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# The digital gender gap in secondary school: differences in self-perceived competence and attitude towards technology

## *Brecha digital de género en secundaria: diferencias en competencia autopercibida y actitud hacia la tecnología*

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**ABSTRACT**

The digital gender gap, defined as the difference between men and women in the use and exploitation of digital technologies (DTs), translates into an unfavorable social and economic scenario for women. Responding to this reality means exploring the development of Digital Competence (DC) and the attitude towards the use of DTs, to offer training that truly reduces possible differences between genders. This article investigates gender differences, both in self-perceived DC, and in the attitude towards the use of DTs throughout secondary education in Spain. The research is quantitative, with a survey design. The sample is made up of 3249 boys and girls, students in the 2nd and 4th year of ESO and the 2nd year of upper secondary school. The Digitalis-ESO questionnaire measures self-perceived DC (α=.908),

attitude (α=.914), and other demographic data. A descriptive analysis of frequencies, a comparative and correlational study, using chi-squared, t-tests and Pearson correlations, is performed. Boys report higher levels of DC perception and attitude than girls, with medium effect sizes. Furthermore, DC improves with the course for both genders, while attitude worsens significantly for girls. The detail of the DC items indicates that girls perceive themselves as more skilled in academic and communication-related activities, while boys believe they excel in technical activities. Finally, the analysis of attitude towards the use of DTs shows a strong incidence on the self-perception of DC, both for boys and girls. These results confirm the existence of a digital gap in favor of boys, thus training and support actions are necessary for girls, especially in technical aspects of DC, which also help them improve their attitude towards the use of DTs.

**Keywords:** digital competence, secondary school students, attitude, gender, self-perception

## RESUMEN

La brecha digital de género, entendida como la diferencia entre hombres y mujeres en el uso y aprovechamiento de las tecnologías digitales (TD), se traduce en un escenario social y económico desfavorable para las mujeres. Responder a esta realidad supone explorar el desarrollo de la Competencia Digital (CD) y la actitud hacia las TD, para ofrecer una formación que verdaderamente reduzca las diferencias de género. Este artículo indaga sobre las posibles diferencias entre chicos y chicas, tanto en CD autopercibida como en actitud, a lo largo de la educación secundaria en España. La investigación es de corte cuantitativo, con diseño de encuesta. La muestra está compuesta por 3249 chicos y chicas, estudiantes de 2º y 4º de la ESO y 2º de Bachillerato. El cuestionario Digitalis-ESO mide la CD autopercibida (α=.908), la actitud (α=.914), y otros datos demográficos. Se realiza un análisis descriptivo de frecuencias, un estudio comparativo y correlacional, mediante Chi-cuadrado, pruebas t y correlaciones de Pearson. Los resultados señalan que los chicos poseen niveles de percepción de la CD y actitud superiores a las chicas, con tamaños de efecto medios. La CD, además, mejora con el curso para ambos géneros mientras que, la actitud empeora significativamente para las chicas. El detalle de los ítems de la CD indica que las chicas se perciben como más hábiles en actividades académicas y comunicativas, mientras los chicos creen destacar en actividades técnicas. Finalmente, la actitud muestra una fuerte incidencia sobre la autopercepción de la CD, tanto para chicos como para chicas. Esto confirma la existencia de una brecha a favor de los chicos, por lo que son necesarias acciones formativas y de acompañamiento para chicas, sobre todo en los aspectos técnicos de la CD, y que también les ayuden a mejorar su actitud hacia las TD.

**Palabras clave:** competencia digital, estudiante de secundaria, actitud, género, autopercepción

## INTRODUCTION

Digital competence (DC) education for students is now regarded as a fundamental requirement for their engagement in society (European Commission, 2006). Students are making increasing use of digital technologies (DTs), prompting the need for an educational strategy that emphasizes the efficient, secure, critical, and responsible use of those tools in order to ensure the development of digital competence (Santana-Vega et al., 2019). To meet societal and, consequently, educational needs, the discussion must center on how to teach digital citizenship at the different stages of compulsory education.

Enormous efforts are being made to improve DC levels in teachers and students alike. However, providing this type of competence poses new challenges for schools because of the rapid pace at which digital technologies are evolving and the difficulties presented by the changing needs of our modern multimedia society (Jacobs, 2014). Reports such as that recently published by the statistical office of the European Union (Eurostat, 2020) continue to present evidence that, despite all the efforts being made, many members of the general public, especially women, still have only a basic level of DC. The COVID19 pandemic further demonstrated this low level of DC development, not only among the general population, but among students and teachers as well (Zhang et al., 2020). Therefore, teaching and learning strategies must include ways to improve DC, and these approaches must be based on an analysis of how DC develops during the various educational stages, along with the factors that may have an influence on that development.

It is also important to acknowledge the presence of a digital gender gap, which exists not only in relation to the use of technologies, but also in terms of more complex digital skills, such as programming and computational thinking (Mateos-Sillero & Gómez-Hernández, 2019). Although after reviewing a variety of studies on this subject, Wang and Degol (2017) concluded that there are no differences in cognitive aspects. They emphasized three factors that are responsible for the gender gap: occupational interests or preferences, including lifestyle values or work-family balance preferences; gender-related stereotypes and biases; and field-specific ability beliefs, in this case those related to technology.

The existence of this digital gap has significant consequences for the DC levels achieved by students. It puts limits on their full development even under conditions of equality, especially in terms of their need to make progress in the context of a digital culture in a way that will facilitate their incorporation into society and the workplace. Gender-based differences also affect a country's economic development because this type of inequality leads to a scarcity of women in industries such as engineering and electronics (Mateos-Sillero & Gómez-Hernández, 2019).

