

# GENDER DIFFERENCES IN ICT SELF-EFFICACY AND COMPUTER LITERACY ACROSS ICILS 2018 AND 2023

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## ABSTRACT

**Aim.** This study examines the predictive relationships between students' general ICT self-efficacy (S\_GENEFF), specialised ICT self-efficacy (S\_SPECEFF), and computer and information literacy (CIL) scores within the framework of ICILS 2018 and 2023. It also examines gender-based differences in ICT self-efficacy perceptions across two independent ICILS assessment cycles.

**Methods.** The research employs a secondary data analysis approach using ICILS datasets from 13 participating countries. Both descriptive and inferential statistical

analyses were conducted to explore gender differences in general and specialised ICT self-efficacy. Regression analyses were then applied to determine the extent to which these variables predict students' CIL scores across the two assessment years.

**Results.** The findings reveal a persistent gender gap favouring boys in specialised ICT self-efficacy (S\_SPECEFF), though the effect sizes declined in 2023. General ICT self-efficacy (S\_GENEFF) was found to be a positive predictor of CIL scores for both genders, whereas specialised ICT self-efficacy emerged as a negative predictor, an effect that was stronger in 2023. These results may suggest a discrepancy between students' perceived competence in specialised ICT tasks and their demonstrated CIL performance, rather than providing direct evidence of overconfidence.

**Conclusions.** The study suggests that while access to technology and gender equity in digital participation have improved, disparities in confidence and competence remain. Educational policies should aim to align students' perceived and actual ICT competencies, particularly in advanced technological tasks, while fostering gender-balanced digital learning environments.

**Keywords:** ICT self-efficacy, computer and information literacy, gender differences, ICILS 2018, ICILS 2023, digital education

## INTRODUCTION

Digital technologies are now central to education and professional life, and students' confidence in using information and communication technology (ICT) known as ICT self-efficacy has become vital for equitable educational outcomes. ICT self-efficacy reflects students' belief in their ability to perform digital tasks, which significantly predicts their computer and information literacy (CIL). Studies show that students' self-efficacy, particularly in specialised ICT tasks, often falls below international standards (Kim & Kim, 2022). This underlines the importance of targeted strategies to build confidence in complex digital contexts.

Gender differences in ICT self-efficacy have become a critical research focus. Males tend to report higher self-efficacy in specialised ICT tasks (Gebhardt et al., 2019), while females generally show greater confidence in foundational or communicative applications (Bostan, 2014; Tsai & Tsai, 2010). These differences are shaped by socio-cultural dynamics, including gender roles and technology access (Vekiri & Chronaki, 2008).

Environmental factors, such as school technology integration and home access to digital tools, also shape ICT self-efficacy. Programmes like school-issued laptops can help reduce gender disparities by ensuring equal exposure to technology (Schaumburg, 2001). Similarly, early access to computers at home, especially when supported by parents, builds ICT confidence, particularly among boys (Nelson, 2011). However, the notion of students as "digital natives" has been challenged.

Effective digital literacy requires structured pedagogy and support (Frailon et al., 2020; Livingstone & Helsper, 2007), and ICT use should be promoted for cognitive development, not just social engagement (Hatlevik et al., 2015; OECD, 2021).

Teacher confidence in ICT use also impacts student outcomes. Xiaorui Chen (2023) found that teacher ICT self-efficacy positively influences students' digital literacy. Broader cultural norms further affect student confidence across regions. For instance, varying patterns in countries like Estonia, China, and others (Chen, 2023; Gebhardt et al., 2019; Yu & Hu, 2022) indicate that local practices and stereotypes significantly influence digital self-perception.

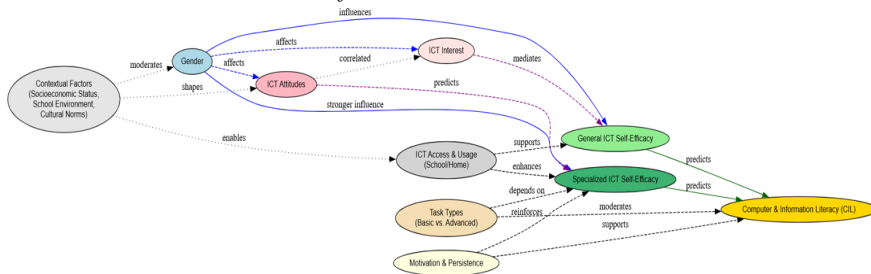
Several interventions have helped reduce gender gaps in ICT self-efficacy. Programmes like laptop initiatives and coding workshops (e.g., Gunbatar & Karalar, 2018) have improved female confidence. Other STEM-based interventions also show promise in building girls' resilience and interest in digital learning (Birney & McNamara, 2023; Drossel et al., 2022; Tam et al., 2020). Enhancing female ICT self-efficacy is also associated with increased digital task performance (Yu & Hu, 2022).

Longitudinal studies remain limited but offer important insights. Timo Gnambs (2021) found that boys' higher ICT confidence at age 15 led to slight literacy advantages by age 18, suggesting a potential gap between confidence and actual ability. Lauren Birney and Denise McNamara (2023) observed a decline in female self-efficacy over time, especially as academic tasks became more complex. This aligns with studies showing that even with frequent school-based computer use, confidence gaps persist (Cussó-Calabuig et al., 2018; Gebhardt et al., 2019). These findings point to the need for consistent teacher guidance and evidence-based digital pedagogies to foster equitable digital skills (Ertmer & Ottenbreit-Leftwich, 2010).

Globally, gendered issues of ICT self-efficacy are evident across various educational systems. Cross-national assessments such as ICILS and PISA provide critical data for comparison (Chen & Hu, 2020; Drossel et al., 2022). Yet, most existing research is cross-sectional and lacks longitudinal depth, limiting our understanding of how these dynamics evolve over time.

Building on previous research, this study examines the predictive power of gender-based ICT self-efficacy on students' CIL across two ICILS cycles (2018 and 2023). Because the same students were not followed across time, the study adopts a repeated cross-sectional comparative approach rather than a longitudinal design. It aims to understand how general and specialised self-efficacy vary by gender and assessment cycle, and how these perceptions relate to actual CIL outcomes. The conceptual framework (Figure 1) illustrates the theoretical relationships among gender, ICT self-efficacy, contextual factors, and CIL performance; however, the empirical analyses focus specifically on the predictive roles of S\_GENEFF and S\_SPECEFF.

**Figure 1**  
*Conceptual Model Illustrates the Relationships Among Gender, ICT Self-Efficacy, Contextual Factors, and CIL Performance*



Source. Own research.

## LITERATURE REVIEW

The rapid digitalisation of education systems worldwide has intensified the focus on students' Computer and Information Literacy (CIL), which is broadly defined as the ability to use digital technologies to access, manage, evaluate, and create information effectively (Fraillon et al., 2020). As a critical 21st-century skill, CIL is closely linked to academic achievement, digital participation, and lifelong learning (OECD, 2021). Among the cognitive and affective variables influencing CIL, ICT self-efficacy has received substantial scholarly attention, particularly for its predictive power in shaping students' engagement and performance in technology-rich environments (Bandura, 1997; Hatlevik et al., 2015).

### ICT Self-Efficacy and CIL

ICT self-efficacy refers to an individual's belief in their capability to perform specific technology-based tasks (Compeau & Higgins, 1995). Research consistently shows a positive correlation between ICT self-efficacy and students' performance in digital reading, information literacy, and complex problem-solving tasks (Hatlevik et al., 2015; Yu & Hu, 2022). In their multilevel analysis, Ove Edvard Hatlevik et al. (2015) demonstrated that students with higher ICT self-efficacy not only performed better on digital tasks but also employed more effective strategies for information gathering and evaluation. This aligns with findings that ICT self-efficacy mediates the relationship between socioeconomic status and digital competence, emphasising its role in overcoming structural barriers (Drossel et al., 2020). Furthermore, the effectiveness of ICT use is closely tied to students' abilities in critical thinking, digital navigation, and problem-solving, which are enhanced by confident engagement with digital tools (Hatlevik et al., 2015).

