skill (Sánchez-Caballé et al, 2019). Gender differences in this

type of literacy in higher education are evident in subjects such as computer science. Men tend to choose engineering courses that focus on hardware and software, whilst women tend to choose courses that address theoretical aspects of computer science, as well as humanities and social science topics (Ioannis & Maria, 2019). Female students are often assigned the role of task coordinator for group work, with their male peers taking on complex technical tasks (Blaney, 2021).

Multimedia Literacy (ML), related to audiovisual content, is highly rated by students in terms of perceived DC (Sánchez-Caballé et al., 2020; Sánchez-Caballé et al., 2019). Smartphones are frequently used devices, and if university students judge their self-efficacy in technical learning by their proficiency with their mobile phones, then it would make sense that men and women currently experience similar levels of self-efficacy (Harmon & Walden, 2020).

Communicative Literacy (CL) is related to communication using digital tools. This literacy, in line with what is expected of this generation, which frequently uses social networks, presents the highest levels of self-perception (Sánchez-Caballé et al., 2020). These literacies involve the use of various media and languages to express themselves and communicate with others (Llopis et al., 2021). Students' appreciation of this type of literacy is high, a perception that could perhaps be related to the use of mobile devices and social networks. Thus, network communication and collaboration is one of the areas with the highest student achievement (Silva & Morales, 2022). In this aspect, they feel more skilled in the field of digital technology and online presentations than girls (Vázquez-Cano et al., 2017).

The purpose of this article is to analyse the effect that some variables, such as region of origin, grade point average or area of knowledge, have on the self-perception of DC of undergraduate students in different Spanish universities, according to gender.

METHODOLOGY

This study aims to analyse the possible gender differences in terms of total self-perceived DC, and at the level of their literacies (IL, TL, ML and CL), of Spanish undergraduate university students, based on the region of Spain they are from, the average mark, as well as to evaluate the role of the studies completed, i.e. whether the gender differences are observed equally in Engineering/architecture - Sciences - Health Sciences - SSCSS - Arts and Humanities studies.

To this end, this research has been carried out from a quantitative approach of a descriptive and inferential nature, with a survey design that aims to study the opinions and characteristics of a large group of people (Creswell & Guettermann, 2013), but which, in turn, also allows us to identify possible relationships between variables, always including the gender variable.

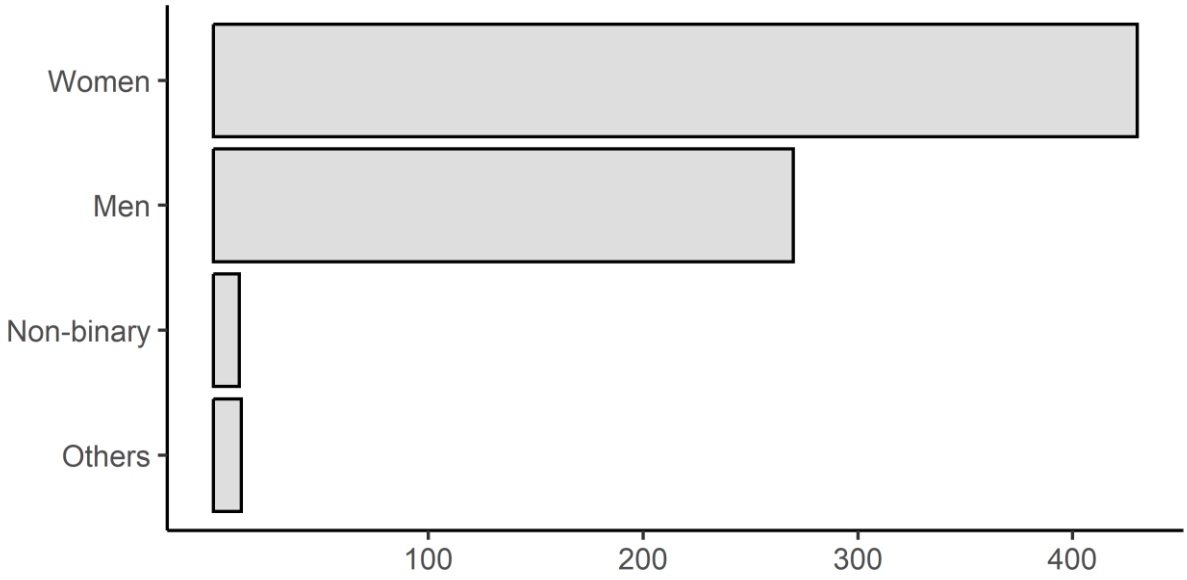
Sample

The sample is drawn from the total population of Spanish undergraduate students. A convenience sample was taken from 67 higher education institutions located in 16 autonomous regions throughout Spain. Data collection took place between January 2022 and April 2023.

A total of 909 responses were obtained, of which 725 corresponded to Bachelor's studies, 178 to Master's studies and only 6 to PhD studies. In this research, only the observations corresponding to undergraduate students have been considered.

In terms of gender, the sample of undergraduate students is mainly represented by women and men, 430 and 270 observations respectively, with a very low representation of non-binary or other gender, 12 and 13 observations in each case (Figure 1). For this reason, for the identification of a possible gender gap only the first two categories (corresponding to 700 responses among the undergraduate totals) will be taken hereafter.

Figure 1
Distribution of responses by gender for undergraduate studies



Instrument

Students' self-perceived DC was measured with the Information and Communication Technologies Competencies Inventory (INCOTIC) instrument, with registration number i-DEPOT 116247, a tool designed to carry out a self-diagnostic assessment of the DC of undergraduate university students with high reliability, with a Cronbach's alpha = 0.913 (González-Martínez, et al., 2018). This is a questionnaire that measures the self-perception of DC taking into account the four literacies that, according to Larraz (2013), make up DC: information, technological, multimedia and communicative literacy. Each literacy consists of 5, 5, 4 and 5 items, respectively, which measure the self-perceived ability to perform different tasks with a 5-value ordinal scale (from '1. I do not know how to do it' to '5. I can do it confidently'). The reliability study in González-Martínez et al. (2018) was conducted with a sample of 49 students from a population of 113 students of a Master's degree in Education. Subsequent studies have used this tool to assess the digital competence of university students, both in the version validated by González-Martínez et al. (2018), and in Sánchez-Caballé et al. (2019), as well as in later validated adaptations, as in Henríquez-Coronel (2020).

Procedure and data analysis

The survey was implemented online using the Alchemer application and distributed to a total of 67 public universities in 16 of Spain's 17 Autonomous Communities (all except the Balearic Islands). The response file was downloaded from the same platform in Microsoft Excel format and was processed to anonymise it and eliminate information not relevant to the analysis. This file consists of 909 observations or records (rows) and 83 variables (columns), which correspond to the information collected from each record (as a unique identifier of the record) and the responses to the different items of the questionnaire.

For the analysis of the answers, version 4.2.3 of R and its integrated development environment RStudio (version 2023.06.0) have been used. One of the main features of R is that it is highly extensible thanks to the use of a large number of packages that the developer community generates and makes freely available to users. These packages consist of data, functions and code snippets to perform specific tasks. In addition to the packages that are installed by default, in the analysis of the responses collected from the INCOTIC 2.1 questionnaire, the tidyverse packages (for data management and processing), ggplot2 and complementary packages (for generating graphical representations) and ARTool (for carrying out the main hypothesis tests performed) have been mainly used.

Bar charts were used to visualise the frequency of occurrence of the different categories of qualitative variables (gender), and box plots were used to identify the distribution of values of the quantitative variables analysed (assessment of total DC and its literacies). In the latter case, facets have been used when this distribution has been compared separately for the different categories of some of the qualitative variables analysed, such as the areas of knowledge of the degrees. Heatmaps were used to analyse the distribution of observations between categories of pairs of qualitative variables.

