Young people's digital competences: does gender matter?

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***Abstract*— This research explores the intersections between gender and young people's self-perceived digital competences. Previous research has identified differences between the self-perceived digital competences of girls and boys, but this paper further explores these differences comparing the ratings of ICT related curricular units with the self-perceived digital competences. A case study in one basic education school of Setúbal, Portugal, analyzed by gender the ratings to the ICT related curricular units, and the results of a digital competences self-assessment online questionnaire. The ICT related curricular units' ratings showed that girls and boys have similar results, however the digital competences self-assessment online questionnaire identifies a lower self-perceived digital competence of girls, and decreasing as they get older. This understanding of how girls' self-perceived digital competences vary with age is an important information to organize educational actions to reinforce girls' self confidence in their digital competences and promote gender equality in technology-related professions.**

Keywords— gender, young people, digital competences, ICT

I. INTRODUCTION

Our society is increasingly digital. Everyday life is ever more embedded with digital technologies, with high social and economic impact, shaping the way we live our lives. This digital transformation has a significant impact on the youngest generations and requires young people to quickly build the skills and competences needed for the digital era [1].

The need for digital competences in the work market is rapidly growing [2]. However, the gender gap in Information and Communication Technologies (ICT) studies and careers is an enduring situation [3]. European and Portuguese public policies on digital competence highlight the importance of promoting gender equality in ICT related activities.

Research has identified self-perceived digital competences has one of the major reasons for future career decisions [4], [5]. As such, it is important to further understand gender differences in self-perceived digital competences, particularly in an age of educational and career decisions, such as teenage years. Differences of self-perceived digital competences between boys and girls are well documented [6], [7], but it is important to understand how self-perceived digital competences relate to practices and how they change over the years.

This paper presents one case study research with students of the 7th, 8th and 9th grade, ages ranging from twelve to sixteen years old, of a basic education school in Portugal. The case study analyzed two types of results of boys and girls: ICT related curricular units' ratings, and answers to a digital competences self-assessment online questionnaire. The results are presented and analyzed, and conclusions summarize the main findings. The paper finalizes presenting proposals for further research.

II. DIGITAL COMPETENCE AND PUBLIC POLICIES

The Council of the European Union adopted a recommendation on key competences for lifelong learning [8] and identified digital competence as one of the key competences essential to citizens for personal fulfilment, a healthy and sustainable lifestyle, employability, active citizenship and social inclusion.

Considering that young people have lived all their lives embedded in digital technologies, it could be expected that they are digitally competent. However, being "digital natives" [9] and having "digital lives" [10], does not imply that young people are automatically digital competent [11]–[13]. Recent research [1] has identified gaps in digital skills, 95% of young people who access the Internet daily, do not inherently possess the skills to use digital technologies safely and effectively. Young people's digital engagement is usually limited to entertainment and communication, and only 13% participate in programming activities. Furthermore, significant inequalities are reported between minority backgrounds and their peers, as well as between boys and girls [1].

Education is central to improve the digital skills of children and young people, and overcoming inequalities [5]. The European Union Digital Education Action Plan (2021-2027) [14] aims to support the sustainable and effective adaptation of the education and training systems of EU Member States to the digital age. Following the EU Digital Education Action Plan guidelines, Portugal has implemented the Education Digital Transition Plan [15] to promote a digital school, where students, teachers, and schools collaborate, teach and learn in a digital environment. The key initiatives to implement the digital school in Portugal, are: to provide equipment and an internet connection to students, teachers, and schools; to instruct and prepare teachers for a digital world; to provide digital collaboration platforms and access to digital pedagogical resources for students and teachers; and to establish an action plan for digital development in each school. Alongside the Portuguese government established the National Digital Competences Initiative e.2030 (INCoDe.2030) [16], an integrated public policy to enhance and foster digital competences.

The EU Digital Education Action Plan [14], the Education Digital Transition Plan [15] and the INCoDe.2030 [16] identify as one of the main objectives to ensure that girls and young women are equally represented in digital studies and careers. In particular, INCoDe.2030 has an Action Plan "Closing the Gender Gap in Digital Technologies" 2030 Agenda [17] which aims to contribute to challenging stereotypes; the promotion of digital skills and education; and advocate for more women entrepreneurs and in leadership. This action plan understands equality of opportunities not just as equal numbers, but mainly as equal distribution of power. The major challenges are to tackle structural constraints and inequalities, generate inclusive opportunities for girls and

women to participate, ensuring that both men and women may be engaged in purposeful and significant education and work activities [17].