## Gender Differences in ICT Self-Efficacy and CIL

The literature documents persistent gender disparities in both ICT self-efficacy and CIL outcomes. Male students consistently report higher levels of ICT confidence and interest in technology-intensive career paths, which in turn positively affects their performance in CIL assessments (Tømte & Hatlevik, 2011; Vekiri & Chronaki, 2008). These differences are not solely biological but are shaped by socio-cultural expectations, educational experiences, and pedagogical influences, with male students often benefiting from greater encouragement in technical domains (Vekiri & Chronaki, 2008). Conversely, female students tend to undervalue their digital abilities, often due to internalised stereotypes and lower exposure to technology-rich environments (Kim & Kim, 2022). This is particularly evident in digital reading, where female students' lower performance is significantly linked to reduced ICT self-efficacy (Tømte & Hatlevik, 2011; Yu & Hu, 2022).

Several studies emphasise the importance of early and equitable exposure to digital learning tools in narrowing gender gaps. For instance, Cathrine Tømte and Ove Hatlevik (2011) found that when access to ICT was balanced and embedded within instructional practices, gender-based disparities in self-efficacy were significantly diminished. Moreover, access to social and cultural capital plays a critical role in shaping ICT self-efficacy, influencing students' confidence and engagement in digital environments (Bourdieu, 1986). Despite these findings, few studies have conducted longitudinal or comparative analyses to examine whether and how these gender dynamics evolve over time in response to changes in digital policy, curriculum, or technology access.

## Insights from ICILS

The International Computer and Information Literacy Study (ICILS), conducted by the IEA, provides a valuable dataset for understanding students' digital competencies across multiple countries and time points (Fraillon et al., 2020). ICILS 2018 data revealed that ICT self-efficacy was among the most significant predictors of CIL performance globally. Moreover, substantial gender differences in both self-efficacy and digital achievement were found across most participating countries (Drossel et al., 2020). The notion of students as "digital natives" has been challenged by ICILS findings, which show that digital literacy requires explicit instruction and pedagogical support, rather than relying on assumed innate competence (Fraillon et al., 2020; Livingstone & Helsper, 2007). While the 2018 cycle provided important benchmarks, the newly released ICILS 2023 dataset offers a unique opportunity to revisit and compare these patterns to identify shifts in gender dynamics and the stability of predictive models.

Despite the growing body of literature, several gaps remain. First, few studies use comparative longitudinal analysis to explore how gender-based predictors of ICT

self-efficacy change over time. Most existing research either relies on single-time datasets or focuses exclusively on one country or region (Livingstone & Helsper, 2007). Second, there is a lack of complex modeling techniques, such as multilevel structural equation modeling, that can simultaneously address individual and systemic factors influencing CIL. Third, while the mediating role of ICT self-efficacy has been explored, its interaction with cultural capital and resilience in shaping gender differences remains underexplored (Drossel et al., 2022). Fourth, its moderating effects, particularly by gender, remain theorised and under-tested in empirical research (Yu & Hu, 2022).

To address these gaps, the study conducts a cross-cohort analysis of ICILS 2018 and 2023, using gender-disaggregated data to examine how the predictive relationship between ICT self-efficacy and CIL has changed over time. By incorporating cultural capital and resilience as contextual factors, it extends the theoretical framework to account for the socio-cultural dimensions of digital competence (Bourdieu, 1986; Drossel et al., 2022). In doing so, the study updates the empirical evidence base and provides a broader understanding of how self-efficacy relates to digital learning across different contexts. Furthermore, the use of comparative cross-national data and advanced statistical methods helps to clarify how gender, self-efficacy, and digital literacy intersect across educational systems.

## **Contribution to Literature**

This study offers a comparative cross-national analysis of gender-based differences in ICT self-efficacy and their predictive effects on computer and information literacy (CIL). Unlike prior research that typically focuses on single-country data or a single year, this study uses ICILS 2018 and 2023 datasets from 13 countries to highlight temporal and gendered trends. Methodologically, the study distinguishes between general and specialised ICT self-efficacy, providing a clear understanding of how different types of confidence relate to digital literacy. The findings advance the literature by showing that specialised ICT self-efficacy was negatively associated with CIL performance in both cycles, with this negative association becoming more pronounced in 2023.

## **METHODS**

### **Research Model**

A correlational survey model using secondary data analysis is employed in this study. The study examines how students' general and specialised ICT self-efficacy (S\_GENEFF and S\_SPECEFF) predict their computer and information literacy (CIL) scores in ICILS 2018 and 2023, with a focus on gender differences. The analysis addresses both gender-based variations and changes between the two assessment years are focused on in the analysis.

## Dataset and Participants

Data from the International Computer and Information Literacy Study (ICILS), conducted by the International Association for the Evaluation of Educational Achievement (IEA) in 2018 and 2023, were used in this study. Countries that participated in both years and for which data access was granted are included in the analysis: Chile, Denmark, Finland, France, Germany, North Rhine-Westphalia (NRW), Italy, Kazakhstan, Korea, Luxembourg, Portugal, USA, and Uruguay. The analysis focuses on eighth-grade students and is conducted separately for girls and boys.

The dependent variable is students' computer and information literacy (CIL) score, represented by the five plausible values provided by ICILS. Two independent variables are included: S\_GENEFF (ICT self-efficacy in general applications) and S\_SPECEFF (ICT self-efficacy in specialised applications), both derived from student questionnaires administered in 2018 and 2023.

## Data Analysis and Tools

The study employed three main statistical methods: (a) Descriptive statistics and independent samples *t*-tests to assess gender differences and year-over-year changes, with effect sizes measured by Cohen's *d*; (b) Multiple linear regressions conducted separately by gender for 2018 and 2023, evaluating how S\_GENEFF and S\_SPECEFF predict CIL scores using  $\beta$  coefficients, *t*-values, and  $R^2$ ; (c) Change analysis over time using effect sizes to assess significance.

All analyses were conducted in R, accounting for ICILS's complex sampling design using the *intsvy*, *dplyr*, and *survey* packages. The International Database Analyzer (IDB Analyzer) developed by IEA was also used to automatically incorporate sample weights and plausible values. Weighted analysis techniques were applied to minimise variance error. Five plausible values served as dependent variables, and self-efficacy scores (S\_GENEFF and S\_SPECEFF) were included as predictors. Gender-based analyses were conducted separately, and caution was taken when interpreting self-reported data due to potential biases.

## FINDINGS

This research addresses four research questions. The first question examines gender differences in S\_GENEFF and S\_SPECEFF between 2018 and 2023. The detailed results, including means, standard deviations, *t*-test values, and effect sizes by gender, are presented in Appendix (Table A1).

In 2018, countries showing significant gender differences in the S\_GENEFF dimension mostly displayed a 'no effect' level in effect size. However, for the S\_SPECEFF

dimension, many countries showed statistically significant gender differences at ‘small’ or ‘intermediate’ effect levels. By 2023, while some countries still showed significant differences in the S\_GENEFF dimension, the effect size remained predominantly at the ‘no effect’ level. The S\_SPECEFF dimension continued to show notable differences, particularly in countries like Denmark, Finland, Germany, and Luxembourg, where ‘small’ or ‘intermediate’ effect levels persisted.

In both years, boys’ mean scores are significantly higher than girls’ scores in the S\_SPECEFF factor. The gap reaches “intermediate” or “large” effect levels in several countries during 2018, particularly in Denmark ( $d=0.932$ ), Finland ( $d=0.558$ ), Germany ( $d=0.641$ ), and North-Rhine Westphalia ( $d=0.639$ ). While this gender difference decreased by 2023, it remains statistically significant.

The 2023 data show that the differences between boys and girls in the S\_GENEFF dimension have generally decreased or remained stable. However, in several countries, notably Denmark, Germany, and France, the gap favouring boys may have widened. While differences in the S\_SPECEFF dimension have diminished, they still significantly favour boys.