Although the phenomenon known as the digital gender gap has been widely reported outside of the academic environment, the topic has very seldom been addressed in the scientific literature specifically in relation to education. The few studies that do exist suggest that secondary school is a key stage for the development of DC in students and is therefore also a phase in which the digital gender gap may broaden, as students are more heavily influenced by gender-based roles and stereotypes than during their primary education (Dasgupta & Stout, 2014; Niño-Cortés et al., 2022). Another essential factor that affects the development of DC in students is the attitude they have towards DTs (Fernández-Miravete, 2018), and gender can also have an influence on how those attitudes evolve for students during secondary school (Jan, 2017). However, very few studies can be used to identify needs and assist with designing specific curricula that can actually help decrease these inequalities and therefore contribute to improving the development of DC in all students. This context has given rise to a need for new research on how gender may be affecting the development of DC in students throughout their years in secondary school and on the relationship between that development and their attitude towards DTs. Such research would serve to help close the digital gap for women in terms of digital competence and attitude.

## What does digital competence mean and how do students develop it?

Given the complexity of the current context, no unanimous consensus has been reached regarding how the term 'digital competence' should be used and conceptualized (Sánchez-Caballé et al., 2019). However, during the last two decades, a variety of frameworks have been defined regarding the variables that contribute to a student's level of DC. Some of the most notable of these include the standards developed by the International Society for Technology in Education (ISTE, 2016), DigEuLit (Martin, 2006), DigComp (Vuorikari et al., 2016), and specifically in Spain, the framework presented by Larraz (2013). In this article, we use the definition of DC proposed by Larraz, who defines a student's DC in terms of four types of digital literacy (information, technology, multimedia, and communications), and who maintains that an overall understanding of this phenomenon can only be achieved by considering the interactions among all four of these types (2013).

The DC performance testing reported in previous studies suggests that secondary school students demonstrate a basic DC level that is still "far below what is expected" (Fernández-Abuín, 2016, p. 95). However, measuring DC is a complex task because of its nature as a multidimensional construct that is also affected by the rapid changes taking place in the technological environment (González-Rodríguez & Urbina-Ramírez, 2020). For this reason, several studies have focused solely on

understanding self-perceived DC as reported by students (Jin et al., 2020; Siddiq & Scherer, 2019).

All of this creates a need for research that can analyze digital competence through a single evaluation framework, to produce the essential information needed for detailed study and characterization of the digital gender gap and its evolution during secondary school.

## The influence of gender on the development of DC

In recent decades, gender has received special attention as one of the factors that affects the development of digital competence in students (Cai et al., 2017). Studies on gender differences in actual DC performance in primary and secondary school have often reported slightly better performance in girls than boys (Cussó-Calabuig et al., 2018), and Siddiq and Scherer (2019) found that this pattern was already present in primary school. Although the majority of studies of this type have found similar results, other authors, such as Calvani et al. (2021), have reported better DC results in boys than in girls.

Other researchers have reported varied gender-based differences in DC levels, but also found an increase in differences in secondary school students compared to primary school students. For example, Jin et al. (2020) found not only that older students generally show better DC results, but also that significant gender-based differences appear during secondary education. However, those results have also been contradicted. In their metaanalysis on the use of DTs, Siddiq and Scherer (2019) concluded that the largest gender-based differences in DC levels were seen during primary education rather than secondary.

In other studies, researchers have found that gender-based differences are more significant when measured as self-perceived assessments of DC, rather than through actual performance testing. Secondary school boys report higher DC self-perception scores than girls do (Calvani et al., 2012), as they tend to consider themselves as more highly skilled in the use of DTs. Other authors, such as Aesaert and van Braak (2014), have concluded that those differences in self-perception are especially notable when assessed in relation to specific competence indicators. For example, researchers have reported that boys have a higher self-perception than girls do in relation to searching for, selecting, and organizing information (Amor & Serrano, 2019) and in relation to aspects that are more technical (Bunz et al., 2007). On the other hand, girls perceive themselves as being more capable in relation to using DTs for creative purposes, for communication, and for establishing social relationships (Amor & Serrano, 2019; Martínez-Piñeiro et al., 2019). Studies like these provide evidence of a digital gender gap not only in the development of DC, but also in selfperceptions of DC and the various types of digital literacy it includes.

In summary, the results discussed above suggest that gender-based differences are diverse, and that they may be influenced by variables such as context, the measurement tools being used, and other limitations of the studies performed. However, these differences tend to be higher in terms of DC selfperception than actual performance, especially if the students' age is considered along with the ongoing influence of gender stereotypes (Dasgupta & Stout, 2014). In addition, as mentioned above, selfperception is one of the reasons why the gender gap exists, along with interests, preferences, and lifestyle values (Wang & Degol, 2017). However, despite this evidence, there is no research available regarding how selfperceived DC evolves based on gender. This gives rise to the need for more specific studies on how the digital gender gap emerges among secondary school students in Spain.

### The influence of attitude towards DTs on the development of DC.

Attitude towards DTs is another relevant factor related to the digital gender gap. Some studies have revealed a direct relationship between that attitude and DC levels (Fernández-Miravete, 2018). Some research suggests that although students tend to report a positive attitude towards technology, their actual performance levels are not always as positive (Martínez-Piñeiro et al., 2019; Porat et al., 2018). Authors such as González-Martínez et al. (2018) and Jan (2017) have shown a correlation between a positive student attitude towards DTs and higher levels of DC development. In view of this close relationship, researchers often measure not only DC levels in students, but also their opinions, attitude, and beliefs about DTs (González-Martínez et al., 2018; Hatlevik et al., 2015).