Finally, in order to determine whether the possible differences identified at the descriptive level are significant, an inferential analysis was carried out. Given the nature of the DC variable (both the total and per each of the four literacies separately), which takes mean values between 1 and 5, it is difficult to meet the assumptions of normality required in parametric hypothesis testing. For this reason, the Mann Whitney Wilcoxon test and the Aligned ranks transformation ANOVA (ART anova) test were used to make comparisons with one and two factors respectively. Where significant differences were identified, two-by-two post-hoc comparisons were performed to highlight the main effects.

RESULTS

General description of participants

The 700 responses selected for the analysis are distributed among 16 Spanish regions. The regions with the largest representation in the sample are the Canary Islands (n = 223), Andalusia (n = 117), Valencia (n = 117), Catalonia (n = 102) and Madrid (n = 91).

The questionnaire also asks for the approximate average mark of the current transcript of the participating Bachelor's and Master's degree students. The response options are: C- (5-5.9), C+ (6-7.9), B (8-8.9) and A (9-10). Table 1 shows the number

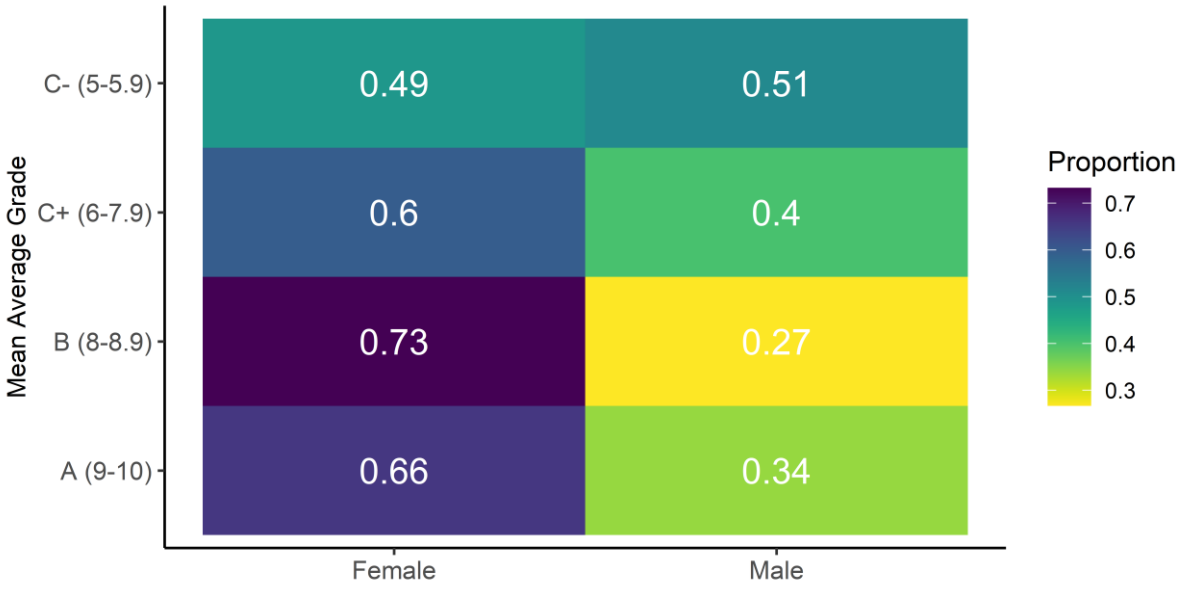
of observations at each level of undergraduate grade point average according to gender, with the percentages that these values represent with respect to the 700 observations in the sample analysed.

Table 1
Distribution of responses according to average score and gender

		Female	Male	Total
Real mean undergraduate average	C- (5-5.9)	56 (8%)	59 (8%)	115
	C+ (6-7.9)	226 (32%)	152 (22%)	378
	B (8-8.9)	115 (16%)	42 (6%)	157
	A (9-10)	33 (5%)	17 (2%)	50
	Total	430	270	700

Figure 2 analyses the distribution of each average grade category between male and female.

Figure 2
Distribution of responses by gender for each grade point average category



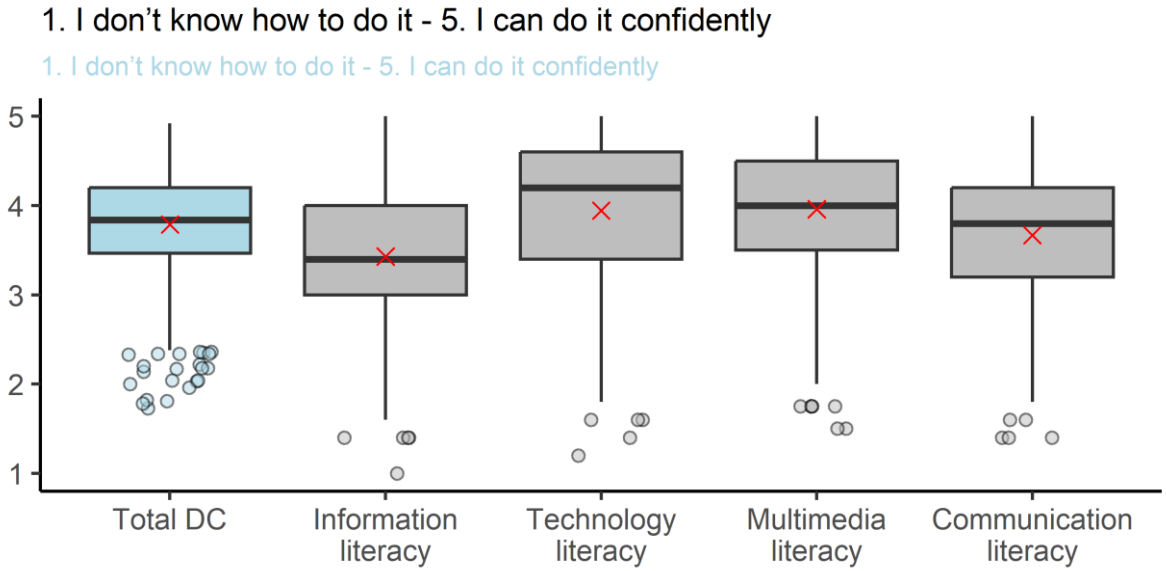
As can be seen in Figure 2, for each category of average grade, the highest percentage corresponds to the female gender, except for C- grades, where the majority gender is male (although it is very close to 50%).

However, for both the female and male genders, more than 50% of the respondents have an average grade of C+ (53% and 56%, respectively). For women, the next most frequent grade category is B (representing 27% of female respondents) and for men C- (representing 22% of male respondents).

As for the total DC and its four literacies (IL, TL, ML and CL) for the 700 selected observations (Figure 3), it could be highlighted that the average values are concentrated in medium-high values with a bias to the left. The mean values for both

total DC and each of the literacies are around 4, being slightly lower for information literacy.