Several countries show notable results in gender differences. In Denmark, the S\_SPECEFF dimension showed a very high difference in 2018 ( $d=0.932$ ), which decreased to a small effect ( $d=0.49$ ) by 2023. While boys’ self-efficacy levels remained consistently higher than girls’, the gap narrowed over time. Finland maintained a significant boy advantage in S\_SPECEFF across both years (2018:  $d=0.558$ ; 2023:  $d=0.472$ ). For S\_GENEFF, a small but significant difference emerged in 2023 ( $d=0.16$ ). France showed patterns similar to Finland in S\_SPECEFF, with stable, small-effect differences favouring boys in both years. In Germany, the boy advantage in S\_SPECEFF decreased from intermediate ( $d=0.641$ ) in 2018 to small effect ( $d=0.387$ ) in 2023, while S\_GENEFF showed significant but negligible differences favouring boys. Kazakhstan demonstrated statistically significant differences in S\_GENEFF in both years, though Cohen’s  $d$  values indicate minimal practical impact. However, the gender difference in S\_SPECEFF, while significant in 2018 ( $d=0.096$ ), became non-significant by 2023, suggesting a narrowing of the gap in specialised applications. Notably, Italy showed an increase in the S\_SPECEFF gender gap, rising from  $d=0.319$  in 2018 to  $d=0.451$  in 2023, one of the few countries where the boy advantage in specialised applications widened rather than narrowed. The Republic of Korea maintained small-effect differences favouring boys in S\_GENEFF throughout 2018 and 2023, while in S\_SPECEFF, a significant difference in 2018 became non-significant by 2023.

Gender differences in ICT self-efficacy remain evident across countries, though their effect size remains small in most countries. These differences are more pronounced in specific applications (S\_SPECEFF) compared to general efficacy (S\_GENEFF). While the 2023 data indicate a reduction in these disparities across many countries, boys maintain higher ICT self-efficacy in specific applications than girls.

The second research question examines whether there are changes between S\_GENEFF and S\_SPECEFF during 2018–2023, and whether these changes vary by

gender. Table 2 presents the results. The detailed results, including means, standard deviations, *t*-test values, and effect sizes by gender and year, are presented in Appendix (Table A2).

This study analysed gender-based changes in students' ICT self-efficacy levels using ICILS data from 2018 and 2023. The analysis focused on two dimensions: ICT self-efficacy for general applications (S\_GENEFF) and self-efficacy for specific applications (S\_SPECEFF). The results showed that both boys and girls experienced changes in these dimensions over the study period.

Analysis of the S\_GENEFF dimension shows that scores changed for both genders in 2023, though the direction varied by country. Boys in Denmark, Finland, Portugal, and Chile showed lower average scores compared to 2018, with Cohen's *d* values ranging from 0.15 to 0.27, generally at the "No Effect" level. Conversely, boys in France ( $d=0.27$ ), Germany ( $d=0.18$ ), North Rhine-Westphalia ( $d=0.26$ ), Italy ( $d=0.16$ ), and Kazakhstan ( $d=0.13$ ) showed increases in S\_GENEFF scores between 2018 and 2023. Girls, however, experienced more notable decreases in several countries. In Denmark ( $d=0.44$ ), Finland ( $d=0.46$ ), Korea ( $d=0.25$ ), France ( $d=0.23$ ), Portugal ( $d=0.22$ ), and the USA ( $d=0.27$ ), the decreases reached the "Small Effect" level. In contrast, girls in North Rhine-Westphalia ( $d=0.24$ ), Germany ( $d=0.14$ ), Italy ( $d=0.08$ ), and Kazakhstan ( $d=0.16$ ) showed increases in S\_GENEFF scores. This indicates that girls' ICT self-efficacy perceptions in general applications have shown mixed patterns across countries, with notable declines in some and increases in others.

The S\_SPECEFF dimension findings reveal a striking trend: boys' self-efficacy levels in specialized It applications have significantly decreased across many countries. These decreases reached "Small Effect" levels in Denmark ( $d=0.37$ ), Finland ( $d=0.21$ ), Germany ( $d=0.29$ ), North Rhine-Westphalia ( $d=0.25$ ), Chile ( $d=0.21$ ), and Uruguay ( $d=0.26$ ). Additionally, boys in Kazakhstan ( $d=0.18$ ), Luxembourg ( $d=0.18$ ), Italy ( $d=0.13$ ), Portugal ( $d=0.12$ ), and the USA ( $d=0.13$ ) also showed decreases in S\_SPECEFF, though at the "No Effect" level. This decline suggests a weakening of boys' traditionally high competencies in specialised applications over time.

Changes in the S\_SPECEFF dimension have generally been more limited for girls, though some countries showed notable results. Significant decreases were recorded in Finland ( $d=0.20$ ), and Uruguay ( $d=0.19$ ). Notably, Korea showed a significant increase in girls' S\_SPECEFF scores ( $d=0.19$ , Small Effect), indicating that girls' confidence in specialised applications actually improved between 2018 and 2023 in this country. Additionally, Luxembourg ( $d=0.11$ ) and the USA ( $d=0.12$ ) also showed modest decreases at the "No Effect" level. In other countries, girls' scores either remained stable or showed minimal changes.

Analyzing these findings collectively shows that gender-based differences in ICT self-efficacy perceptions have generally declined over the years. While boys showed consistent decreases in S\_SPECEFF across most countries, their S\_GENEFF scores increased in several countries, notably France, Germany, and North Rhine-Westphalia.

Girls' scores showed mixed patterns: notable S\_GENEFF decreases in Denmark, Finland, and Korea, but increases in France, Germany, and North Rhine-Westphalia. Korea stands out as the only country where girls' S\_SPECEFF scores increased significantly between 2018 and 2023. Girls' scores have also decreased significantly in some countries. This trend suggests both a narrowing gender gap and an overall shift in the distribution of technology self-efficacy patterns across countries and genders.

These findings suggest that information technology education policies need redesign to better support students of all genders. Building competence with complex applications is essential for fostering student confidence and developing lasting digital skills.

The third research question examines how S\_GENEFF and S\_SPECEFF independently predict CIL achievement for boys and how these predictions vary between genders. The detailed regression results for boys in 2018 and 2023, including  $\beta$  coefficients, t-values, and explained variance ( $R^2$ ), are presented in Appendix (Table A3).

Regression analyses examined two predictors of boys' Computer and Information Literacy (CIL) scores: "general ICT self-efficacy (S\_GENEFF)" and "specialised ICT self-efficacy (S\_SPECEFF)" for 2018 and 2023. The analyses showed that S\_GENEFF had positive effects on CIL scores in both years, while S\_SPECEFF had significant negative effects. The strength and pattern of these effects varied notably across countries over time.

In 2018, S\_GENEFF was a positive and significant predictor across all countries. Korea showed the highest  $\beta$  coefficient ( $\beta=0.57$ ), followed by Finland ( $\beta=0.52$ ), Kazakhstan ( $\beta=0.50$ ), and Italy ( $\beta=0.46$ ), indicating that boys' general ICT self-efficacy strongly influenced their computer and information literacy. By 2023, while this effect largely persisted, some countries saw decreases in  $\beta$  coefficients; Korea declined to  $\beta=0.41$  and Finland to 0.42. Conversely, the relationship strengthened in Portugal ( $\beta=0.48$ ), USA ( $\beta=0.49$ ), and North Rhine-Westphalia ( $\beta=0.46$ ). These results confirm that digital competence remains a fundamental skill for boys' CIL performance.

S\_SPECEFF showed a negative and significant correlation with CIL scores throughout both years. In 2018, this negative relationship was strongest in Portugal ( $\beta=-0.35$ ), Uruguay ( $\beta=-0.29$ ), and Kazakhstan ( $\beta=-0.21$ ). By 2023, the effect intensified in some regions, particularly in Kazakhstan ( $\beta=-0.40$ ) and the USA ( $\beta=-0.30$ ), while France, Germany, and North Rhine-Westphalia maintained minimal negative effects. This pattern suggests that increased technical competence might lead to negative outcomes like overconfidence, automation dependence, or distraction among some students.

The model's explanatory power varied by country. In 2018, Korea ( $R^2=0.23$ ), Finland ( $R^2=0.20$ ), Portugal ( $R^2=0.18$ ), Uruguay ( $R^2=0.18$ ), and the USA ( $R^2=0.17$ ) showed the highest explained variance. By 2023, some countries experienced decreased variance, notably Korea, dropping to  $R^2=0.09$ , suggesting that CIL influencing factors have become more diverse over time.

In conclusion, S\_GENEFF's positive effect on boys' CIL largely persisted from 2018 to 2023, though its strength varied across countries. S\_SPECEFF's negative

effect continued in most countries, intensifying in some cases. These findings highlight that digital competency's impact varies by type, emphasizing the importance of not just possessing digital skills but using them effectively and mindfully.