However, the relationship between gender and attitude towards DTs remains controversial, with a lack of conclusive evidence. Some studies have found no gender-based differences in terms of attitude towards DTs, while others have found evidence that boys have a more positive attitude towards DTs than girls do (Cussó-Calabuig et al., 2018). On the other hand, a study conducted by Gargallo et al. (2016) found that in secondary school contexts, boys seemed to demonstrate more competence in their use of DTs, while girls demonstrated more a positive attitude towards them.

In conclusion, there is a lack of clear evidence that could lead to a better understanding of the relationships between these variables or the influence they might have on decreasing the digital gender gap. This scarcity of evidence underscores the need for further research on this subject, with attitude treated as a relevant factor.

### Research questions

Despite the fact that, when assessed by performance tests, girls perform slightly better than boys, when asked about their competence, girls perceive themselves as less competent than boys (Martínez-Piñeiro, 2019; Cai et al., 2017). As discussed above, a more negative attitude towards DTs could be related to girls' lower self-perception of their level of DC. Other factors must also be considered, such as the students' particular year in school or age because although DC should improve with each year of classwork, as students get older, they may also be more strongly influenced by gender-based roles and stereotypes with regard to DTs. However, the information available for Spain is only partial because, to date, no studies focusing on secondary education have included a quantitative, overall analysis of the influence of these factors on self-perceptions of DC and its various aspects.

The aim of the research being reported here was to study potential inequalities in the way that DC develops among secondary school students based on their gender, year in school, and attitude towards DTs, in order to address the following research questions:

- Question 1 (Q1). What gender-based differences can be identified in secondary school students in Spain in terms of their levels of DC self-perception and their attitude towards DTs?
- Question 2 (Q2). What relationships among secondary school year, DC self-perception, and attitude towards DTs can be identified among students in Spain based on their gender?

## METHODS

This research aimed, firstly, to describe the levels of self-perceived DC and attitude towards DTs among students in the various years of secondary school and, secondly, to measure any potential differences between boys and girls. We have therefore taken a quantitative approach using a survey-based research design. The objective was to study the opinions and characteristics of a large number of students (Creswell & Guettermann, 2013), while at the same time enabling us to determine and measure possible correlations among the variables.

### Sampling

To address the research questions, non-probability convenience sampling was used to collect survey responses from voluntary respondents, who were students

from the Spanish regions of Catalonia, the Valencian Community, Extremadura, the Community of Madrid, Andalusia, Aragon, Cantabria, and Murcia. As shown in Table 1, a total of 3363 responses were obtained from students between 13 and 18 years of age in the 2nd year of ESO, 4th year of ESO, and 2nd year of upper secondary school.[1] It is important to point out that 46 of those students identified as gender nonbinary and 68 preferred not to respond to the question on gender (DK/NR), so the total sample used in the study consisted of 3249 boys and girls.

**Table 1**
*Distribution of the study sample by gender and grade level*

| Gender | 2nd ESO | 4th ESO | 2nd upper secondary | Total |
|---|---|---|---|---|
| Girls | 732 | 707 | 229 | 1668 |
| Boys | 756 | 645 | 180 | 1581 |
| Sample | 1488 | 1352 | 409 | 3249 |

*Note*. The numbers express the number of students in each category and for each course.

Of all the participants in the study, 50% identified as female, 47% identified as male, 1% percent identified as gender nonbinary, and 2% preferred not to give a response. A chisquared test showed that the distribution of genders for the respondents from the 2nd year of ESO is representative of Spain's entire population between 10 and 14 years old (49% female and 51% male): ($\chi^2_{1,\ n=1488}$ = .000, $p$ = 1.000), and that the distribution of genders for the respondents from the 4th year of ESO and 2nd year of upper secondary is representative of Spain's entire population between 15 and 19 years old (48% female and 52% male): ($\chi^2_{1,\ n=1761}$ = .002, $p$ = .317).

## Tools and procedures

The survey tool used in this study to measure the students' self-perceived DC levels was DigitalisESO, which is an updated version of the INCOTICESO survey tool (González-Martínez et al., 2012). The tool has been used in numerous studies (Abou & Martínez, 2017; Fernández-Miravete, 2018) after being designed, tested,

[1] 'ESO' refers to the four required years of secondary school in Spain (*Educación Secundaria Obligatoria*), and 'upper secondary' refers here to the optional *Bachillerato*, which is an additional 2year advanced secondary school phase.

and validated for use with secondary school students in Spain. It was created as an adaptation of the INCOTIC survey tool (Gisbert et al., 2011), which was originally designed and validated for use with university students for DC selfassessment and other aspects related to DTs based on the definition of DC published by Larraz (2013).