Figure 3
Total level of DC and literacy for grade level and binary gender students



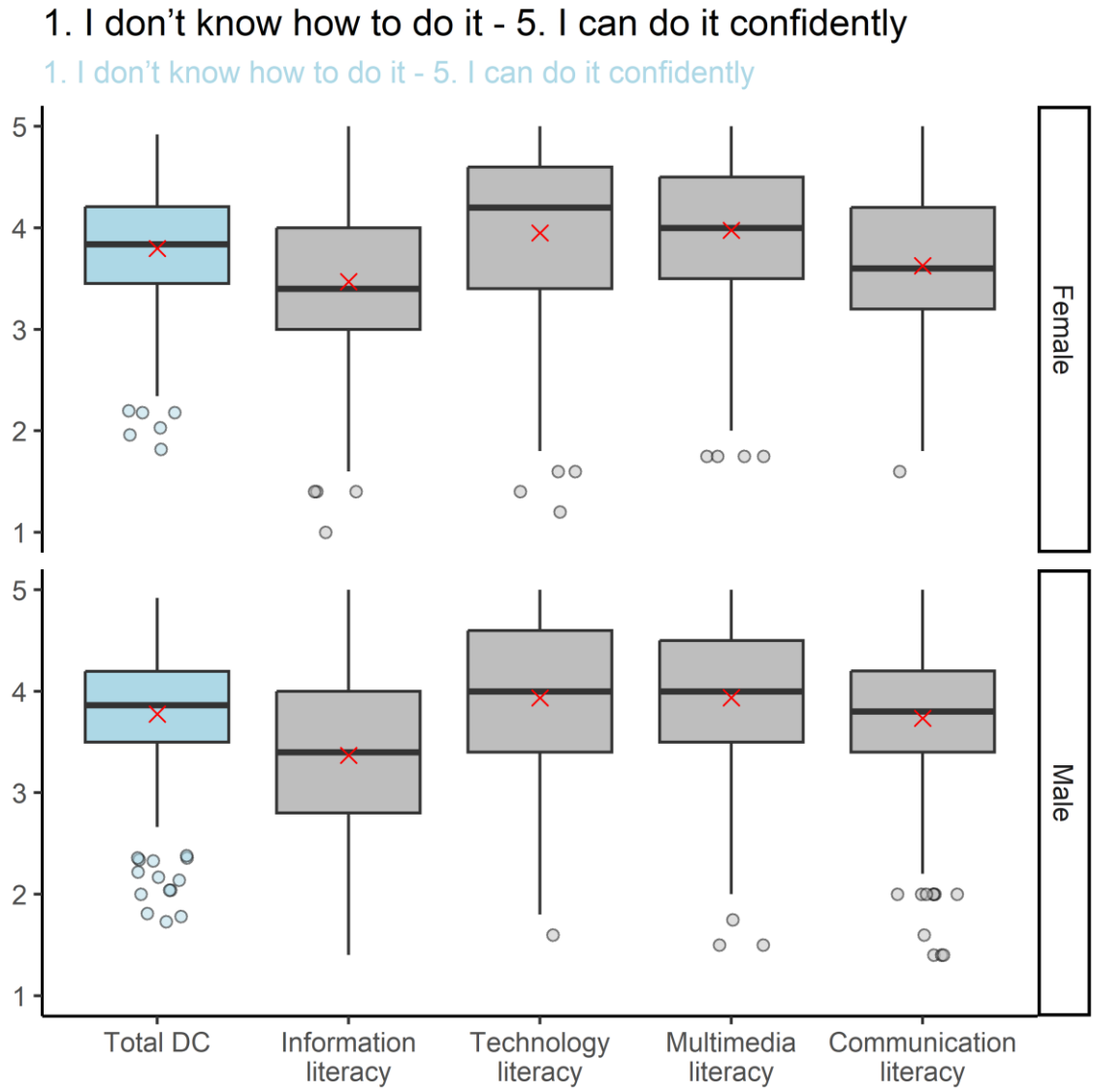
Digital Gender Gap

In this section the average self-perceived DC score was cross-checked, both overall and separately for each of the four component literacies, with the gender variable to determine whether there is a gap. Assuming the possibility of the effect of other variables in this comparison, the analysis has now been repeated taking into account, in addition to gender, the autonomous region, the area of knowledge of the degrees (both taking five and two categories) and the average degree mark.

Digital competence by gender

When plotting the DC self-perception values by gender, there are no obvious differences between the male and female genders (see blue shaded box in Figure 4). When the four literacies are plotted separately, however, there is a greater dispersion among males than females for information literacy, whilst the opposite is true for communication literacy, with a greater dispersion among females. The average value for women seems to be slightly lower than for men. In order to identify which of these differences are statistically significant and therefore extrapolable, the relevant hypothesis tests have been carried out.

Figure 4
Total level of DC and by literacies vs. gender



The aim is to test whether the gender difference (male and female) in the self-perceived DC of undergraduate students is significant. To carry out this analysis, a Mann Whitney Wilcoxon test was used, as the hypothesis of normality in the distribution of self-perceived DC was not fulfilled, both jointly (p-value = 4.406e-12, Shapiro-Wilk normality test) and by gender (p-value = 1.759e-06, for female gender; p-value = 6.668e-09, for male gender).

The results show that there are no significant gender differences in self-perceived DC when considered overall (see Annex, Table A.1), without distinguishing by dimensions (p-value = 0.9949). No gender digital divide is identified when averaging the self-perceived results of the DC-related questionnaire items.

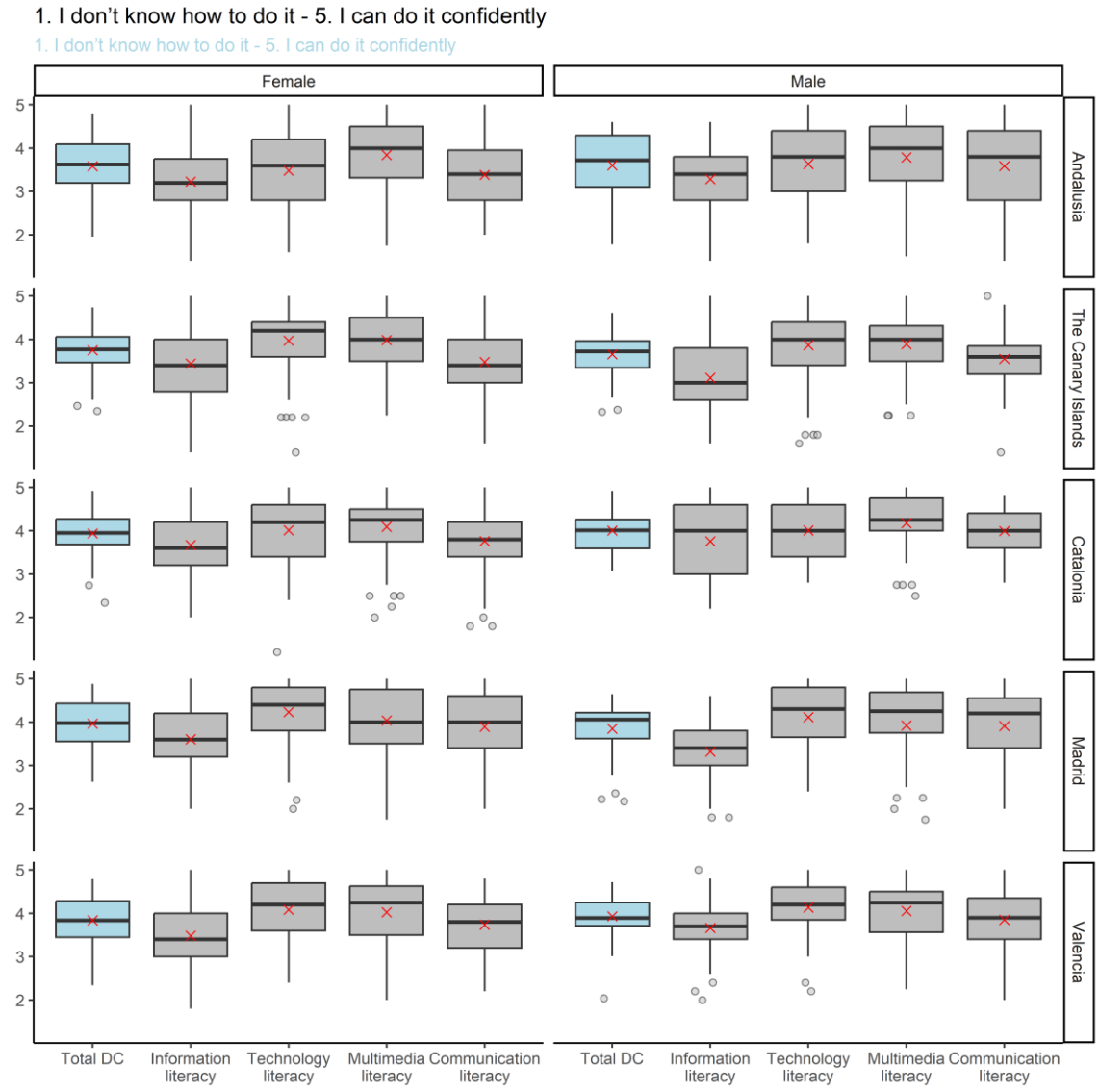
When the gender gap is studied for each of the four DC literacies separately, significant differences are only observed in communicative literacy (p-value = 0.04257). In this case, the self-perception of communicative literacy for the female