Research has identified self-perceived digital competences as one of the reasons why girls do not choose digital studies and careers [4], [6], [18], [19]. And, as such, it is important to further understand gender differences in self-perceived digital competences to be able to promote more equal access to digital studies and careers.

III. ICT AND GENDER

Information and communication technologies (ICT) are part of our lives, being one of the essential aspects of the ways we communicate, work, and socialize. Although ICTs are increasingly a structural aspect of societies, they continue to be a professional area with significant gender differences.

There is an increasing demand for digital skills and higher qualifications in ICT, with employment growth more than eight times higher than the average employment growth in the EU [2]. However, there is a very low number of women ICT specialists in the EU, only around 19,1% of the almost 8 million [2], and a decreasing trend of women graduating in ICT studies over the last decade [3]. In Portugal, there is a significant difference between women and men ICT graduates in higher education, from 2012 to 2021 there has been an average of 80% male graduates and 20% female graduates [20].

The under-representation of women in ICT is not only about gender equality, but it also has implications for the EU's innovative and economic potential in the future. Gender segregation in the labor market reduces the life choices, education and employment options of women and men, further reinforces gender stereotypes and perpetuates unequal gender-power relations in the public and private spheres [21].

Gender disparities in educational decisions and professional choices are not related to innate differences in skills between girls and boys, but rather to different self-representations about competences and aspirations for the future [4]. OECD studies [19] identify social contexts and gender stereotypes as decisive factors in the future career decisions of girls and boys.

In this context, it is important to study the self-perceived digital competences of young people, namely the differences between boys and girls. There are some interesting results of research projects in Portugal that studied digital practices and competences of young people, and that have data on self-perceived digital competences and gender differences.

The Net Children Go Mobile (NCGM) research project, carried out in 2014 in seven European countries, identified gender differences in digital practices [22]. The results in all countries, including Portugal, revealed that boys claim to have more digital skills and show more self-confidence in using computers and the Internet [22].

A recent study in Portugal with children from three to eight years old and their families, 'Growing Up Between Screens' [23], disclosed different strategies of parental mediation for girls and boys: more focused on security issues for girls and in autonomy and exploration of digital practices for boys. By controlling girls' digital practices more than boys, families are restricting girls' opportunities to develop their digital competences, which can have important effects on their career choices [24].

The EU Kids Online network, with the participation of 33 countries, has been investigating the opportunities and risks of the internet for European children and young people since 2010. During the 2017-2018 biennium, a new EU Kids Online survey was carried out in several European countries. In Portugal, the survey was applied in public and private schools and was answered by a national sample composed of 1,974 boys and girls aged 9 to 17 years [25]. The EU Kids Online survey has also explored gender differences in terms of self-representations and found significant differences between boys and girls. Although girls report greater use of mobile platforms, the boys consider themselves more proficient in mobile digital skills. However, girls more than boys report helping their parents when they need help with technology. Girls use more mobile technologies and have the skills to help others, but in self-representation, they report less confidence in their mobile digital skills. The self-representation of their skills is influenced by factors other than their practices [26].

Another particularly interesting and up-to-date research on young people's digital skills is the European project ySKILLS (Youth Skills). This project, funded by the European Union Horizon 2020 program, examines how digital skills mediate the risks and opportunities related to ICT use by 12 to 17 year olds in Europe [27]. In 2021, 2022 and 2023, a group of young people from six countries (Germany, Estonia, Finland, Italy, Poland, and Portugal) answered the same questions about digital access, uses and skills. Four different dimensions of skills are identified: (1) technical and operational skills; (2) information navigation and processing skills; (3) communication and interaction skills; and (4) content creation and production skills [27]. The project results address many items, but we will focus on the Portuguese gender-related outcomes. Gender differences were identified, girls value their communication and interaction skills a little more than boys, and boys are more confident in their technical and operational skills [28].

IV. RESEARCH QUESTIONS

This study aims to explore the intersections between gender and young people's self-perceived digital competences in one basic education school of Setúbal, Portugal. In order to explore these intersections, four sub-questions were used:

- How do girls and boys perform in ICT related curricular units at school?
- Are there differences in the self-perceived digital competences between girls and boys?
- Do the self-perceived digital competences vary with age?