Although there is a version of INCOTIC updated by González-Martínez et al. (2018), INCOTICESO had not been modified since 2012. For this reason, DigitalisESO was created in late 2019 by updating the wording of items from that INCOTICESO survey tool, which was necessary because of the emergence of new digital technologies. That qualitative work was performed by a group of five teaching and research experts from the field of educational technology. In early 2020, the new DigitalisESO was used in a pilot study with 344 secondary school students, with a final version then produced by modifying the wording of certain items. Its factor structure and reliability were then studied using the responses of 3363 secondary school students. A principal components analysis (PCA) indicated a good sampling adequacy using the Kaiser-Meyer-Olkin test (KMO = .928, $p$ = .000), and a twofactor structure was determined (see Appendix 1), explaining 63% of the total variance. Those two factors correspond to the variables DC and attitude towards DTs. Finally, Cronbach's alpha was calculated for the sample used in this study, for the entire survey tool and for each factor, and the results were similar to those obtained with other versions of INCOTIC, indicating good internal consistency ($\alpha_{DC}$=.845; $\alpha_{Att}$=.832; $\alpha$=.882).

The Digitalis-ESO survey consists of two sections. The first section measures aspects related to use of DTs and access to them (these aspects were not included in the present study), and it also includes 19 items used to measure DC self-perception and 9 items on attitude towards DTs. A 5point Likert scale is used for all these responses (1: I don't know how to do it; 5: I know how to do it perfectly) (see Appendix 1). Based on those responses, and following the recommendations of González-Martínez et al. (2012), the scores obtained for the male and female participants were categorized into three development levels for self-perceived DC: low ($1 \leq x < 3.2$), medium ($3.2 \leq x < 3.8$), and high ($3.8 \leq x \leq 5$), and three categories were also created for attitude towards DTs: low ($1 \leq x < 3.6$), medium ($3.6 \leq x < 4.2$), and high ($4.2 \leq x \leq 5$).

The survey tool's second section collects socio-demographic data. Specifically, and in accordance with the focus of this research, the students were asked about their primary gender identity: girl, boy, neither response (gender nonbinary), or don't know / no response (DK/NR). As mentioned in the previous section, in order to facilitate the statistical analyses, and for consistency with existing studies that have only made use of binary gender options (male or female), only the responses from students answering either boy or girl were included in the present study. The students were also asked to give their age, secondary school year, and whether they

had repeated any years (and if so, which one). Finally, the students were asked to indicate the Spanish region and municipality where their school is located.

Data were collected through a public opinion research firm, which directly contacted several secondary schools via their published addresses as well as regional education services in the Spanish regions included in the study. The participating students obtained an automated response by email, which provided feedback on the responses they gave for their DC levels and attitude. The questionnaire was administered during the last quarter of the 2020-2021 academic year and the first quarter of the 2021-2022 academic year. Both the survey tool (implemented using the Alchemer survey platform) and the data collected were stored on the university's server. The data were anonymized and adapted to spreadsheet format to create the pertinent database. Sample selection, survey tool creation and administration, and data processing took place in strict compliance with ethical principles on anonymity and consent for data disclosure established by the British Educational Research Association. These procedures were also approved by the university's research ethics committee (Ref. CEIPSA-2021-PR-0046).

### Analysis

To address the research questions, a descriptive analysis was first conducted on the overall data on DC self-perception, with indicators for DC, secondary school year, and gender. Next, attitude towards DTs was analyzed, also in terms of students' secondary school year and gender. The distributions of the resulting level categories were then examined using the chisquared ($\chi^2$) test with a significance level of $p$=.05 because of the ordinal (DC and attitude) and nominal (gender) nature of the variables. A ttest with the same significance level was then used to measure potential differences between the mean scores for boys and girls, with effect size also determined (Cohen's D). Finally, to assess the relationship between self-perceived DC and attitude towards DTs, for the boys and for the girls, a nonparametric measure of rank correlation was performed using Spearman's rho, which is suitable for ordinal data (Creswell & Guettermann, 2013). The software used to analyze the data was IBM SPSS Statistics for Windows, version 28.0.

## RESULTS

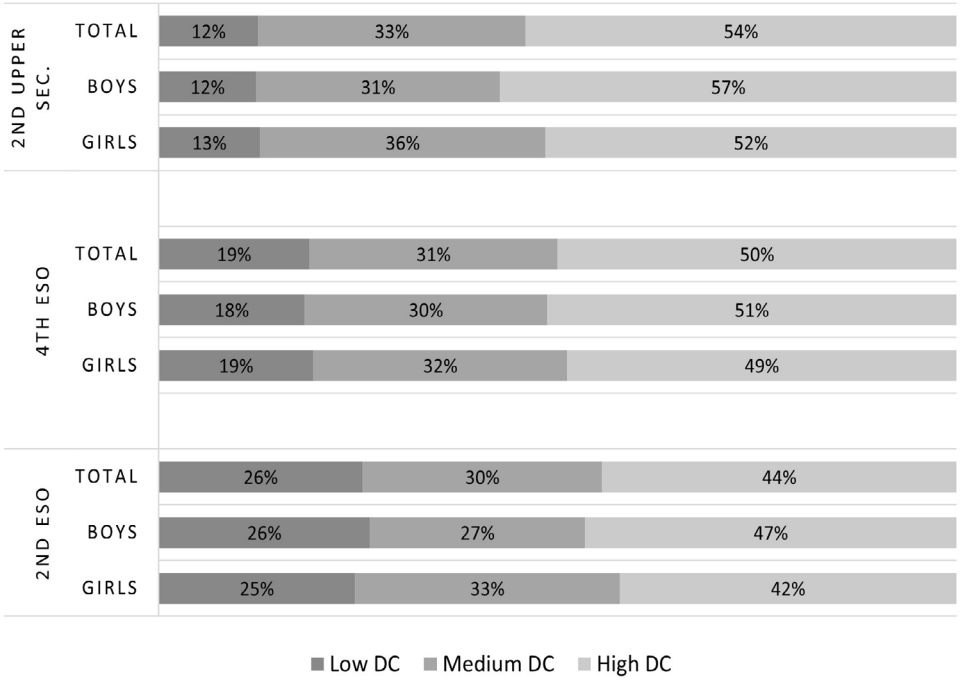
### Gender-based differences among secondary school students in self-perceived DC and attitude towards DTs (Q1)

Figure 1 shows the values obtained for self-perceived DC for each of the three secondary school years included in the study, classified by level (low, medium, and

high) and broken down by gender. In general, the students from all the school years studied consider themselves digitally competent.