gender is lower (with a median of 3.6 out of 5) than for the male gender (with a median of 3.8 out of 5). These results show a gender gap in the self-perceived ability to communicate information through the use of digital technologies.

Digital competence by gender and Autonomous Regions of Spain.

This only takes into account the five comparable regions in terms of data volume and binary gender for undergraduate students (650 observations). The gender pattern identified in the previous section for total DC does not seem to hold true in each of the five regions analysed, with Andalusia having more dispersion in the male gender, while in the Community of Madrid and the Community of Valencia there is a higher dispersion in the female gender. The central values are similar by gender in the five autonomous regions mentioned. As for the different DC literacies, Figure 5 shows that there is a clear effect of the autonomous regions.

Figure 5
Total level of DC and by dimension vs autonomous regions and gender



Again, there is no normality in the self-perceived DC data, both when looking at the data as a whole (p-value = 6.055e-10), and for each of the five Spanish regions considered separately (Andalusia p-value = 0.0003341, Canary Islands p-value = 0.008255, Valencian Community p-value = 0.001186, Canary Islands p-value = 0.008255, Valencia p-value = 0.001186). The data for the five regions considered separately (Andalusia p-value = 0.0003341, Canary Islands p-value = 0.008255, Valencian Community p-value = 0.001186, Community of Madrid p-value = 0.00111) except for Catalonia (p-value = 0.2). To analyse the effect of the autonomous region and gender on total DC, the ART anova test shows that only the autonomous region has a really significant effect (p-value = 3.6141e-06), not the gender variable nor the interaction between both (see Annex, Table A.2).

If post-hoc comparisons are made for the main effects, significant differences were found between Andalusia with Catalonia, the Community of Madrid and the Community of Valencia, but also between the Canary Islands with these same three Spanish regions.

When the four literacies of the DC are analysed separately, it is identified that for the information dimension both the autonomous region and the interaction have a significant effect (p-value = 1.1004e-05 and 0.010737, respectively), but not the gender variable. When post-hoc comparisons are made for the main effects, significant differences are identified between Catalonia and the Valencian Community with respect to Andalusia and the Canary Islands, finding further differences by gender between these pairs of regions. When gender is taken into account, differences are also identified in the Community of Madrid with respect to Catalonia and the Canary Islands.

With regard to technological literacy, only the regions seem to have a significant effect (p-value = 7.9389e-07), not the gender variable or the interaction between the two. When post-hoc comparisons are made, differences between Andalusia and the other four regions are identified.

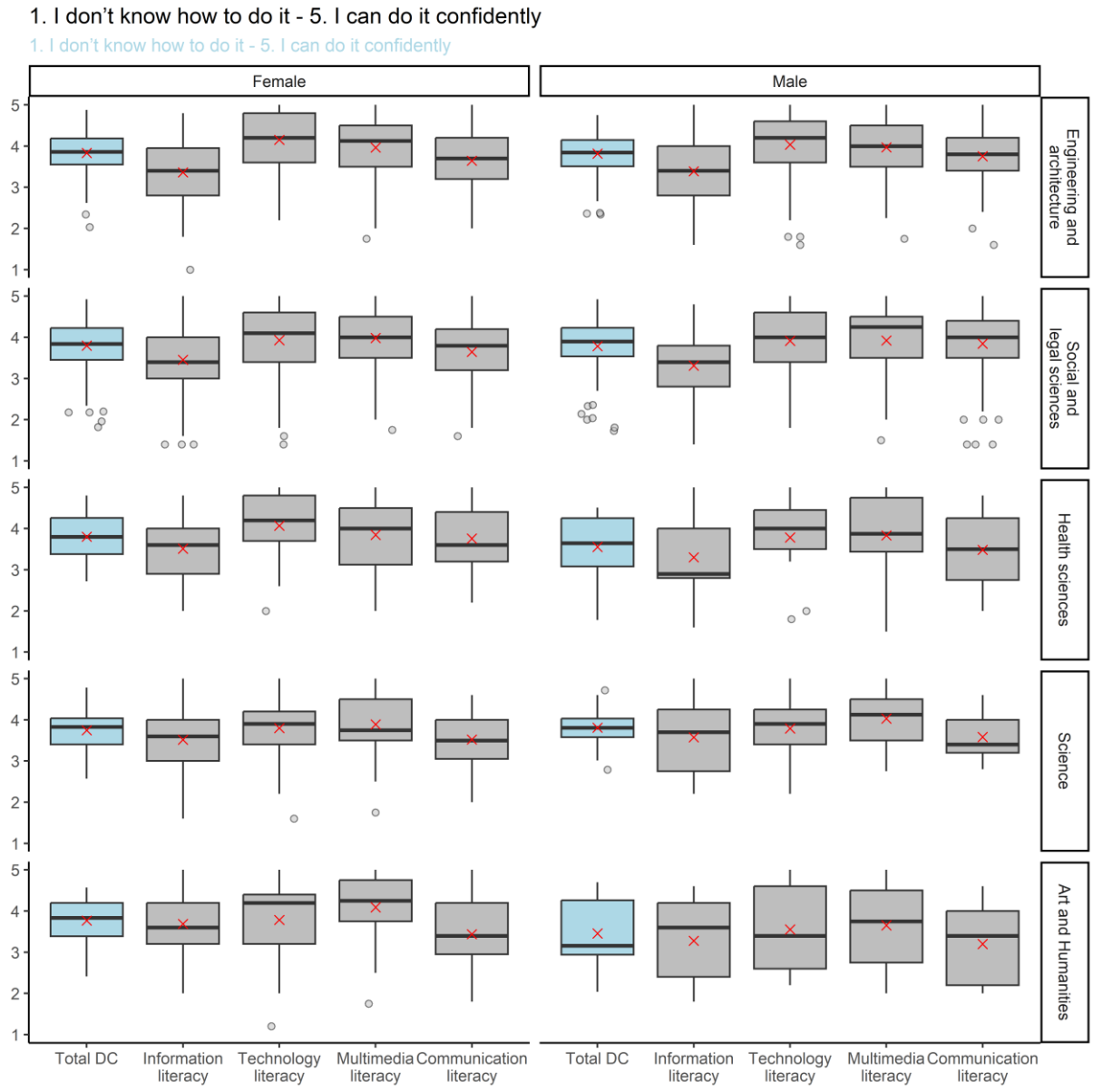
Neither autonomous region, nor gender, nor the interaction between the two has a significant effect on self-perceived multimedia literacy. The same is not true for communicative literacy, for which both autonomous region and gender have a significant effect (p-value = 1.7052e-07 and 0.016988, respectively), but not the interaction between the two. In the post-hoc comparisons for the main effects, differences are detected between the Canary Islands and Andalusia with Catalonia, with the Community of Madrid and the Community of Valencia, respectively.