It is important to analyze the ratings of ICT related curricular units to compare with the self-perceived digital competences. This comparison can provide valid information on the accuracy of possible differences of the self-perceived digital competences between girls and boys. Previous research [4], [29], [30] has identified differences between the self-perceived digital competences of girls and boys, but what is the relation with actual performance on ICT related curricular units?

V. RESEARCH DESIGN

An exploratory case study explored these research questions in context, using diverse collection methods [31]. An exploratory case study allows to describe a case in depth and to identify research questions and methods for further research process. In one basic education school of Setúbal, Portugal, the ratings to the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR), and the results of a digital competences self-assessment online questionnaire, were analyzed by gender.

A. Characterization of the participants

The compulsory education in Portugal is divided into preschool (for those under age six), basic education (nine years, in three cycles) and secondary education (three years). The participants in the research are 366 students (52% boys and 48% girls) from the 3rd cycle basic education of the School Sebastião da Gama. These 366 students are from the 7th grade (146), the 8th grade (116), and the 9th grade (104), with ages ranging from twelve to sixteen years old.

The School Sebastião da Gama is situated in the city of Setúbal, in the Lisbon metropolitan area. Setúbal is a city with a population of 120.000 residents (medium size city for Portugal), at about 40 km from Lisbon, the capital of Portugal.

B. ICT related curricular units' ratings

The curricular units' ratings analyzed in this research are Information and Communications Technology (ICT) and Programming & Robotics (PR). The ICT curricular unit is part of the curricular structure of the basic education 3rd cycle. The essential learnings of the ICT curricular unit are organized into four work domains: Safety, responsibility and respect in digital environments; Investigate and research; Collaborate and communicate; Create and innovate. Over the three years, the four work domains advance towards a greater proficiency of the development of students' analytical skills, through the exploration of age-appropriate computing environments and providing an approach to emerging technologies.

The Portuguese curricular structure of the 3rd cycle basic education allows schools to organize local curricular units, and the curricular unit Programming & Robotics is a School Sebastião da Gama offer. The PR curricular unit is specific of the 8th and 9th grade, and its curricular contents, are: Introduction to logical thinking and algorithm; Introduction and exploration of elementary concepts of Computer Science; Exploration of a block-based programming language for developing projects of increasing complexity; Robotics Basics; Distinguish sensors and their functionalities; Initiation of the use of software for robot programming; Programming robots to move in a simple way. These curricular contents are worked over the two years, 8th and 9th grade.

C. Online questionnaire – digital competences self-assessment

The online questionnaire was adapted from the online tool of the Digital Skills & Jobs Platform of the European Commission [32], which is based on the European Digital Competences Framework for Citizens DigComp 2.1 [33]. The DigComp 2.1, includes five competence areas: Information and data literacy; Communication and collaboration; Digital content creation; Safety; and Problem solving.

The online questionnaire has two types of questions:

- Self-perceived digital competences - ten questions with descriptors of digital competences and four options to reply: I don't know how to do it; I can do it with help; I can do it on my own; I can do it with confidence and, if needed, I can support/guide others;
- Correct answers - four questions with statements and false/true option + eight questions with a list of software's names or statements, and the participant has to choose the right one(s).

At the end of the online questionnaire there is a description of digital competences: (1) the capacity to use digital technologies, (2) the capacity to use these technologies specifically for work, study and the various activities related to the daily life, (3) the ability to critically evaluate digital technologies and (4) the motivation to participate in digital culture, followed by two questions:

- Which of the following statements about digital competences do you most agree with? (choose only 1 answer): Girls have more digital competences than boys; There are no differences in digital competences between girls and boys; Boys have more digital competences than girls.
- Do a self-assessment of your digital competences, and honestly compare yourself with young people your age. Please indicate which level best suits your self-assessment in a 5-point rating scale, from 1 = much lower to 5 = much higher.

D. Field work

The ratings of the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR) of School Sebastião da Gama during the school year 2021/22 were analyzed. This research collected the ratings of eighteen classes (seven of the 7th grade, six of the 8th grade, and five of the 9th grade) of Information and Communications Technology (ICT), and eleven classes (six of the 8th grade, and five of the 9th grade) of Programming & Robotics (PR).