**Figure 1**

*Self-perceived digital competence levels by gender and secondary school year.*




*Note.* Results show the proportion of students in each DC level (low, medium, and high). Source: authors.

The data on gender-based differences in DC self-perception show that over the course of their secondary school years, a higher proportion of boys report a high level of DC compared to girls. In contrast, girls are more likely to report a medium DC level for all of the secondary school years examined.

A more detailed comparative analysis of the mean scores by gender (Table 2), using a ttest, shows that for both boys and girls, self-perceived DC improves as the students advance through secondary school, although the mean score for girls is always a few tenths of a point lower. These differences were found to be statistically significant ($p$=.039) in the 2nd year upper secondary students, which is also confirmed by the effect size (Cohen's D), which is close to the value of 0.8.

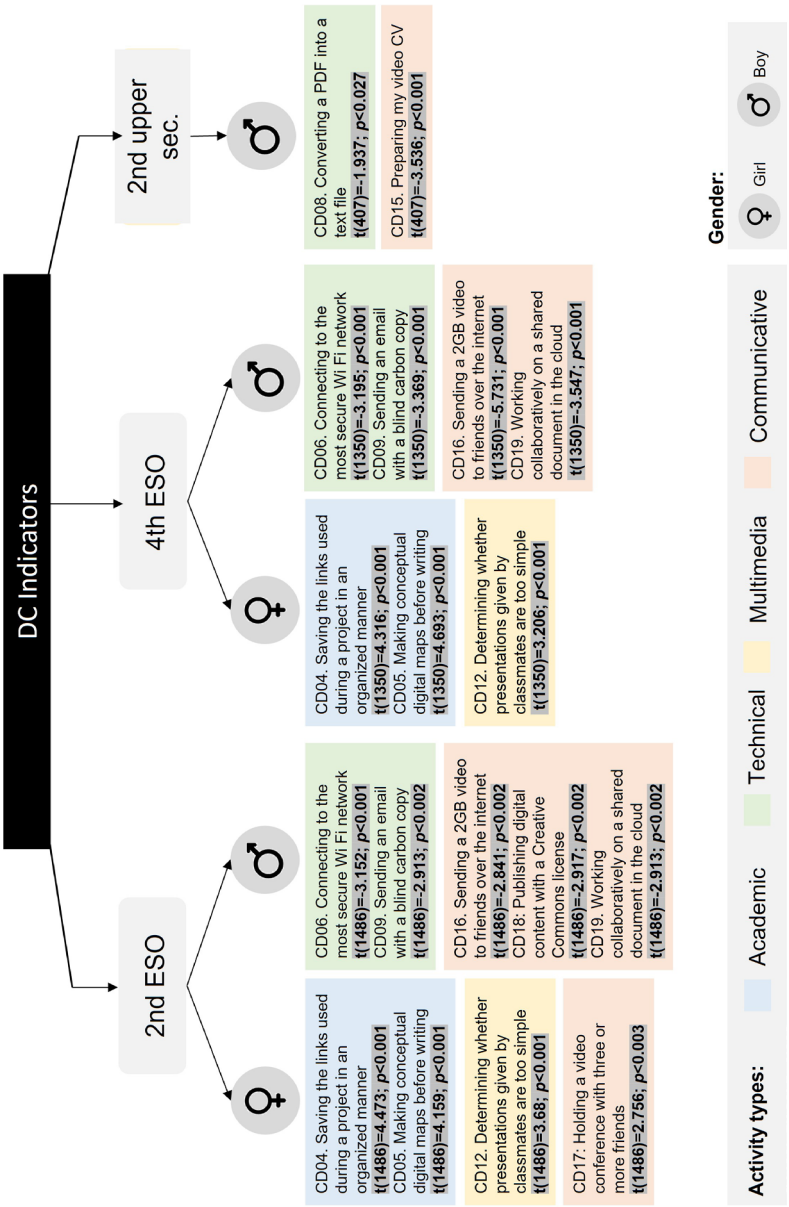
**Table 2**
*Results of the gender-based DC analysis for each secondary school year studied*

| DC | Girls | | Boys | | t | p | Cohen's D |
|---|---|---|---|---|---|---|---|
| | M | DT | M | DT | | | |
| 2nd ESO | 3.63 | 0.595 | 3.64 | 0.682 | -0.374 | .354 | 0.636 |
| 4th ESO | 3.71 | 0.619 | 3.75 | 0.619 | -1.181 | .119 | -0.619 |
| 2nd upper sec. | 3.80 | 0.535 | 3.90 | 0.573 | -1.769 | .039* | -0.552 |

*Note*. M: mean; SD: standard deviation; *$p$<.05.