Consequently, a gender gap is identified in certain autonomous regions in terms of the ability to evaluate and create information using digital technologies. Reinforcing the result shown in the previous section, there is a gender gap in communicative literacy. This ability to communicate information through digital technologies also shows significant differences between regions.

Digital competence by gender and subject area

Figure 6 plots the self-perceived DC value distinguishing between the five subject areas of the degrees (eliminating the category 'Not interpreted', which has only three observations) and the binary gender for undergraduate students. The sample analysed, after eliminating the cases in which it was not possible to categorise the degree programme, has 693 observations. There are no obvious differences in DC between men and women and subject areas.

Figure 6
Total level of DC and by literacies vs. degree areas and gender



As there is no normality, both when viewed jointly (p-value = 5.237e-12) and for each of the five areas separately (Engineering and Architecture p-value = 0.0003759, Social and Legal Sciences p-value = 4. 901e-09, Arts and Humanities p-value = 0.01792) except for Health Sciences (p-value = 0.2665) and Science (p-value = 0.2485), the ART anova test was performed to analyse the effect of subject area and gender on total DC. Neither variable has a significant effect. There is also no significant effect of the interaction between the two variables (see Annex, Table A.3).

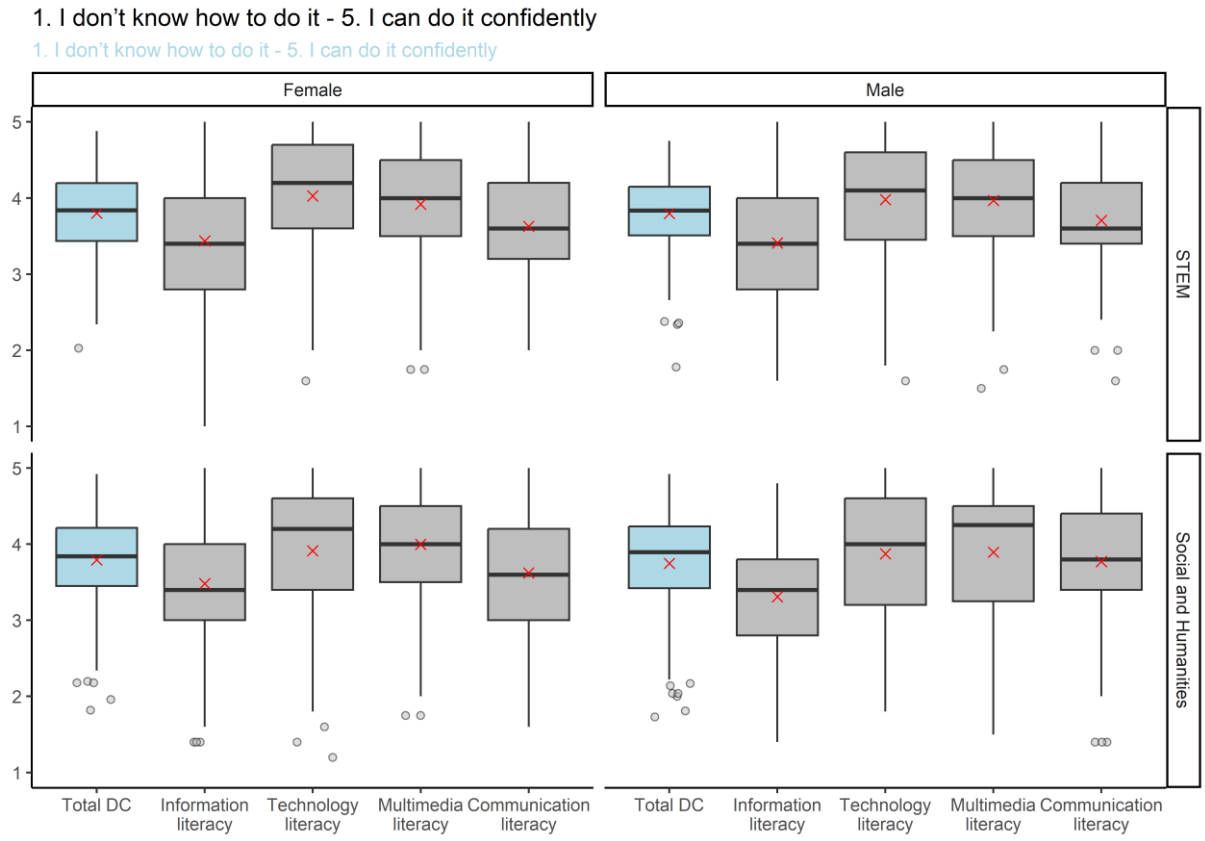
When analysing the four dimensions of DC separately, no significant effects of either variable or of the interaction between the two variables are identified for information literacy, technological literacy and multimedia literacy. In communicative literacy the area of knowledge does seem to have a significant effect (p-value =

0.033611). However, in the post-hoc comparisons for the main effects no differences are visible.

Digital competence by gender and knowledge blocks

Next, the data obtained by grouping the subject areas into two blocks was analysed: STEM (Science, Health Sciences and Engineering and Architecture) and Social and Humanistic (Arts and Humanities and Social and Legal Sciences), as represented in Figure 7.

Figure 7
Total level of DC and by literacies vs. degree blocks and gender



In this case, the normality hypothesis is not met, both when viewed jointly (p-value = 5.237e-12) and when viewed in each of the two major knowledge blocks separately (STEM p-value = 0.0001948, Social and Humanistic p-value = 6.337e-10). To analyse the effect of degree block and gender on total DC, the ART anova test shows that neither variable has a significant effect. There is also no significant effect of the interaction between the two variables (see Annex, Table A.4).

When considering the four DC literacies separately for something similar to what was observed for the five knowledge areas, no significant differences are identified for information literacy, technological literacy or multimedia literacy, but there are significant differences for communicative literacy. In this dimension only gender has a significant effect (with a p-value of 0.010206), consolidating the gender gap identified in this literacy.

Digital competence by gender and average grade point average

As can be seen in Figure 8, for high grades (A), the average value is higher for females than for males, both at the level of total DC and in the different literacies.

The degree of dispersion is similar, except for total DC and multimedia, where the standard deviation is lower for females. These differences in dispersion can also be seen in the width of the respective boxes in Figure 8.

As for the B grades, the average grades are very similar between the female and male genders. Somewhat higher scores in technological literacy and communicative literacy stand out for the male gender. The dispersion values are also very similar, being slightly lower for technological literacy for the female gender and multimedia for the male gender.