The online questionnaire of digital competences self-assessment was completed between 19 April and 3 May 2022, in an online environment in the classroom. A total of 366 students answered the questionnaire. To understand how students identify themselves, the questionnaire had the question: Who are you? The answer options were: I don't know, I prefer not to say, a boy, a girl. We have 328 students who identified either as a boy (168) or a girl (160) and whose results we will analyze.

VI. RESULTS

A. Curricular units' ratings

The curricular units' ratings of the Portuguese basic education 3rd cycle, range from 1 to 5. The ICT ratings of 366 students and the PR ratings of 220 students have been analyzed. Each grade has a different teacher, but all the classes from the same grade have the same teacher. The means, standard deviation, and t-Test results are identified in Table I and Table II.

TABLE I. ICT RATINGS - INDEPENDENT T-TEST 95% CONFIDENCE INTERVAL

Grade	Girls			Boys			
	N	*Mean*	*StDev*	*N*	*Mean*	*StDev*	*T-test*
7th	78	4.00	0.49	68	3.67	0.47	**t(144) = 4.14, p < .001**
8th	57	3.44	0.65	59	3.16	1.01	t(114) = 1.77, p = .08
9th	57	3.66	0.75	47	3.86	1.07	t(102) = -1.12, p = .28

On the 7th and 8th grade girls ICT ratings mean was higher than boys ratings (Table I), and on the 7th grade the difference is significant t(144) = 4.14, p < .001 (T-test 95% confidence interval). On the 9th grade there is no significant difference between girls and boys rating means, despite boys have a higher rating mean. It is noteworthy that the rating mean difference changes over the years, younger girls performed better than boys, and as they get older boys tended to perform better.

PR curricular unit is mostly about programming and ICT curricular unit is more about production software and digital practices. On PR curricular ratings girls perform better than boys on the 8th grade but the situation changes on the 9th grade, with boys having higher ratings (Table II).

TABLE II. PR RATINGS - INDEPENDENT T-TEST 95% CONFIDENCE INTERVAL

Grade	Girls			Boys			
	N	*Mean*	*StDev*	*N*	*Mean*	*StDev*	*T-test*
8th	57	3.63	0.44	59	3.35	0.30	**t(114) = 4.02, p < .001**
9th	57	3.34	1.09	47	3.90	0.67	**t(102) = -3.07, p = 0.002**

The ICT and PR curricular units' ratings show that girls can perform as well as boys. In the first grades of the 3rd cycle, girls even perform better than boys, and progressively the difference reduces, with a tendency for boys improving their ratings each year. We are aware that these are results from specific classes, in one school in a given school year. They cannot be taken as representative of young people in Portugal. However, these results are important to compare with the results of the digital competences self-assessment online questionnaire.

B. *Online questionnaire - digital competences self-assessment*

The curricular units' ratings of all the 366 students were analyzed considering that in Portugal all students are identified as a boy or a girl. In the online questionnaire we only analyzed the answers of students who identified themselves either as a boy (168) or a girl (160), in a total of 328 students.

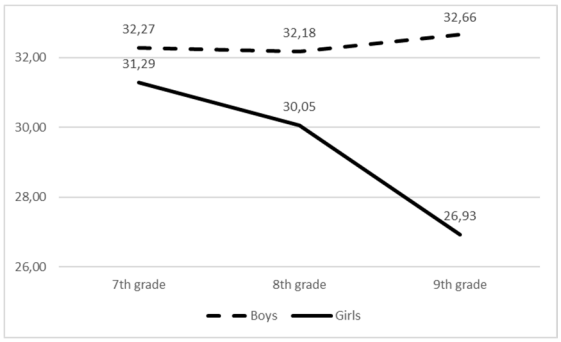
The online questionnaire is a self-assessment instrument and reflects self-perceived digital competences. It does not measure, in any way, real digital competences. The online questionnaire maximum rating is 100, divided equally by the five DigComp areas. The mean results of the online questionnaire, by DigComp area and total, (Table III) show that boys have higher mean results in all DigComp areas, with a greater difference in problem solving, and the exception of information and data literacy. These results are in line with previous research, such as, EU Kids Online [25] and ySKILLS [28].