The fourth research question examines how S\_GENEFF and S\_SPECEFF independently predict CIL achievement for girls and how these predictions compare to those observed for boys. The detailed regression results for girls in 2018 and 2023, including  $\beta$  coefficients,  $t$ -values, and explained variance ( $R^2$ ), are presented in Appendix (Table A4).

Regression analyses were conducted to examine the effects of two variables on girls' computer and information literacy (CIL) scores: S\_GENEFF (ICT self-efficacy for general tasks) and S\_SPECEFF (ICT self-efficacy for specific tasks) from 2018 and 2023. The findings showed that S\_GENEFF positively predicted CIL scores while S\_SPECEFF negatively predicted them in both years.

The 2018 data revealed S\_GENEFF as a strong predictor of CIL scores across all countries. Korea showed the highest  $\beta$  coefficient ( $\beta=0.50$ ), followed by Kazakhstan ( $\beta=0.47$ ), Italy ( $\beta=0.45$ ), and Uruguay ( $\beta=0.43$ ). These results highlight how girls' self-efficacy in general ICT skills significantly influences their computer and information literacy. By 2023, though  $\beta$  coefficients slightly decreased overall in most countries, S\_GENEFF's effect persisted and even strengthened in some cases. The highest predictors in 2023 were the USA ( $\beta=0.46$ ), Chile and Portugal (both  $\beta=0.44$ ), and Korea ( $\beta=0.42$ ). These values confirm that general ICT self-efficacy maintained its positive influence on CIL over time.

S\_SPECEFF consistently showed negative predictions for CIL scores across both years. In 2018, this effect was notable in Uruguay ( $\beta=-0.28$ ), Chile ( $\beta=-0.25$ ), Finland ( $\beta=-0.23$ ), and Italy and Kazakhstan (both  $\beta=-0.21$ ). The negative effect intensified markedly in most countries by 2023, with the strongest effects observed in the USA ( $\beta=-0.35$ ), Chile ( $\beta=-0.34$ ), Finland ( $\beta=-0.33$ ), and Portugal ( $\beta=-0.30$ ). Kazakhstan ( $\beta=-0.29$ ) and Denmark ( $\beta=-0.25$ ) also showed notable intensification ( $\beta=-0.25$ ). Notably, Italy ( $\beta=-0.18$ ) and Uruguay ( $\beta=-0.16$ ) were the only countries where the negative effect did not intensify, in fact, it weakened. This trend suggests that overconfidence or perceived competence in complex digital technologies might hamper actual performance.

The model's explanatory power ( $R^2$ ) showed variation across countries in both years. The 2018 models explained the most variance in Korea ( $R^2=0.21$ ), Uruguay ( $R^2=0.18$ ), Italy ( $R^2=0.17$ ), and the USA ( $R^2=0.16$ ). By 2023, the pattern shifted considerably: Portugal rose to the highest explanatory power ( $R^2=0.14$ ), followed by Chile ( $R^2=0.13$ ), while Korea dropped to  $R^2=0.11$  and Finland remained at  $R^2=0.11$ . Notably, Uruguay showed a sharp decline ( $R^2=0.02$ ) and the USA also decreased substantially ( $R^2=0.03$ ) suggesting that the predictors explain considerably less variance in these countries in 2023.

In conclusion, S\_GENEFF remains the strongest positive predictor of girls' CIL scores, maintaining its influence across both years. Notably, S\_SPECEFF's negative

impact grew stronger and more widespread by 2023 in 11 out of 13 countries. However, Italy and Uruguay were notable exceptions, showing a weakening of this negative association, which may reflect country-specific educational or cultural factors influencing how girls relate specialised application skills to broader computer literacy. These findings demonstrate that success depends not just on technology access and general competency, but also on the quality and practical application of these skills. Educational policies should focus on building girls' self-efficacy while ensuring it's grounded in solid knowledge and effective strategies.

## DISCUSSION

Gender differences in ICT self-efficacy and their relationship to computer and information literacy (CIL) among secondary school students reveal important patterns with implications for education. Drawing on large-scale assessments, including ICILS 2018 and 2023, the discussion synthesises findings across six themes: the roles of general and specialised ICT self-efficacy, gender differences, environmental influences, intervention effectiveness, and longitudinal patterns, and implications for policy incorporating cultural and societal perspectives on digital competence as a form of capital and social reproduction (Lesková et al., 2023).

### **Predictive Roles of General and Specialised ICT Self-Efficacy**

General ICT self-efficacy (S\_GENEFF) consistently predicts higher CIL scores across countries and genders, confirming its fundamental role in digital competence. Sun-Kyoung Kim and Hyun-Kyung Kim (2022) and Hangyan Yu and Jie Hu (2022), using ICILS and PISA data, show that students confident in basic ICT tasks such as software use and information retrieval perform better in literacy assessments. This aligns with the conceptual link between confidence in routine digital tasks and the ability to demonstrate information literacy and digital problem-solving skills, as supported by Deborah Compeau and Christopher Higgins (1995) and Hatlevik et al. (2015). From a sociocultural perspective, digital confidence can be interpreted as a form of "digital cultural capital," where students' social backgrounds and cultural access to technology shape their perceived competence (Lesková et al., 2023).

Conversely, specialised ICT self-efficacy (S\_SPECEFF), defined as confidence in advanced tasks such as programming or database management, negatively predicts CIL scores, with a stronger effect in the 2023 ICILS data. This counterintuitive finding may reflect overconfidence, curriculum misalignment, or limitations in the S\_SPECEFF measurement scale, which may not fully capture the practical skills assessed in CIL (Campos & Scherer, 2024). Eveline Gebhardt et al. (2019) noted that male students'

elevated self-efficacy in advanced tasks often failed to translate into superior CIL performance, potentially due to superficial engagement with complex technologies (Miklyaeva, 2021). This discrepancy might mirror symbolic imbalances in technological habitus, where perceived confidence in “elite” ICT skills is socially valorised yet not matched by pedagogical grounding (Mazur et al., 2025).

These contrasting roles of general and specialised self-efficacy highlight the need to align confidence with actual competence. Educational interventions should develop authentic specialized skills while maintaining broad confidence in general ICT tasks, a balanced approach that prepares students for the complexities of a digital world. This balance may also support more equitable participation in technology use and digital learning environments (Ortiz Cobo & Jeri Levano, 2023).

## **Gender Differences in ICT Self-Efficacy and Literacy**

The reviewed studies consistently show distinct gender patterns in ICT self-efficacy: males report higher confidence in advanced tasks, while females often show greater self-efficacy in basic or communicative tasks. Gebhardt et al. (2019) documented a 0.5 standard deviation gap favouring males in advanced tasks, compared to a 0.1 gap in basic tasks where females sometimes excelled. Similarly, Meng-Jung Tsai and Chin-Chung Tsai (2010) found females performed better in communicative Internet self-efficacy, while males led in exploratory tasks. This pattern extends to digital reading performance, where male students often outperform females due to higher ICT self-efficacy, mediated by socio-cultural expectations (Tømte & Hatlevik, 2011; Yu & Hu, 2022). These gendered perceptions of technological skill are socially constructed through cultural narratives that frame ICT as a masculine domain (Lesková et al., 2023).

The 2023 ICILS data indicate a narrowing of gender gaps in self-efficacy. This improvement may stem from increased access to technology and targeted interventions, such as laptop programs (Schaumburg, 2001) and programming workshops (Gunbatar & Karalar, 2018). The narrowing gap, especially in Denmark, Finland, and Germany, suggests systemic policy effects (Caeli et al., 2025). However, persistent gaps in specialised tasks suggest that entrenched stereotypes and differential encouragement such as parents favouring boys in ICT (Nelson, 2011) remain influential. These results reinforce calls to deconstruct cultural scripts associating technological expertise with male identity (Mazur et al., 2025).

The relationship between self-efficacy and performance reveals intriguing gender nuances. Though males report higher confidence, it doesn't always align with stronger performance. Gnambs (2021) observed that gender differences favouring boys in ICT literacy emerge by age 18, despite earlier confidence gaps. This suggests that confidence–competence alignment evolves over time and may be mediated by socialisa-

tion processes; female students might undervalue their abilities due to cultural modesty norms or lack of recognition for their technical identity (Kildè, 2023).