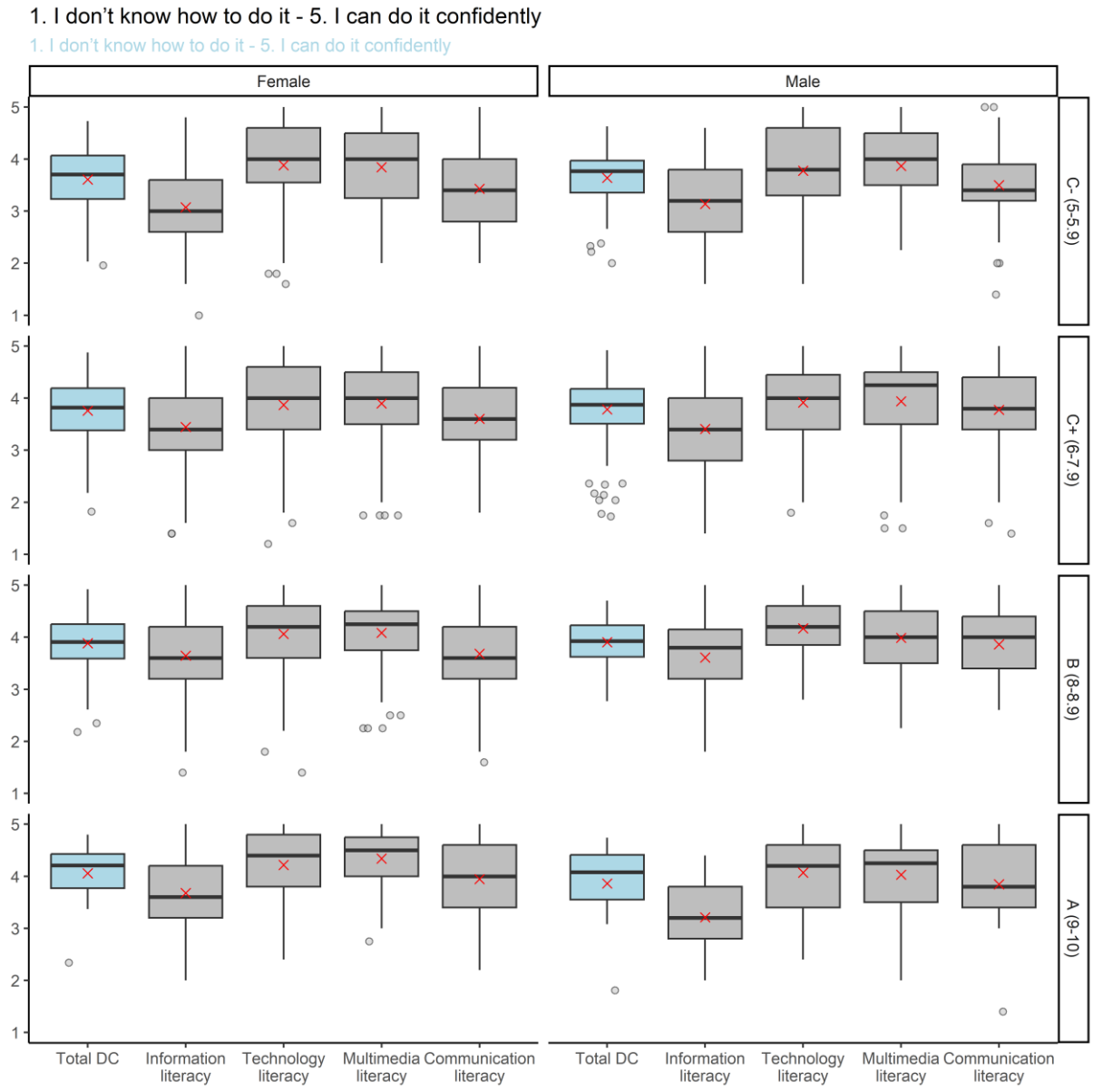
For C+ grades, the average grades are quite similar except for communicative literacy, where the average is somewhat higher for the male gender than for the female gender. The dispersion in grades is very similar for both genders.

For C- grades, the average grades are quite similar. Perhaps slightly higher in technological literacy for the female gender and somewhat lower in information literacy and communication literacy. The dispersion in grades is very similar for both genders, although perhaps a little lower for the female gender for total DC.

Again, the lack of normality both when viewed jointly (p-value = 4.406e-12) and for each of the four grade categories separately (C- p-value = 0.003038, C+ p-value = 1.785e-07, B p-value = 0.007963, A p-value = 9.336e-05), leads us to opt for the ART anova test to analyse the effect of degree block and gender on total DC. Only the grade variable has a significant effect (p-value = 0.00023692). Neither gender nor the interaction between both variables (see Annex, Table A.5).

When repeating the calculations considering the four dimensions of DC separately, for information literacy a significant effect of grade point average is identified (p-value = 1.0364e-06), where the main effects detected in the post-hoc comparisons are between the C- grade with respect to the other grades and between the C+ grade with respect to the B grade. For technological literacy, again only the average grade has a significant effect (p-value = 0.012105), but in this case no significant effects are identified in the post-hoc comparisons. For multimedia literacy there is also a significant effect of the mean score (p-value = 0.031594), with significant differences now between the extreme grades, C- and A. Finally, for communicative literacy, the mean score again has a significant effect (p-value = 0.00034407), with significant differences between the C- grade and the rest in the post-hoc comparisons.

Figure 8
Total level of DC and by literacies vs. grade point average and gender



DISCUSSION AND CONCLUSIONS

The perception of overall DC does not vary significantly between genders when analysed globally. This qualifies the findings of several authors, where men overestimate their skills and competences, whilst women tend to underestimate them (Yates & Plagnol, 2022; He & Zhu, 2017). There are no significant gender differences in DC, except in communicative literacy, where women perceive themselves as less competent. The results of the study agree with Vázquez-Cano et al. (2017) that they perceive themselves as more competent in the use of digital technology and online exhibitions. The communicative and multimedia literacies, more linked to social networks, are those with the highest levels of self-perception, and students understand that these literacies are the ones that contribute most to their DC (Llopis et al., 2021;

Sánchez-Caballé et al., 2020). Thus, the area of networked communication and collaboration is one of the most successful among students (Harmon & Walden, 2020; Silva & Morales, 2022). Thus, Fernández and Silva (2022) point out that, in relation to gender and students' self-perceived level of CD, there are differences between male and female students, which is evidence of a gender gap. They observe marked differences in the areas of digital content creation, online communication and collaboration, and problem solving. Even so, women do not perceive themselves as digitally less competent, yet are more cautious about assessing their digital competence than men (Luttenberger et al., 2019). Alternatives should be explored to reinforce different types of literacy in these differences by empowering teachers and learners in the classroom (Blaney, 2021; De las Cuevas et al., 2022).

Considering the results by region and gender, the questioning of the notion of digital natives intensifies. The data show that the main differences are due to the region. However, in communication literacy there is also a clear effect of the gender variable. As for the relationship between gender and region, this mainly affects information literacy. It is observed that the students involved exhibit substantial divergence in terms of literacy, despite being born in the same country and having access to technology more or less extensively, something they also point out (Akçayır et al., 2016). This contradicts the expectations associated with the traditional concept of digital natives. Some authors indicate that these students are considered digital natives, and a level of competence is attributed to them by virtue of using mobile devices or being born with digital tools (Harmon & Walden, 2020). For this reason, the results question this concept of digital natives, highlighting the need to train students in digital competences, reinforcing the role of teachers (Kirschner & De Bruyckere, 2017).

Regarding the degree of origin, and the grouping of participants by degree, according to whether or not they were linked to the STEM field, no significant differences were found in terms of gender on the perception of total DC. This is consistent with Lewis (2022) that STEM and non-STEM students do not differ significantly in terms of their academic self-concept. When the effect of gender and the five subject areas on self-perception of DC is studied, only a significant effect of subject area on communicative literacy is highlighted. When the subject areas are grouped into two blocks (STEM and non-STEM), there is again only a significant effect on communicative literacy, but in this case of the gender variable.