We were also able to perform a detailed analysis of gender-based differences in the students' DC self-perception for each of the indicators that were used to measure that competence. In total, for the three years in school studied, significant differences were found in 12 of the 19 indicators, with $p$<.05 (see Appendix 1). Additionally, seven indicators presented significant differences in the 2nd year of ESO and 4th year of ESO groups: DC04, DC05, DC06, DC09, DC12, DC16, and DC19 (Figure 2). Specifically, girls in both of those secondary school years perceive themselves as more competent than boys do in relation to performing certain academic activities: (a) saving the links used during a project in an organized manner (DC04) and (b) making digital concept maps before writing (DC05); and multimedia activities: (c) determining whether presentations given by classmates are too simple (DC12). In contrast, boys in both of those school years perceive themselves as more competent than girls in relation to certain technical activities: (a) connecting to the most secure WiFi network (DC06) and (b) sending an email with a blind carbon copy (Bcc) recipient; and in a higher number of communication activities: (c) sending a 2GB video to friends over the internet (DC16) and (d) working collaboratively on a document (DC19). For these types of activities, gender-based differences in perceptions persist in the secondary school years studied, although for the 2nd year of upper secondary group statistically significant differences were only found in two indicators.

**Figure 2**
*DC indicators with the highest mean scores by secondary school year, gender, and activity type*

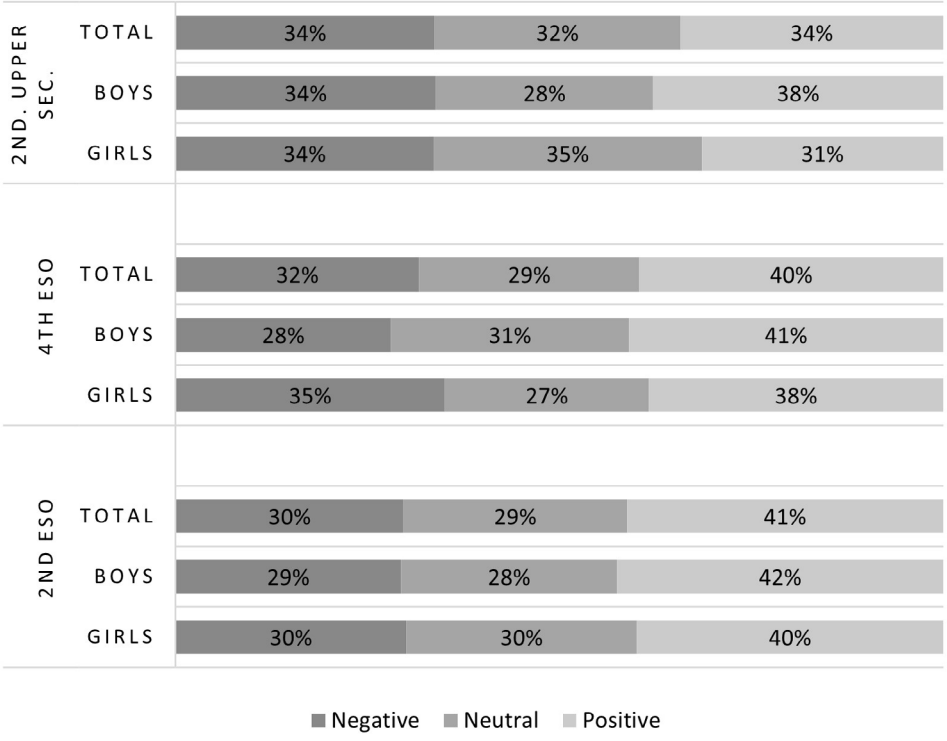



*Note.* The gender symbols indicate the group of students perceiving themselves as significantly more competent for the indicator described.

The same types of analysis were performed in order to study potential gender-based differences in attitude towards DTs. Figure 3 shows the proportion of students, broken down by gender and secondary school year, who have a more positive, neutral, or negative attitude towards DTs. In general, most students reported a positive attitude, although in similar proportions to the numbers of students who said they had a more neutral attitude, especially in the 2nd year of upper secondary school. Table 3 shows the data on the mean scores for attitude, broken down by gender.

**Figure 3**

*Attitude towards DTs by gender and secondary school year*




*Note.* Results shown as percentages of students responding in each attitude category (negative, neutral, and positive).

We also found differences between the attitude of boys and girls, both in terms of the proportions of students identifying themselves as belonging in each of the categories and the mean scores calculated. The proportion of boys with a positive

attitude towards DTs was higher than that of girls, all the way from the 2nd year of ESO through the 2nd year of upper secondary school. However, these gender-based differences were only statistically significant for students in the 4th year of ESO ($\chi^2_{2, n=1352}$ = 8.10, $p$=.017), not for the 2nd year of ESO or 2nd year of upper secondary students. Therefore, only in the 4th year of ESO was the proportion of boys reporting a positive (41%) or neutral (31%) attitude towards DTs significantly higher than for girls. A comparison of the mean scores confirms these results (Table 3): the difference between genders is only significant in terms of mean values for students in the 4th year of ESO ($p$=.037). And, again, the effect size is close to 0.8, which is considered sufficiently significant for the sample studied.

**Table 3**

*Results of the gender-based analysis of students' attitude towards DTs*

| Attitude | Girls | | Boys | | t | p | Cohen's D |
|---|---|---|---|---|---|---|---|
| | M | DT | M | DT | | | |
| 2nd ESO | 3.94 | 0.673 | 3.94 | 0.734 | -0.111 | -.456 | 0.709 |
| 4th ESO | 3.86 | 0.739 | 3.93 | 0.728 | -1.179 | .037* | -0.733 |
| 2nd upper sec. | 3.82 | -0.732 | 3.87 | 0.749 | -0.633 | .263 | -0.741 |

*Note*. M: mean; SD: standard deviation; *$p$<.05.