## **Environmental Influences on Gender Differences**

Environmental factors significantly shape gender differences in ICT self-efficacy and literacy. School technology integration helps reduce gender gaps through equitable digital access (Schaumburg, 2001). Laptop programmes particularly benefit female students, demonstrating how consistent technology exposure can address access-based disparities. Digital engagement also reflects cultural capital transmission within families and local communities, as research indicates connections between home culture and technology participation (Lesková et al., 2023).

Home technology access also matters. Mathew Nelson (2011) shows early computer ownership impacts self-efficacy; access disparities can widen gender gaps, particularly in contexts where economic or cultural constraints limit girls' access outside school. In this light, digital inequality becomes both a social and symbolic phenomenon, a mirror of deeper structural inequalities (Ortiz Cobo & Jeri Levano, 2023).

National cultural contexts shape these dynamics. Yu and Hu (2022) and Chen (2023) reveal variation: Estonian females lag in self-efficacy, while in Turkey computational thinking self-efficacy shows no significant gender difference (Ibili & Günbatar, 2020). The decline in girls' general self-efficacy in Denmark and Finland between 2018 and 2023 suggests that access alone is insufficient without attention to identity, motivation, and cultural narratives (Caeli et al., 2025). Thus, it is important to consider how educational systems may reinforce differences in students' access to and confidence in digital learning opportunities (Lesková et al., 2023).

Teachers' and parents' roles are critical. Teacher ICT self-efficacy is positively linked to student information literacy (Chen, 2023). Yet, parental favouritism toward boys in ICT (Nelson, 2011) perpetuates stereotypes. Teachers' expectations may unconsciously encode cultural habitus that reinforces inequality (Kildè, 2023).

## **Effectiveness of Interventions**

Evidence shows that targeted interventions can effectively address gender differences in ICT self-efficacy and literacy. Laptop programmes (Schaumburg, 2001) and programming workshops (Gunbatar & Karalar, 2018) successfully narrow gender gaps through hands-on experience. Notably, Mustafa Serkan Gunbatar and Halit Karalar's (2018) mBlock programming intervention eliminated initial gender-based self-efficacy differences, showing how targeted skill-building can equalise confidence. Cultural

contextualisation of these interventions, embedding digital learning in collaborative, identity-affirming contexts, can further enhance equity (Lesková et al., 2023).

Gender-specific programmes show particular promise. ICT training workshops for female students in Hong Kong (Tam et al., 2020) effectively build confidence in supportive environments. Similarly, integrated approaches like the CCERS STEM + C Program (Birney & McNamara, 2023) build female technological confidence by placing ICT within broader learning contexts. Structured opportunities for girls to reflect on their digital competencies, as suggested by Albert Bandura's (1997) social cognitive theory, can bridge the confidence gap by fostering interest and identity alignment with technology (Yu & Hu, 2022).

Classroom interventions incorporating coding and IT training, as studied by Tuba Taşdöndüren and Agah Tuğrul Korucu (2022), demonstrate curriculum design's importance. These programmes enhance self-efficacy and provide practical ICT experience, helping counter stereotypes and build lasting competence. However, the limited research on long-term effectiveness creates uncertainty about sustained benefits. Future studies should examine whether these improvements persist throughout students' education.

## **Longitudinal Patterns and Grade-Level Variations**

Though longitudinal studies are scarce, available evidence reveals important trends in gender differences over time. Gnambs (2021) found that while ICT confidence gaps at age 15 remained stable, literacy differences favouring boys emerged by age 18. This suggests that early confidence predicts engagement, but skill development may diverge later due to varying opportunities and social pressures. The overall decline in both self-efficacy dimensions between 2018 and 2023, particularly among boys, may reflect broader challenges in sustaining digital confidence amid evolving technologies (Caeli et al., 2025). Such generational trends can also be read through the lens of cultural adaptation, where shifting technologies require continuous reconstruction of digital identities and literacies.

Grade levels show distinct patterns. Birney and McNamara (2023) found higher self-efficacy among 9th-grade females compared to older students, suggesting confidence may decline through high school. This aligns with observations that female self-efficacy peaks early in secondary education but decreases with increased task complexity, reduced support, or internalized stereotypes. Jennifer Ashlock, Miodrag Stojnic and Zeynep Tufekci (2022) identified significant gender gaps in secondary school (6th to 8th grade), indicating early emerging disparities that persist without intervention.

Task complexity interacts significantly with grade progression. Gebhardt et al. (2019) observed that 8th-grade females showed higher self-efficacy in basic tasks while males led in advanced tasks, a pattern that may intensify as curricula become

more technical. These findings highlight the need for age-appropriate interventions that help female students maintain confidence while tackling increasingly challenging ICT applications. Incorporating sociotechnical aspects of computing, as Randy Connolly (2020) suggests, can empower students to understand digital systems' societal impacts, enhancing engagement across genders.

Gender stereotypes persist despite increased school technology use, as Cussó-Calabuig et al. (2018) noted. Boys continue receiving favourable treatment in computer anxiety and self-efficacy measures, showing the enduring influence of cultural factors. Addressing these patterns requires combining educational interventions with broader efforts to challenge technology-related gender norms.

## Implications for Educational Policy and Practice

These findings carry important implications for educational policy and practice. First, general ICT self-efficacy's strong predictive role suggests prioritising foundational digital skills in curricula to build student confidence. This requires early technology exposure, as Nelson (2011) support, and enhanced teacher ICT training Chen (2023). Policies should also aim to cultivate "digital cultural capital" across genders, ensuring that technology use is embedded in inclusive, participatory learning cultures (Lesková et al., 2023).

Second, specialised self-efficacy's negative predictive effect highlights the need to align confidence with competence in advanced tasks. Curricula should feature hands-on, project-based learning that applies technical skills to real-world situations, reducing overconfidence risks. Programming workshops like those in Gunbatar and Karalar's (2018) study provide effective models.

Third, gender-specific interventions like ICT training for female students (Tam et al., 2020) should expand to address specialised task confidence gaps. These efforts should include stereotype-challenging initiatives, such as highlighting female technology leaders and role models. Parent and teacher support (Chen, 2023; Nelson, 2011), remains crucial for equitable engagement. Teacher training on gender-responsive digital pedagogy (Cho & Huang, 2024) can mitigate biases and foster inclusive digital learning environments.

Finally, closing gender gaps requires equitable technological access in schools and homes. Policymakers should support initiatives like laptop programmes (Schaumburg, 2001) and ensure adequate digital infrastructure in underserved areas, as studied in South Pakistan (Majeed & Ahmad, 2024). Curricular integration of ICT across disciplines, as recommended by Diego Campos and Ronny Scherer (2024), can normalise advanced tasks and reduce gendered perceptions of technology. Broader initiatives that frame technology as a tool for global citizenship and intercultural understanding can further strengthen cross-cultural educational equity (Mazur et al, 2025).

## CONCLUSIONS

This study examined the predictive dynamics of students' ICT self-efficacy, both general (S\_GENEFF) and specialised (S\_SPECEFF), on their computer and information literacy (CIL) scores using ICILS 2018 and 2023 data. Findings consistently showed that general ICT self-efficacy positively predicted CIL scores across both genders and years, affirming its central role in digital competence. Conversely, specialised ICT self-efficacy negatively predicted CIL scores, with stronger negative effects in 2023, suggesting a potential mismatch between perceived and actual competence in advanced digital tasks.

Gender-based analyses revealed that boys consistently reported higher S\_SPECEFF scores, with effect sizes in 2018 that generally declined by 2023, indicating a narrowing gender gap. However, girls' self-efficacy scores, particularly in general applications, also declined in several countries, highlighting a broader decrease in digital confidence over time. The negative predictive effect of S\_SPECEFF on girls' CIL scores intensified in most countries by 2023, though country-level patterns varied: while the effect strengthened in the majority of countries, Italy and Uruguay showed the opposite trend, with the negative association weakening over time. Despite these declines, general self-efficacy remained a positive predictor of CIL for both genders.