TABLE III. ONLINE QUESTIONNAIRE MEAN RESULTS - BY DIGCOMP AREA AND TOTAL

DigComp area	Boys n=168	Girls n=160
Information and data literacy	13,05	13,29
Communication and collaboration	14,10	13,65
Digital content creation	11,27	11,06
Safety	12,71	12,09
Problem solving	12,14	10,79
Total	**63,27**	**60,88**

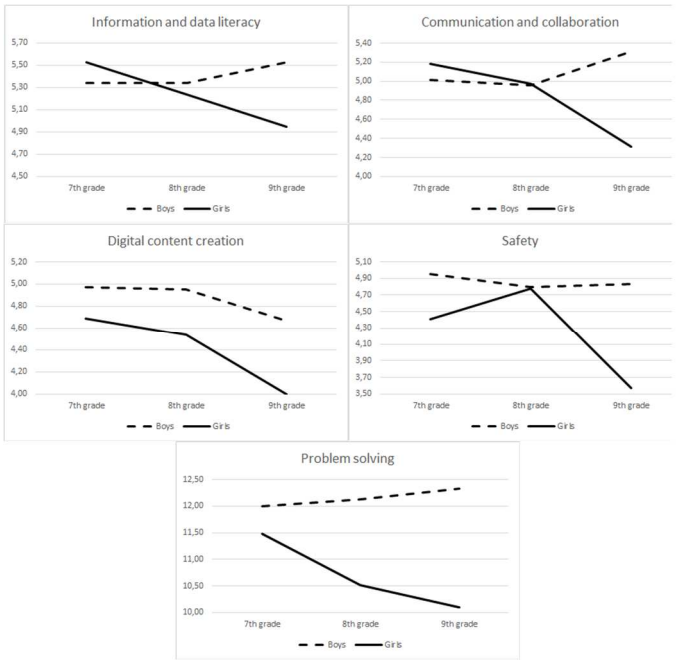
Analyzing the total mean results by sex and grade, we see a trend, girls self-perceived digital competences tend to diminish, and boys tend to increase (Figure 1).

Fig. 1. Mean results of self-perception questions by grade



Looking into more detail and analyzing the mean results by DigComp area and grade (Figure 2) it is possible to identify different trends. Comparing the mean results from the 7th to the 9th grade, we identify a downward trend in all DigComp areas of girls' self-perceived digital competences. Boys, on the contrary, have a trend of growth of mean results in all DigComp areas, except for digital content creation and safety.

Fig. 2. Mean results of self-perception questions by grade and DigComp area



The online questionnaire has self-perception questions and questions with a correct answer. The analysis of the self-perception questions vs. the questions with a correct answer can help understanding the differences of self-perceived

digital competences between boys and girls (Table V). It is noteworthy that boys' higher mean results are clearly related to the self-perception questions and not to the questions with a correct answer.

TABLE IV. SUM OF MEAN RESULTS FROM SELF-PERCEPTION AND CORRECT ANSWER QUESTIONS

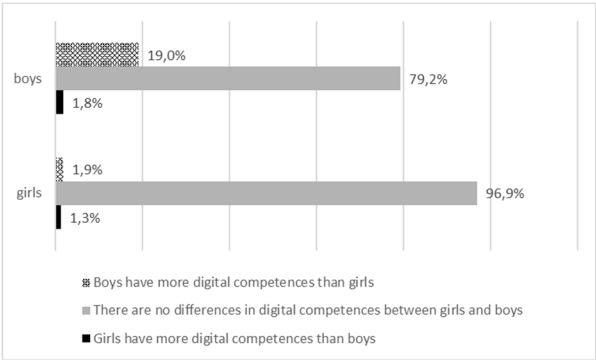
Type of questions	Boys	Girls
Self-perception	32,39	29,73
Correct answers	30,88	31,15
Total	63,27	60,88

If we analyze the results of self-perception questions by grade, it is noteworthy that boys' results tend to increase or to be stable, and the girls' results tend to decrease as they grow older (Figure 1). This tendency is consistent to all DigComp areas (Figure 2), and it must be further studied.

By the 9th grade, in the Portuguese education system, students must decide what area of studies they will proceed. This decision will impact their access to higher education and career opportunities. Previous research has identified self-perceived digital competences as one of the reasons why girls do not choose digital studies and careers [4], [6], [7], [18]. Considering the gender inequality in technology-related professions [17], [21], it is important in future research to expand our knowledge on the evolution of the self-perceived digital competences of girls.

After presenting a description of digital competences (section V. C. Online questionnaire – digital competences self-assessment) students had to choose one of the followed statements: Girls have more digital competences than boys; There are no differences in digital competences between girls and boys; Boys have more digital competences than girls (Figure 3).