Although the average grade between men and women tends to be equal, perceptions of their competence may vary (Card & Payne, 2021; Ioannis, & Maria, 2019; Hunt et al., 2022), and women may perceive themselves as less digitally competent, despite obtaining higher grades (De las Cuevas et al., 2022). The results indicate that grade and gender are linked, albeit only grade seems to have a significant effect, both on total DC and on the different literacies. It is in the communicative literacy variable that differences appear between men and women, the latter being perceived as lower, although the mean scores are higher for women.

In any case, it should be taken into account that the differences are due to various, sometimes complex, factors, such as the 'gender equality education paradox', which is a phenomenon where countries with higher gender equality show a lower proportion of women in STEM careers, in contrast to those with lower gender equality (Stoet & Geary, 2018). This could be due to aspects related to the need to thrive and the remuneration of jobs (Stoet and Geary, 2022). Therefore, in gender-related aspects, it would be appropriate to deepen the subdivision of DC, through a variety of

programmes that aim to support women and girls who want to pursue STEM subjects (Bahar et al., 2022). One example is projects such as 'Coding Girls' (Basiglio et al., 2023), which sought to increase the participation and interest of women and girls through a STEM training programme. Another very successful project was the CyberMentor programme, which consisted of virtual mentoring for one year by an expert, a woman who is proficient in a STEM field (Stoeger et al., 2023). The girls who participated in the programme showed better results in terms of their elective preferences in STEM and their clarity about their career goals. In any case, this article responds to the Spanish context, in certain regions, and relates the results of such other research in these regions. It is believed that this information could be useful for characterising the students studied.

Considering the objectives of the study, and the discussion of the results, it could be concluded that, although on average women still perceive themselves to be somewhat lower than men in some of the dimensions of digital competence, this difference only seems to be significant in their ability to communicate information through digital technologies. The results of this research have practical applications for educational policy decisions in order to reduce the gender gap in digital competence, especially in terms of communicative literacy. This phenomenon appears at an early age and women self-perceive themselves worse, although they might perform better than men.

As for the limitations of this study, the main limitation corresponds to not obtaining a representative sample of all the regions. It has only been possible to carry out the comparative study with five of the 16 Spanish regions from which data has been collected. Furthermore, caution is required when extrapolating the results to other universities outside the Spanish context, due to cultural, socio-demographic or educational planning factors. With regard to the prospective, it would be necessary to look more closely at the factors that influence the perception of DC in other educational stages prior to higher education. On the other hand, it would also be necessary to investigate the combination of other factors that could affect decisions by gender, and other aspects such as social status, economic status or cultural aspects, among others, may come into play (Stearns et al., 2020).

REFERENCES

Akçayır, M., Dündar, H., & Akçayır, G. (2016). What makes you a digital native? Is it enough to be born after 1980? *Computers in Human Behavior, 60*, 435-440. https://doi.org/10.1016/j.chb.2016.02.089

Anaya, L., Stafford, F., & Zamarro, G. (2022). Gender gaps in math performance, perceived mathematical ability and college STEM education: The role of parental occupation. *Education Economics*, *30*(2), 113-128. https://doi.org/10.1080/09645292.2021.1974344

Bahar, A. K., Kaya, E., & Zhang, X. (2022). Gender Disparities in AP Computer Science Exams: Analysis of Trends in Participation and top Achievement. *Journal of Advanced Academics*, *33*(4), 574-603. https://doi.org/10.1177/1932202X221119499

Basiglio, S., Boca, D. D., & Pronzato, C. (2023). *The Impact of the "Coding Girls" Program on High School Students' Educational Choices*. IZA Institute of Labor Economics. https://doi.org/10.2139/ssrn.4331408

Beroíza, F., & Salas, N. (2024). STEM and gender gap: a systematic review in WoS, Scopus, and ERIC databases (2012-2022). *Frontiers in Education, 9,* 1378640. https://doi.org/10.3389/feduc.2024.1378640

Beyer, S. (2014). Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, valors, and interests and predictors of future CS course-taking and grades. *Computer Science Education*, *24*(2-3), 153-192. https://doi.org/10.1080/08993408.2014.963363

Blaney, J. M. (2021). Developing computing and technology leaders: How undergraduate women make meaning of their leadership experiences. *Journal of Women and Gender in Higher Education, 14*(2), 204-227. https://doi.org/10.1080/26379112.2021.1951745

Cabezas González, M., Casillas Martín, S., Sanches-Ferreira, M., & Teixeira Diogo, F. L. (2017). ¿Condicionan el género y la edad el nivel de competencia digital?: un estudio con estudiantes universitarios. *Fonseca, Journal of Communication, (15)*, 109-125. https://doi.org/10.14201/fjc201715109125

Card, D., & Payne, A. A. (2021). High school choices and the gender gap in STEM. *Economic Inquiry*, *59*(1), 9-28. https://doi.org/10.1111/ecin.12934

Casillas, S., Cabezas, M., Ibarra, M. S., & Rodríguez, G. (2017, October). Evaluation of digital competence from a gender perspective. In *Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality* (pp. 1-5). https://doi.org/10.1145/3144826.3145372

Creswell, J. W., & Guetterman, T. C. (2013). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson.

De las Cuevas, P., García-Arenas, M., & Rico, N. (2022). Why not STEM? A study case on the influence of gender factors on students' higher education choice. *Mathematics*, *10*(2), 239. https://doi.org/10.3390/math10020239

Fernández-Sánchez, M. R., & Silva-Quiroz, J. (2022). Evaluación de la competencia digital de futuros docentes desde una perspectiva de género. *RIED-Revista Iberoamericana de Educación a Distancia, 25*(2), 327-346. https://doi.org/10.5944/ried.25.2.32128

Getenet, S., Haeusler, C., Redmond, P., Cantle, R., & Crouch, V. (2024). Bridging the digital divide: gender and learning mode impacts on pre-service teacher digital competence and online engagement. *Irish Educational Studies*, 1–17. https://doi.org/10.1080/03323315.2024.2359694

González-Martínez, J., Esteve-Mon, F. M., Rada, V. L., Vidal, C. E., & Cervera, M. G. (2018). INCOTIC 2.0. Una nueva herramienta para la autoevaluación de la competencia digital del alumnado universitario. *Profesorado, Revista de Currículum y Formación del Profesorado*, *22*(4), 133-152. https://doi.org/10.30827/profesorado.v22i4.8401

Harmon, K., & Walden, E. (2020). Comparing three theories of the gender gap in information technology careers: The role of salience differences. *Journal of the Association for Information Systems, 22*(4), 1099-1145. https://doi.org/10.17705/1jais.00690

He, T., & Zhu, C. (2017). Digital informal learning among Chinese university students: the effects of digital competence and personal factors. *International Journal of Educational Technology in Higher Education, 14*(1), 1-19. https://doi.org/10.1186/s41239-017-0082-x

Henríquez-Coronel, P., Fernández-Fernández, I., & Usart-Rodríguez, M. (2020). Factores determinantes en la competencia digital de los universitarios latinoamericanos. In I. Aguaded & A. Vizcaino, (Coords.), *Redes sociales y ciudadanía: hacia un mundo ciberconectado y empoderado*, 521-531.