## Changes over time in secondary students' self-perceived DC levels and attitude towards DTs, and correlation between those two variables (Q2)

With regard to self-perceived DC, the highest proportions of students in all of the secondary school years studied perceived themselves as having a high level of DC: 2nd ESO (44%); 4th ESO (50%); and 2nd upper secondary (54%). These results show a statistically significant upward trend over time in the overall level of self-perceived DC ($\chi^2_{2, n=3249}$ = 40.99; $p$=.000). In other words, as the students advance through their secondary school years, they see themselves as having increasing levels of DC. This trend was found to be significant in relation to both girls ($\chi^2_{4, n=1668}$ = 18.86; $p$=.001) and boys ($\chi^2_{4, n=1581}$ = 24.43; $p$=.000).

Differences over time were also detected in attitude towards DTs. The highest proportions of students reporting a positive attitude towards DTs were those in the 2nd year of ESO (41%) and the 4th year of ESO (40%), while students in the 2nd year of upper secondary school exhibited a lower percentage of a positive attitude (34%). In other words, attitude towards DTs get worse as students advance through

their secondary school years. This downward trend was statistically significant for girls ($\chi^2_{4,\ n=1668} = 10.544$, $p$=.032), but not for boys ($\chi^2_{4,\ n=1581} = 3.460$, $p$=.484).

The results described above were confirmed by the correlation analysis (Table 4). Self-perceived DC improved significantly over time for both girls and boys, in a very similar manner. On the other hand, attitude towards DTs worsened significantly only for girls. Although the data for boys also showed a downward trend, it was not statistically significant.

Finally, the correlation analysis also showed a positive and statistically significant relationship between attitude and self-perceived DC level (Table 4): students who reported higher levels of self-perceived DC also reported a more positive attitude towards DTs. This correlation was observed for both girls and boys, although the correlation coefficient was slightly higher for the boys.

**Table 4**

*Spearman's correlation coefficient. Secondary school years, DC levels, and attitude towards DTs by gender*

| Gender | Variable | | Year | DC | Attitude |
|---|---|---|---|---|---|
| Boys | Year | Correlation coeff. | 1 | .124** | -.032 |
| | | Sig. (2-tailed) | | .000 | .163 |
| | DC | Correlation coeff. | .124** | 1 | .501** |
| | | Sig. (2-tailed) | .000 | | .000 |
| | Attitude | Correlation coeff. | -.032 | .501** | 1 |
| | | Sig. (2-tailed) | .163 | .000 | |
| Girls | Year | Correlation coeff. | 1 | .119** | -.069** |
| | | Sig. (2-tailed) | | .000 | .003 |
| | DC | Correlation coeff. | .119** | 1 | .453** |
| | | Sig. (2-tailed) | .000 | | .000 |
| | Attitude | Correlation coeff. | -.069** | .453** | 1 |
| | | Sig. (2-tailed) | ,003 | ,000 | |

*Note.* (*) Correlation is significant at the .05 level; (**) Correlation is significant at the .01 level.

## DISCUSSION AND CONCLUSIONS

The purpose of this research was to analyze gender-based differences over the course of secondary school education in relation to the students' self-perception of DC, both in general and for each of the specific DC indicators studied. An additional aim was to detect any possible correlations among the variables secondary school year, self-perceived DC level, and attitude towards DTs, and to compare the results obtained for girls and boys.

We found that the secondary school students surveyed generally perceived themselves as being digitally competent. However, when those DC self-perception levels were analyzed in further detail and in relation to the other individual variables examined in this study (gender, secondary school year, and attitude towards DTs), significant differences emerged. These differences can contribute to better understanding specific aspects of the digital gender gap in secondary education. For example, we found low levels of self-perceived DC in similar proportions among boys and girls in all of the secondary school years studied, which is consistent with the results of previous research (Jin et al., 2020). However, the proportion of students who reported having a high level of DC was higher in boys than in girls, with girls showing a higher tendency to perceive themselves as having a medium level of DC. This difference was statistically significant for students in their final year of secondary education.

The fact that boys reported higher DC self-perception scores than their female classmates coincides with results reported in the existing literature (Cussó-Calabuig et al., 2018; Ardies et al., 2015). Having confidence in one's own abilities, especially in relation to the use of DTs, is in line with the attributes socially associated with masculinity (Ruiz Repullo, 2016), and a lack of female mentors and successful role models to imitate, and a lack of recognition or equal career opportunities for girls (Gasgupta & Stout, 2014), would reinforce differences in that behavior. These are factors that, in turn, are associated with scientific and technological self-efficacy: boys show more interest in science and enjoy using technology more than girls do (Stoet & Geary, 2018). Therefore, although there could be other factors that also influence or affect these differences, such as socio-economic status (Amor & Serrano, 2019), the research reported here indicates that gender is a key factor to consider when endeavoring to understand how DC self-perceptions develop over the course of secondary school education.

Our results also show that DC self-perception tends to improve over time, both for girls and boys. As discussed in previous studies (Jin et al., 2020), students are expected to acquire greater digital competence as they receive more education and training in this specific area. However, gender-based differences between male and female students continue to exist even as this development occurs. This suggests,

again, that gender stereotypes could be negatively impacting girls from an early age, and that the weight of that impact may be increasing with each year in school (Bian et al., 2017).