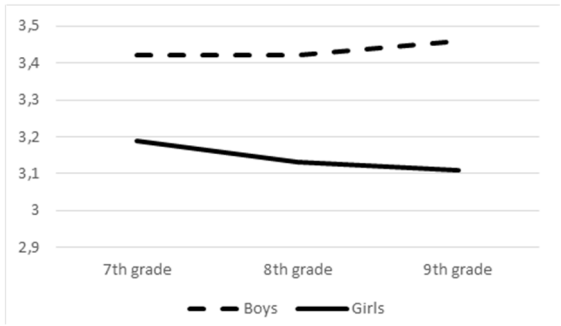
Fig. 3. Boys' and girls' choices of the statements about digital competences gender differences



Although most of both girls and boys choose the statement 'There are no differences in digital competences between girls' and boys' (79,2% of boys and 96,9% of girls), there is an important difference between their answers. We have 19,0% of boys choosing the statement 'Boys have more digital competences than girls' and 1,3% of girls choosing the statement 'Girls have more digital competences than boys'. There is a clear difference between girls' and boys' self-representation of their digital competences.

The answers to the final question "Do a self-assessment of your digital competences, and honestly compare yourself with young people your age. Please indicate which level best suits your self-assessment in a 5-point rating scale, from 1 = much lower to 5 = much higher" (Figure 4) further confirm this idea.

Fig. 4. Self-assessment of digital competences on a scale from 1 = much lower to 5 = much higher



Girls mean results to the self-assessment scale of digital competences are lower than boys' mean results and tend to decrease as they grow older. Boys, on the contrary, tend to improve their mean results as they grow older.

Gender differences in self-perceived digital competences in Portugal have been researched before [25], [26], [28], but what is significant in this case study is the understanding that they change during teenage years. School has a major role to change this situation. This knowledge is an opportunity to make a difference and reinforce girls' self confidence in their digital competences.

VII. CONCLUSIONS

This study aimed to explore the intersections between gender and young people's self-perceived digital competences. A case study in one basic education school of Setúbal, Portugal, analyzed by gender the ratings to the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR), and the results of a digital competences self-assessment online questionnaire.

The ICT and PR curricular units' ratings showed that girls and boys have similar performances. Girls' ratings are as good as boys' ratings, and in the first grades of the 3rd cycle, girls even perform better than boys. Throughout the 3rd cycle boys tend to perform better. However, the ratings of boys and girls are equally positive. If we only analyzed the ICT related curricular units' ratings, we could conclude that girls are as capable as boys of having positive results, with a tendency for boys improving over the years.

However, as we analyzed the results of the digital competences self-assessment online questionnaire, we found some interesting data. The online questionnaire, based on the European Digital Competences Framework for Citizens DigComp 2.1 [33], had two types of questions: self-perceived digital competences and questions with correct answers. On the questions with correct answers, girls' results were as good as boys' results, but on the questions about self-perceived digital competences there was a difference. Girls' self-perceived competences were lower and decreasing by the year in all DigComp areas. So, we can claim that in this case study, we found differences in the self-perceived digital competences between girls and boys, and that they changed over the years. Girls' self-perceived digital competences are lower and decrease as they grow older.

Moreover, in the last part of the online questionnaire, the self-assessment scale of digital competences, further confirmed this idea. Girls' and boys' self-representation of their digital competences is different, girls' have a lower self-assessment of their digital competences. But the most

interesting result is the evidence that girls' self-assessment of their digital competences tends to decrease as they grow older, contrary to boys, who increase the self-assessment of their digital competences.

Knowing that self-perception of one's competences is often a cause of academic performance [7], we can advance the hypothesis that it is the decreasing self-perceived digital competences that affect the curricular units' ratings, and not the other way around. Further research is needed to explore this hypothesis.

The interrelation of gender and self-perceived digital competences is well documented [4], [29], [30], but this research contributed with new information about the changes of self-perceived digital competences during teenage years. This new information is particularly important if we consider the impact on girls' and boys' educational and professional choices and that gender inequality in technology-related professions [3], [17] is an enduring reality. The understanding of changes on self-perceived digital competences during teenage years is an opportunity for educational actions. The school can make a difference by reinforcing girls' self confidence in their digital competences and contributing to a more equal society. Further research is needed to expand our knowledge on the interrelations of gender and the evolution of self-perceived digital competences during teenage years.

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