Overall, the results suggest that while gender disparities in ICT self-efficacy are gradually diminishing in terms of the gender gap in S\_SPECEFF scores, overall student confidence in digital skills appears to be weakening. Notably, the negative relationship between specialised self-efficacy and CIL performance became more pronounced by 2023, suggesting that the misalignment between perceived and actual digital competence may be deepening, particularly for girls in most countries. Educational efforts should therefore focus on strengthening both general and specialized ICT competencies, ensuring that self-efficacy aligns with demonstrated skills, and supporting all students in becoming confident, capable participants in an increasingly digital world.

## LIMITATIONS AND FUTURE RESEARCH

Despite the use of cross-national data, this study has several limitations. First, the self-efficacy measures used in ICILS may not fully capture the socio-affective and identity-related dimensions of technological confidence. Second, the cross-sectional design limits the ability to establish causal relationships between self-efficacy and performance across time.

Future studies should adopt longitudinal and mixed-methods approaches to better understand how self-efficacy evolves with experience and exposure to technology. Qualitative and comparative research could further explore how educational environments, teaching practices, and access to digital resources shape students' confidence and competence across different contexts.

## USE OF ARTIFICIAL INTELLIGENCE TOOLS

The authors acknowledge the use of OpenAI ChatGPT for translation, language editing, and proofreading purposes only. The use of generative AI did not involve data analysis, interpretation of results, or generation of original scientific content. All intellectual responsibility for the manuscript remains with the authors.

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## APPENDIX

Table A1

Summary of Means, Standard Deviations, *t*-Tests, and Effect Sizes by Gender

Countries	Factors	Gender	2018						2023					
			N	M	SD	t	d	di	N	M	SD	t	d	di
Chile	S_GENEFF	Boy	1474	51.34	9.20	2.39*	0.087	No Effect	1346	49.80	11.50	1.64*	0.06	No Effect
	S_GENEFF	Girl	1522	52.12	8.52				1342	50.49	10.31			
	S_SPECEFF	Boy	1474	52.19	9.46	5.32*	0.194	No Effect	1346	50.05	10.64	1.18		
	S_SPECEFF	Girl	1522	50.39	9.07				1342	49.57	10.29			
Denmark	S_GENEFF	Boy	1187	52.10	8.41	0.31			1414	50.65	8.47	6.53*	0.25	Intermediate Effect
	S_GENEFF	Girl	1158	52.00	7.87				1361	48.73	6.88			
Finland	S_SPECEFF	Boy	1187	51.26	9.19	22.57*	0.932	Large Effect	1414	47.77	9.51	12.88*	0.49	Small Effect
	S_SPECEFF	Girl	1158	43.05	8.41				1361	43.29	8.80			
	S_GENEFF	Boy	1235	52.35	9.53	1.06			1955	49.74	10.29	5.06*	0.16	No Effect
	S_GENEFF	Girl	1226	51.98	7.92				2040	48.27	8.07			
France	S_SPECEFF	Boy	1235	52.44	8.65	13.55*	0.558	Intermediate Effect	1955	50.48	9.82	14.91*	0.472	Small Effect
	S_SPECEFF	Girl	1226	47.82	8.28				2040	46.10	8.74			
	S_GENEFF	Boy	1379	49.68	9.62	1.05			1628	52.29	9.99	2.93*	0.102	No Effect
	S_GENEFF	Girl	1388	49.31	8.81				1661	51.34	8.58			
S_SPECEFF	Boy	1379	51.83	9.92	9.22*	0.351	Small Effect	1628	51.46	9.62	9.53*	0.332	Small Effect	
	Girl	1388	48.44	9.44				1661	48.31	9.34				

Countries	Factors	Gender	2018						2023					
			N	M	SD	t	d	di	N	M	SD	t	d	di
Germany	S_GENEFF	Boy	1517	49.16	9.94	0.98		2106	50.92	9.51	3.62*	0.112	No Effect	
	S_GENEFF	Girl	1475	48.83	8.45			2080	49.96	7.63				
	S_SPECEFF	Boy	1517	51.16	9.54	17.52*	0.641	Intermediate Effect	2106	48.38	9.69	12.52*	0.387	Small Effect
	S_SPECEFF	Girl	1475	45.19	9.06			2080	44.81	8.74				
Germany, North- Rhine Westphalia	S_GENEFF	Boy	798	48.59	9.68	0.55		1090	51.14	9.57	2.13*	0.092	No Effect	
	S_GENEFF	Girl	771	48.34	8.53			1050	50.33	7.82				
Italy	S_SPECEFF	Boy	798	50.87	9.15	12.66*	0.639	Intermediate Effect	1090	48.53	9.78	8.88*	0.381	Small Effect
	S_SPECEFF	Girl	771	45.01	9.18			1050	44.92	9.00				
Kazakh- stan	S_GENEFF	Boy	1425	49.73	9.66	1.51		1672	51.22	9.50	0.95			
	S_GENEFF	Girl	1303	50.27	8.96			1616	50.94	7.67				
	S_SPECEFF	Boy	1425	50.70	9.97	8.31*	0.319	Small Effect	1672	49.41	9.38	5.47*	0.451	Small Effect
	S_SPECEFF	Girl	1303	47.58	9.61			1616	47.74	8.11				
Korea, Republic of	S_GENEFF	Boy	1544	45.30	13.30	2.85*	0.104	No Effect	2323	46.90	10.56	5.31*	0.157	No Effect
	S_GENEFF	Girl	1482	46.68	13.23			2245	48.47	9.51				
	S_SPECEFF	Boy	1544	53.95	10.62	2.65*	0.096	No Effect	2323	52.21	9.16	1.23		
	S_SPECEFF	Girl	1482	53.07	10.78			2245	52.54	8.84				
Korea, Republic of	S_GENEFF	Boy	1489	46.63	11.49	10.56*	0.395	Small Effect	1861	46.22	10.54	6.58*	0.218	Small Effect
	S_GENEFF	Girl	1378	50.84	9.82			1791	48.40	9.42				
Korea, Republic of	S_SPECEFF	Boy	1489	49.00	11.25	3.4*	0.127	Small Effect	1861	49.45	10.23	0.49		
	S_SPECEFF	Girl	1378	47.47	9.63			1791	49.29	9.40				

Countries	Factors	Gender	2018					2023									
			N	M	SD	t	d	di	N	M	SD	t	d	di			
Luxembourg	S_GENEFF	Boy	2571	48.54	10.84	0.33						2078	49.39	10.39	1.99*	0.062	No Effect
	S_GENEFF	Girl	2385	48.44	9.64							2041	48.79	8.63			
Portugal	S_SPECEFF	Boy	2571	52.28	10.60	16.12*	0.458	Intermediate Effect	2078	50.37	10.13	12.66*	0.397	Small Effect			
	S_SPECEFF	Girl	2385	47.56	10.02				2041	46.49	9.53						
	S_GENEFF	Boy	1622	52.78	8.99	0.44			1756	50.53	10.22	0.54					
	S_GENEFF	Girl	1549	52.64	8.38				1768	50.70	8.88						
United States	S_SPECEFF	Boy	1622	52.98	9.37	9.1*	0.323	Small Effect	1756	51.83	9.28	4.51*	0.152	No Effect			
	S_SPECEFF	Girl	1549	50.00	9.05				1768	50.47	8.62						
United States	S_GENEFF	Boy	2995	50.37	10.04	7.45*	0.193	No Effect	908	48.87	10.97	1.78					
	S_GENEFF	Girl	2987	52.17	8.67				977	49.72	9.58						
Uruguay	S_SPECEFF	Boy	2995	49.99	10.38	7.76*	0.201	Small Effect	908	48.69	9.93	3.97*	0.183	No Effect			
	S_SPECEFF	Girl	2987	48.02	9.16				977	46.94	9.22						
Uruguay	S_GENEFF	Boy	1020	49.67	10.22	2.59*	0.115	No Effect	1263	49.02	9.99	3.67*	0.148	No Effect			
	S_GENEFF	Girl	1025	50.80	9.46				1186	50.39	8.43						
	S_SPECEFF	Boy	1020	52.08	10.36	3.62*	0.160	No Effect	1263	49.54	9.43	2.27*	0.092	No Effect			
	S_SPECEFF	Girl	1025	50.47	9.68				1186	48.72	8.57						

*Note.* S\_GENEFF: ICT self-efficacy regarding the use of general applications, S\_SPECEFF: ICT self-efficacy regarding the use of specialised applications, d: Effect size d, di: Effect size d's interpretation.