Hunt, C., Yoder, S., Comment, T., Price, T., Akram, B., Battestilli, L., Barnes, T. M., & Fisk, S. (2022). Gender, Self-Assessment, and Persistence in Computing: How gender differences in self-assessed ability reduce women's persistence in computer science. In *Proceedings of the 2022 ACM Conference on International Computing Education Research*-Volume 1 (pp. 73-83). https://doi.org/10.1145/3501385.3543963

Ioannis, B., & Maria, K. (2019). Gender and student course preferences and course performance in computer science departments: A case study. *Education and Information Technologies*, *24*(2), 1269-1291. https://doi.org/10.1007/s10639-018-9828-x

Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher education, 67*, 135-142. https://doi.org/10.1016/j.tate.2017.06.001

Kurti, E., Ferati, M., & Kalonaityte, V. (2024). Closing the gender gap in ICT higher education: exploring women's motivations in pursuing ICT education. *Frontiers in Education, 9*, 1352029. https://doi.org/10.3389/feduc.2024.1352029

Lapan, J. C., & Smith, K. N. (2023). "No Girls on the Software Team": Internship Experiences of Women in Computer Science. *Journal of Career Development*, *50*(1), 119-134. https://doi.org/10.1177/08948453211070842

Larraz, V. (2013). *La competència digital a la universitat* (Doctoral dissertation). Universitat d'Andorra, Sant Julià de Lòria.

Lewis, J. (2022). *Gender Differences in Academic Self-Concept, Perfectionism, and Math Performance among First-Year STEM and Non-STEM students* (Doctoral dissertation). University of North Florida.

Llopis, M., Santágueda, M., & Esteve, F. (2021). Competencia digital, actitudes y expectativas hacia las tecnologías digitales. Perfil de los

futuros maestros de primaria. *RiiTE. Revista Interuniversitaria de Investigación en Tecnología Educativa, (11)*, 114-130. https://doi.org/10.6018/riite.470331

López Vicent, P., González Calatayud, V., Aguiar Perera, M. V., & Artiles Rodríguez J. (2017). La gestión de la información en entornos personales de aprendizaje: estudio exploratorio en alumnado de último curso de grado. *Revista Complutense de Educación, 28*(4), 1303-1320. https://doi.org/10.5209/RCED.51849

Luttenberger, S., Paechter, M., & Ertl, B. (2019). Self-concept and support experienced in school as key variables for the motivation of women enrolled in stem subjects with a low and moderate proportion of females. *Frontiers in Psychology, (10),* 1-10. https://doi.org/10.3389/fpsyg.2019.01242

McChesney, J. E., Behrend, T. S., & Glosenberg, A. (2022). Stereotypical descriptions of computer science career interests are not representative of many computer scientists. *Scientific Reports*, *12*(1), 5990. https://doi.org/10.1038/s41598-022-09522-0

Niño-Cortés, L. M., Grimalt-Álvaro, C., Lores-Gómez, B., & Usart, M. (2023). The digital gender gap in secondary school: differences in self-perceived competence and attitude towards technology. *Educación XX1, 26*(2), 299-322. https://doi.org/10.5944/educxx1.34587

Pantic, K., & Clarke-Midura, J. (2022). Social interactions and practices that positively influenced women's retention in their computer science major. *Computer Science Education*, *33*(2), 1-29. https://doi.org/10.1080/08993408.2022.2158283

Prensky, M. (2001). Digital Natives, Digital Inmigrants. *On the Horizon, 9*(5). https://doi.org/10.1108/10748120110424816

Sánchez-Caballé, A., Gisbert, M., & Esteve, F. (2019). La competencia digital de los estudiantes universitarios de primer curso de grado. *Innoeduca: International Journal of Technology and Educational Innovation, 5*(2), 104-113. https://doi.org/10.24310/innoeduca.2019.v5i2.5598

Sánchez-Caballé, A., Gisbert, M., & Esteve, F. (2020). The digital competence of university students: a systematic literature review. *ALOMA, 38*(1), 63-74. https://doi.org/10.51698/aloma.2020.38.1.63-74

Silva-Quiroz, J., & Morales-Morgado, E. M. (2022). Assessing digital competence and its relationship with the socioeconomic level of Chilean university students. *International Journal of Educational Technology in Higher Education, 19*(1), 46. https://doi.org/10.1186/s41239-022-00346-6

Smith, K. N., & Lapan, J. C. (2021). Examining women's differential pathways into computer science by BA and BS degree programs. *Computer Science Education, 33*(2), 1-23. https://doi.org/10.1080/08993408.2021.2011570

Stearns, E., Bottia, M. C., Giersch, J., Mickelson, R. A., Moller, S., Jha, N., & Dancy, M. (2020). Do relative advantages in STEM grades explain the gender gap in selection of a STEM major in college? A multimethod answer. *American Educational Research Journal, 57*(1), 218-257. https://doi.org/10.3102/0002831219853533

Stoeger, H., Debatin, T., Heilemann, M., Schirner, S., & Ziegler, A. (2023). Online mentoring for girls in secondary education to increase participation rates of women in STEM: A long-term follow-up study on later university major and career choices. *Annals of the New York Academy of Sciences, (1)*, 62-73. https://doi.org/10.1111/nyas.14989

Stoet, G., & Geary, D. C. (2022). Sex differences in adolescents' occupational aspirations: Variations across time and place. *PLoS ONE, 17*(1), e0261438. https://doi.org/10.1371/journal.pone.0261438

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science, 29*, 581-593. https://doi.org/10.1177/0956797617741719

Tandrayen-Ragoobur, V., & Gokulsing, D. (2022). Gender gap in STEM education and career choices: what matters? *Journal of Applied Research in Higher Education*, *14*(3), 1021-1040. https://doi.org/10.1108/JARHE-09-2019-0235

Vázquez-Cano, E., Meneses, E. L., & García-Garzón, E. (2017). Differences in basic digital competences between male and female university students of Social Sciences in Spain. *International Journal of Educational Technology in Higher Education*, 14, 1-16. https://doi.org/10.1186/s41239-017-0065-y

Verdugo-Castro, S., Sánchez-Gómez, M. C., & García-Holgado, A. (2022). University students' views regarding gender in STEM studies: Design and validation of an instrument. *Education and Information Technologies*, *27*(9), 12301-12336. https://doi.org/10.1007/s10639-022-11110-8

Wild, S., & Schulze Heuling, L. (2020). How do the digital competences of students in vocational schools differ from those of students in cooperative higher education institutions in Germany? *Empirical Research in Vocational Education and Training, 12*(1), 1-18. https://doi.org/10.1186/s40461-020-00091-y

Yates, J., & Plagnol, A. C. (2022). Female computer science students: A qualitative exploration of women's experiences studying computer science at university in the UK. *Education and Information Technologies, 27*(3), 3079-3105. https://doi.org/10.1007/s10639-021-10743-5

ANNEX

Table A.1
Significance of the effect of gender on total DC and its literacies

	Gender
Total DC	
Information literacy	
Technology literacy	
Multimedia literacy	
Communication literacy	x

Table A.2
Significance of the effect of gender and the Spanish region on total DC and their literacies

	Gender	Region	Gender-Region
Total DC		x	
Information literacy		x	x
Technology literacy		x	
Multimedia literacy			
Communication literacy	x	x	

Table A.3
Significance of the effect of gender and areas of knowledge on total DC and their literacies

	Gender	Areas	Gender-Areas
Total DC			
Information literacy			
Technology literacy			
Multimedia literacy			
Communication literacy		x	

Table A.4
Significance of the effect of gender and grouped blocks of areas on total DC and their literacies

	Gender	Blocks	Gender-Blocks
Total DC			
Information literacy			
Technology literacy			
Multimedia literacy			
Communication literacy	x		

Table A.5
Significance of the effect of gender and mean score on total DC and their literacies

	Gender	Grades	Gender-Grades
Total DC		x	
Information literacy		x	
Technology literacy		x	
Multimedia literacy		x	
Communication literacy		x	

Date of reception: 1 June 2024
Date of acceptance: 14 August 2024
Date of approval for layout: 25 September 2024
Date of publication in OnlineFirst: 7 October 2024
Date of publication: 1 January 2025