However, when the specific indicators for DC were analyzed in more detail, it became clear that girls do not always see themselves as having a lower level of DC compared to boys. In the study reported here, girls perceived themselves as having significantly greater skill in performing activities that were primarily academic (making digital concept maps before writing) and related to multimedia (determining whether presentations given by their classmates were too simple). In contrast, boys reported greater skill in technical activities (connecting to the most secure WiFi network) and communications (sending a 2GB video to friends over the Internet, and working collaboratively on a shared document in the cloud). These differences reflect those previously reported by various authors (Amor & Serrano, 2019; Bunz et al., 2007; Martínez-Piñeiro et al., 2019). However, all of these differences disappear by upper secondary school, at which point, in this study, girls no longer reported higher levels of competence than boys in any of the indicators. It is therefore prior to the upper secondary school phase when action must be taken to help girls improve their DC self-perception.

Siddiq and Scherer (2019) suggested that gender-based differences may exist more in relation to specific domains included in the way DC is conceived than in overall DC, results that may contribute to a more nuanced understanding of the digital gender gap. This means that instead of only determining whether some students perceive themselves as generally more or less competent than others do, it is worthwhile to focus on which specific aspects of DC the students perceive themselves as having more expertise in as a way of understanding the types of educational inequalities being perpetuated, and that therefore must be addressed. Our results show that boys consider themselves more competent in aspects that align with attributes related to masculinity. For example, boys reported having a greater inclination towards technological aspects, again in agreement with Siddiq and Scherer (2019), while girls reported higher competence in aspects more closely related to feminine attributes, such as being more studious and more service-oriented (Dasgupta & Stout, 2014).

In relation to the second variable studied, boys reported having a better attitude towards DTs than girls do. This was true across educational levels, but especially for students in the 4th year of ESO. These results are in line with previous research in which girls have reported a more negative attitude towards DTs (Cussó-Calabuig et al., 2018).

In contrast to the results for DC, a general worsening of attitude towards DTs was found to exist over the course of secondary education, for both for boys and girls. However, that downward trend was only statistically significant for girls.

Although a lack of interest among girls in using DTs as academic tools could help explain this result (Cai et al., 2017), another potential explanation when examining this issue from a gender perspective can be found in the higher levels of interest and enjoyment that boys report in relation to studying technological subjects (engineering, ICT), compared to their female classmates (Stoet & Geary, 2018).

Finally, the significant positive correlation found between attitude towards DTs and levels of self-perceived DC points to a need, for both girls and boys, to improve attitude so that DC self-perception can in turn be improved. This is a relationship that also coincides with the results of previous research (González-Martínez et al., 2018; Jan, 2017), and it is one that is especially important in relation to coeducation for girls. This is because it suggests that if teachers can start addressing this attitude in primary school through specific forms of education and mentoring programs, girls may be encouraged to better identify and appreciate real applications of DTs. This could increase girls' interest in learning about aspects that have been historically associated with masculine attributes, such as the more technical DC skills in which they currently consider themselves less competent.

This study does have some limitations, the most significant of which are its non-probability sampling and quantitative focus. Random sampling that covers all of the regions of Spain will be required in the future to confirm our results, using an approach that would correct the imbalance created by the lower number of 2nd year upper secondary students who participated in the survey. This imbalance could represent a methodological limitation when trying to identify differences because the size of the group studied influences the level of significance determined by statistical tests and may only be able to produce a medium effect size. A larger subsample of 2nd year upper secondary students could make it possible to identify additional differences, while also yielding a better understanding of how the digital gender gap evolves during the last two years of secondary school.

In addition, there is a need to supplement the quantitative snapshot given here with additional research into the relationships among all of the potentially-involved variables. There is clearly a need for further research with a gender-based perspective that can take more qualitative aspects into account. That research should focus on all educational stages, beginning in primary school, in order to not only measure but also understand the relationships among social and demographic variables such as the students' socio-economic status, repetition of years, future aspirations, and motivations.

In conclusion, the results of this research have revealed the existence of a digital gender gap in relation to specific aspects of students' self-perceived digital competence. These differences were found to increase, rather than decrease, over the course of students' years in secondary education. This digital gap is especially evident in the way that girls' attitude towards DTs get worse over time, which seems

to also have a negative impact on their self-perception of DC. This scenario has important implications for schools and teachers, including the need to develop coeducational strategies (Heredero, 2019) that take the indisputable digital gender gap into account. To do this, there is a need to address the concept of DC and its various indicators in detail as a way to eliminate the gender-based differences which continue to exist throughout the years of secondary education. For girls, this requires a focus on their lower self-perception in relation to technical aspects, and the less positive attitude they report towards DTs.

Educational actions of this type need to be initiated in primary school, which is the stage where gender stereotypes begin to exert an influence over students (Bian et al., 2017). However, work in parallel must also be performed to close the gender gap that is observed among students in their first years of secondary school and then more intensively during upper secondary school. This is the only way to achieve real equality that will allow women to thrive in a society that demands the efficient, secure, critical, and responsible use of digital technologies.

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## APPENDIX 1.

Factorial Analysis of Digitalis-ESO and comparative analysis of DC and Attitude towards DTs indicators, by gender and grade level. https://doi.org/10.5281/zenodo.7643087

- Table 1. Results of DC and attitude towards DTs analyses for the total sample by gender
- Table 2. Results of DC and Attitude towards DTs analyses for the 2nd year of ESO by gender.
- Table 3. Results of DC and Attitude towards DTs analyses for the 4th year of ESO by gender.
- Table 4. Results of DC and Attitude towards DTs analyses for 2nd year of upper secondary by gender.

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