*Source.* Own research.

**Table A2**  
*Summary of Means, Standard Deviations, t-Tests, and Effect Sizes by Gender and Year*

Countries	Factors	Gender	2018			2023			Differences		
			N	M	SD	N	M	SD	t	d	df
Chile	S_GENEFF	Boy	1474	51.34	9.20	1346	49.80	11.50	-3.90*	0.15	No Effect
		Girl	1522	52.12	8.52	1342	50.49	10.31	-4.56*	0.17	No Effect
Denmark	S_SPECEFF	Boy	1474	52.19	9.46	1346	50.05	10.64	-5.63*	0.21	Small Effect
		Girl	1522	50.39	9.07	1342	49.57	10.29	-2.24*	0.08	No Effect
Denmark	S_GENEFF	Boy	1187	52.10	8.41	1414	50.65	8.47	-4.38*	0.17	No Effect
		Girl	1158	52.00	7.87	1361	48.73	6.88	-11.01*	0.44	Small Effect
Finland	S_SPECEFF	Boy	1187	51.26	9.19	1414	47.77	9.51	-9.48*	0.37	No Effect
		Girl	1158	43.05	8.41	1361	43.29	8.80	0.69	0.03	No Effect
Finland	S_GENEFF	Boy	1235	52.35	9.53	1955	49.74	10.29	-7.32*	0.26	Small Effect
		Girl	1226	51.98	7.92	2040	48.27	8.07	-12.88*	0.46	Small Effect
France	S_SPECEFF	Boy	1235	52.44	8.65	1955	50.48	9.82	-5.91*	0.21	Small Effect
		Girl	1226	47.82	8.28	2040	46.10	8.74	-5.61*	0.20	Small Effect
France	S_GENEFF	Boy	1379	49.68	9.62	1628	52.29	9.99	7.29*	0.27	Small Effect
		Girl	1388	49.31	8.81	1661	51.34	8.58	6.40*	0.23	Small Effect
France	S_SPECEFF	Boy	1379	51.83	9.92	1628	51.46	9.62	-1.05	0.04	No Effect
		Girl	1388	48.44	9.44	1661	48.31	9.34	-0.39	0.01	No Effect

Countries	Factors	Gender	2018				2023				Differences		
			N	M	SD	N	M	SD	t	d	di		
Germany	S_GENEFF	Boy	1517	49.16	9.94	2106	50.92	9.51	5.37*	0.18	No Effect		
		Girl	1475	48.83	8.45	2080	49.96	7.63	4.09*	0.14	No Effect		
Germany, North-Rhine Westphalia	S_SPECEFF	Boy	1517	51.16	9.54	2106	48.38	9.69	-8.57*	0.29	Small Effect		
		Girl	1475	45.19	9.06	2080	44.81	8.74	-1.24	0.04			
Germany, North-Rhine Westphalia	S_GENEFF	Boy	798	48.59	9.68	1090	51.14	9.57	5.67*	0.26	Small Effect		
		Girl	771	48.34	8.53	1050	50.33	7.82	5.10*	0.24	Small Effect		
Italy	S_SPECEFF	Boy	798	50.87	9.15	1090	48.53	9.78	-5.33*	0.25	Small Effect		
		Girl	771	45.01	9.18	1050	44.92	9.00	-0.22	0.01			
Italy	S_GENEFF	Boy	1425	49.73	9.66	1672	51.22	9.50	4.31*	0.16	No Effect		
		Girl	1303	50.27	8.96	1616	50.94	7.67	2.13*	0.08	No Effect		
Kazakhstan	S_SPECEFF	Boy	1425	50.70	9.97	1672	49.41	9.38	-3.70*	0.13	No Effect		
		Girl	1303	47.58	9.61	1616	47.74	8.11	0.47	0.02			
Kazakhstan	S_GENEFF	Boy	1544	45.30	13.30	2323	46.90	10.56	3.96*	0.13	No Effect		
		Girl	1482	46.68	13.23	2245	48.47	9.51	4.51*	0.16	No Effect		
Kazakhstan	S_SPECEFF	Boy	1544	53.95	10.62	2323	52.21	9.16	-5.28*	0.18	No Effect		
		Girl	1482	53.07	10.78	2245	52.54	8.84	-1.59	0.05			
Korea, Republic of	S_GENEFF	Boy	1489	46.63	11.49	1861	46.22	10.54	-1.07	0.04			
		Girl	1378	50.84	9.82	1791	48.40	9.42	-7.06*	0.25	Small Effect		
Korea, Republic of	S_SPECEFF	Boy	1489	49.00	11.25	1861	49.45	10.23	1.19	0.04			
		Girl	1378	47.47	9.63	1791	49.29	9.40	5.35*	0.19	Small Effect		

Countries	Factors	Gender	2018			2023			Differences		
			N	M	SD	N	M	SD	t	d	di
Luxembourg	S_GENEFF	Boy	2571	48.54	10.84	2078	49.39	10.39	2.72	0.08	
		Girl	2385	48.44	9.64	2041	48.79	8.63	1.28	0.04	
Portugal	S_SPECEFF	Boy	2571	52.28	10.60	2078	50.37	10.13	-6.27*	0.18	No Effect
		Girl	2385	47.56	10.02	2041	46.49	9.53	-3.64*	0.11	No Effect
	S_GENEFF	Boy	1622	52.78	8.99	1756	50.53	10.22	-6.81*	0.23	Small Effect
		Girl	1549	52.64	8.38	1768	50.70	8.88	-6.47*	0.22	Small Effect
United States	S_SPECEFF	Boy	1622	52.98	9.37	1756	51.83	9.28	-3.59*	0.12	No Effect
		Girl	1549	50.00	9.05	1768	50.47	8.62	1.51	0.05	
	S_GENEFF	Boy	2995	50.37	10.04	908	48.87	10.97	-3.66*	0.14	No Effect
		Girl	2987	52.17	8.67	977	49.72	9.58	-7.10*	0.27	Small Effect
Uruguay	S_SPECEFF	Boy	2995	49.99	10.38	908	48.69	9.93	-3.41*	0.13	No Effect
		Girl	2987	48.02	9.16	977	46.94	9.22	-3.19*	0.12	No Effect
	S_GENEFF	Boy	1020	49.67	10.22	1263	49.02	9.99	-1.53	0.06	
		Girl	1025	50.80	9.46	1186	50.39	8.43	-1.07	0.05	
	S_SPECEFF	Boy	1020	52.08	10.36	1263	49.54	9.43	-6.04*	0.26	Small Effect
		Girl	1025	50.47	9.68	1186	48.72	8.57	-4.47*	0.19	Small Effect

Note. \* $p < .05$ .

Source. Own research.

**Table A3**  
*Regression Analysis Results for Boys in 2018 and 2023*

Countries	Factors	2018					2023				
		B	SE	$\beta$	t	R <sup>2</sup>	B	SE	$\beta$	t	R <sup>2</sup>
Chile	Constant	393.30	20.96			0.17	406.36	16.44			0.13
	S_GENEFF	4.17	0.36	0.47	13.33***		3.51	0.28	0.43	13.19***	
	S_SPECEFF	-2.50	0.44	-0.28	-5.86***		-2.87	0.37	-0.32	-7.99***	
Denmark	Constant	394.91	16.46			0.17	420.95	18.33			0.11
	S_GENEFF	3.70	0.33	0.45	12.06***		3.27	0.33	0.38	10.95***	
	S_SPECEFF	-0.82	0.26	-0.11	-3.11**		-1.48	0.24	-0.20	-6.10***	
Finland	Constant	418.50	18.89			0.2	485.08	14.38			0.11
	S_GENEFF	4.48	0.38	0.52	14.22***		3.27	0.30	0.42	12.53***	
	S_SPECEFF	-2.50	0.34	-0.26	-7.72***		-2.81	0.26	-0.34	-11.48***	
France	Constant	441.86	14.26			0.11	449.83	11.13			0.1
	S_GENEFF	3.00	0.34	0.37	9.60***		2.72	0.25	0.39	11.13***	
	S_SPECEFF	-1.87	0.30	-0.24	-6.35***		-1.72	0.22	-0.24	-8.33***	
Germany	Constant	440.78	26.50			0.11	414.02	18.01			0.1
	S_GENEFF	3.05	0.44	0.37	8.57***		3.46	0.44	0.38	9.13***	
	S_SPECEFF	-1.47	0.26	-0.17	-5.30***		-1.68	0.42	-0.19	-4.23***	
Germany, North-Rhine Westphalia	Constant	425.32	18.30			0.13	366.86	17.26			0.14
	S_GENEFF	3.18	0.32	0.40	12.17***		4.20	0.46	0.46	10.85***	
	S_SPECEFF	-1.17	0.35	-0.14	-3.35***		-1.77	0.70	-0.20	-2.81***	

Countries	Factors	2018					2023				
		B	SE	$\beta$	t	R <sup>2</sup>	B	SE	$\beta$	t	R <sup>2</sup>
Italy	Constant	331.35	15.55			0.17	409.23	12.33			0.11
	S_GENEFF	3.83	0.27	0.46	16.22***		3.08	0.22	0.40	16.01***	
	S_SPECEFF	-1.29	0.27	-0.16	-4.72***		-1.63	0.24	-0.21	-6.78***	
Kazakhstan	Constant	336.70	16.90			0.14	416.35	12.92			0.13
	S_GENEFF	3.86	0.45	0.50	11.12***		4.31	0.33	0.50	13.90***	
	S_SPECEFF	-2.06	0.48	-0.21	-4.73***		-4.04	0.36	-0.40	-12.30***	
Korea, Republic of	Constant	371.93	14.38			0.23	476.99	11.86			0.09
	S_GENEFF	4.81	0.27	0.57	20.26***		3.30	0.28	0.41	12.30***	
	S_SPECEFF	-1.49	0.29	-0.17	-5.08***		-2.00	0.30	-0.24	-6.60***	
Luxembourg	Constant	416.80	7.94			0.14	430.63	11.21			0.11
	S_GENEFF	3.23	0.17	0.42	20.87***		3.52	0.24	0.42	16.73***	
	S_SPECEFF	-1.82	0.16	-0.23	-11.24***		-2.14	0.25	-0.25	-8.58***	
Portugal	Constant	472.48	17.89			0.18	456.79	13.14			0.12
	S_GENEFF	3.49	0.38	0.44	9.70***		3.66	0.28	0.48	14.96***	
	S_SPECEFF	-2.74	0.33	-0.35	-9.37***		-2.55	0.30	-0.31	-9.17***	
United States	Constant	393.63	8.90			0.17	408.05	25.41			0.17
	S_GENEFF	3.69	0.17	0.46	24.24***		4.67	0.49	0.49	10.99***	
	S_SPECEFF	-1.33	0.18	-0.17	-7.32***		-3.15	0.67	-0.30	-5.03***	
Uruguay	Constant	388.41	22.40			0.18	374.27	19.78			0.16
	S_GENEFF	4.33	0.35	0.46	13.79***		4.59	0.32	0.47	14.84***	
	S_SPECEFF	-2.61	0.36	-0.29	-7.38***		-2.84	0.41	-0.28	-6.73***	

Note. \*  $p < 0.05$  ( $t_{\text{critical}} = 1.96$ ); \*\*  $p < 0.01$  ( $t_{\text{critical}} = 2.58$ ); \*\*\*  $p < 0.001$  ( $t_{\text{critical}} = 3.29$ ).  
Source. Own research.

**Table A4**  
*Regression Analysis Results for Girls in 2018 and 2023*

Countries	Factors	2018				2023					
		B	SE	$\beta$	t	R <sup>2</sup>	B	SE	$\beta$	t	R <sup>2</sup>
Chile	Constant	392.03	20.48			0.15	395.99	16.29			0.13
	S_GENEFF	3.94	0.48	0.42	9.04***		3.96	0.38	0.44	10.64***	
	S_SPECEFF	-2.26	0.44	-0.25	-5.51***		-3.01	0.33	-0.34	-9.43***	
Denmark	Constant	483.68	18.31			0.08	491.09	15.95			0.08
	S_GENEFF	2.04	0.29	0.28	8.01***		2.62	0.33	0.27	8.27***	
	S_SPECEFF	-0.62	0.30	-0.09	-2.12*		-1.92	0.27	-0.25	-7.31***	
Finland	Constant	463.14	17.68			0.12	497.86	13.57			0.11
	S_GENEFF	3.45	0.36	0.39	10.34***		3.22	0.27	0.35	13.06***	
	S_SPECEFF	-1.98	0.37	-0.23	-5.48***		-2.80	0.29	-0.33	-10.08***	
France	Constant	458.49	18.40			0.08	446.85	12.23			0.09
	S_GENEFF	2.48	0.31	0.30	9.11***		2.82	0.26	0.35	11.49***	
	S_SPECEFF	-1.36	0.26	-0.17	-5.19***		-1.68	0.25	-0.23	-7.25***	
Germany	Constant	469.67	20.93			0.06	465.25	18.55			0.06
	S_GENEFF	2.13	0.35	0.25	6.25***		2.76	0.43	0.26	7.29***	
	S_SPECEFF	-0.91	0.34	-0.11	-2.68**		-1.88	0.35	-0.20	-5.68***	
Germany, North-Rhine Westphalia	Constant	487.30	22.41			0.03	450.61	19.40			0.07
	S_GENEFF	1.49	0.39	0.18	3.95***		2.99	0.45	0.28	7.08***	
	S_SPECEFF	-0.76	0.28	-0.10	-2.72**		-2.29	0.38	-0.25	-6.00***	

Countries	Factors	2018					2023				
		B	SE	$\beta$	t	R <sup>2</sup>	B	SE	$\beta$	t	R <sup>2</sup>
Italy	Constant	354.47	12.20			0.17	458.46	16.38			0.05
	S_GENEFF	3.91	0.26	0.45	16.32***		2.27	0.28	0.25	8.91***	
	S_SPECEFF	-1.65	0.25	-0.21	-6.87***		-1.50	0.28	-0.18	-5.18***	
Kazakhstan	Constant	343.56	17.99			0.14	391.72	17.50			0.09
	S_GENEFF	3.59	0.37	0.47	11.28***		3.52	0.36	0.39	10.58***	
	S_SPECEFF	-2.00	0.42	-0.21	-4.95***		-2.73	0.39	-0.29	-7.31***	
Korea, Republic of	Constant	373.81	17.12			0.21	483.07	13.81			0.11
	S_GENEFF	4.59	0.36	0.50	14.13***		3.72	0.29	0.42	12.03***	
	S_SPECEFF	-0.95	0.32	-0.10	-3.00**		-2.15	0.31	-0.24	-6.87***	
Luxembourg	Constant	459.21	10.24			0.08	439.28	11.96			0.11
	S_GENEFF	2.16	0.17	0.27	12.98***		3.52	0.25	0.39	16.44***	
	S_SPECEFF	-1.37	0.14	-0.18	-9.97***		-2.16	0.23	-0.26	-9.57***	
Portugal	Constant	487.02	15.38			0.07	454.21	14.17			0.14
	S_GENEFF	2.14	0.38	0.27	6.29***		3.95	0.29	0.44	16.40***	
	S_SPECEFF	-1.55	0.29	-0.21	-5.69***		-2.71	0.31	-0.30	-9.93***	
United States	Constant	390.72	9.19			0.16	437.29	19.68			0.03
	S_GENEFF	3.65	0.18	0.42	22.16***		5.04	0.47	0.46	11.44***	
	S_SPECEFF	-0.99	0.18	-0.12	-5.58***		-3.92	0.46	-0.35	-9.16***	
Uruguay	Constant	392.62	19.80			0.18	374.93	23.64			0.02
	S_GENEFF	4.13	0.35	0.43	13.77***		3.37	0.39	0.31	9.61***	
	S_SPECEFF	-2.64	0.39	-0.28	-6.96***		-1.65	0.49	-0.16	-3.45***	

Note. \*  $p < 0.05$  ( $t_{critical} = 1.96$ ); \*\*  $p < 0.01$  ( $t_{critical} = 2.58$ ); \*\*\*  $p < 0.001$  ( $t_{critical} = 3.29$ ).

Source. Own research.