Digital Literacy in Context: A Multilevel Analysis of Individual, School, and Country Inequalities Using ICILS Data

# 1. Introduction

Over the last years, new technologies and the use of digital devices have expanded at an exponential pace. In this context, the proliferation of Information and Communication Technologies (ICT) plays a highly relevant role in society, as they have fostered improvements in human quality of life and have contributed to diverse fields such as health, education, banking, transportation, and digital governance (Pritika Reddy, Sharma, and Chandra 2020; Nand and Sharma 2019; Bibhya Nand Sharma et al. 2018; P. Reddy, Sharma, and Chandra 2017; Pojani and Stead 2015; Bibhya N. Sharma et al. 2015). There is no doubt that ICTs have the potential to foster individual agency in new environments involving digital activities, which consequently leads to integration into society and prevents marginalization from proper citizenship (Barroso and Cabero 2011; Cabero 2016). However, the differential mastery of digital technologies also have the potential of widening several social gaps in which they are embedded. This phenomenon has been termed the *digital divide*, which refers to the gap between individuals and societies that can access and participate in the information age and those who cannot (Dijk 2020). These inequalities need to be addressed, as they can shape life chances in multiple dimensions (Robinson et al. 2015).

In a world marked by digitalization and the inequalities that accompany it, digital literacy has become essential in order to reduce these gaps (García-Ávila 2017). This concept refers to a set of technical, cognitive, and metacognitive skills that enable individuals to effectively engage in old and new spaces mediated by digital technology (Guillén-Rascón, Ascensio-Baca, and Tarango 2016; Tinmaz et al. 2022). Part of its relevance has been expressed in the growing concern about measuring digital competences at school-age in a series of international large-scale assessments (i.e. PISA, TIMSS). Among these studies, ICILS is the only international comparative study that incorporate concrete measures of performance in digital literacy. ICILS operationalizes the concept of Computer and Information Literacy to study as “an individual’s ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society” (Fraillon et al. 2013). This is measured applying a standardized practical test to students, and its results have reflected the high disparity in digital literacy between regions (Tinmaz, Fanea-Ivanovici, and Baber 2022).

This paper seeks to address a specific aspect of the digital divide related to the socialization and learning of digital literacy during school age. Schools play a pivotal role in equipping students with the necessary skills to navigate and participate in the digital world, as the educational environment not only provides access to ICTs but also fosters the development of digital competencies through formal instruction and peer interactions (Trucco and Sunkel 2010). To this regard, the early exposure to digital technologies and guided learning experiences have the potential to mitigate existing inequalities at individual, school and country level. By emphasizing the importance of digital literacy as a core component of education, this study highlights how this socio-structural gaps — as socioeconomic status, cultural capital and gender — can be moderated by contextual factors, such as national digital infrastructure, gender gaps in society, and the share of investment in education as part of the national GDP.

# 2. Individual and contextual inequalities in digital literacy

## 2.1 Student level factors

Family social status remains a crucial determinant of students’ digital knowledge and abilities. Recent studies demonstrate that children from higher socio-economic backgrounds benefit from greater access to digital devices, high-speed internet, and supportive home environments, which collectively foster the development of digital skills (Scherer et al. 2023). These families are more likely to provide educational resources, parental guidance, and opportunities for informal digital learning, further enhancing digital literacy (Gui, Fasoli, and Carradore 2023). In contrast, students from lower socio-economic backgrounds often encounter barriers such as limited access to technology and less parental support, which restrict their opportunities to acquire and practice digital competencies (Vandenbulck and De Marez 2022). This persistent disparity in access and support perpetuates broader social inequalities, as digital skills are increasingly vital for educational success and participation in the digital economy.

Gender is a significant factor influencing digital literacy, though recent evidence suggests the nature of this relationship is evolving. While earlier studies often reported that boys held an advantage in digital skills, more recent cross-national research finds that gender gaps are narrowing or even reversing, with girls in some contexts outperforming boys in digital literacy assessments (Caponera, Annunziata, and Palmerio 2025; Siddiq, Scherer, and Tondeur 2016; Gui, Fasoli, and Carradore 2023). Girls tend to excel in competencies related to information management, communication, and safe online behavior, whereas boys may show strengths in technical or gaming-related domains. These patterns are shaped by socialization processes, cultural expectations, and differential access to digital resources at home and school. Importantly, the extent of gender differences in digital literacy is influenced by broader societal gender norms and policies, suggesting that both individual and contextual factors must be considered to understand and address gender disparities in digital skills development (Gui, Fasoli, and Carradore 2023).

Digital self-efficacy (DSE) is another concept widely recognized as a key predictor of students’ digital literacy. Students who believe in their ability to effectively use digital technologies are more likely to engage with digital tools, explore new applications, and persist in overcoming challenges (Scherer et al. 2023; Tsai and Tsai 2010). Higher DSE is associated with greater confidence in navigating online environments, which translates into improved digital skills and learning outcomes (Hatlevik, Gumundsdóttir, and Loi 2015). Furthermore, the frequency and diversity of online learning-related tasks performed at school —such as collaborating on digital platforms, conducting research, or submitting assignments electronically— provide students with practical opportunities to develop and refine their digital competencies (Fraillon et al. 2020). Empirical evidence suggests that students who regularly participate in such activities demonstrate higher levels of digital literacy, as these experiences foster both technical proficiency and critical thinking skills necessary for effective digital engagement (Fraillon et al. 2020; Tsai and Tsai 2010). Thus, both DSE and exposure to online learning tasks at school serve as important mechanisms through which educational environments can help bridge digital skill gaps.

## 2.2 Country level inequalities

Cross-national differences in digital literacy are shaped by a range of country-level factors, including economic development, national digital infrastructure, educational investment, and gender equality indicators. First, countries with higher Gross Domestic Product (GDP) per capita tend to provide better access to digital resources, both at home and at schools, which facilitates the acquisition of digital skills among students. Furthermore, economic prosperity enables greater investment in educational technology, teacher training, and digital learning environments, thereby supporting higher average digital literacy scores (Scherer et al. 2023).

Second, the quality and reach of national digital infrastructure—such as broadband internet penetration, device availability, and connectivity in schools—play a critical role in enabling students to engage with digital tools and resources. Countries with advanced digital infrastructure offer more equitable opportunities for students to develop digital competencies, while those with limited infrastructure may exacerbate existing inequalities (Fraillon et al. 2020). Investments in national ICT infrastructure are thus essential for fostering digital inclusion and supporting effective digital learning.

Third, the level of educational investment—often measured as the share of national GDP allocated to education—directly impacts the resources available for schools, teacher professional development, and the integration of digital technologies into curricula. Higher educational investment can reduce disparities in access to digital tools and support the implementation of digital literacy programs, thereby improving overall student outcomes and narrowing digital divides.

Finally, gender equality at the societal level can influence the extent of gender gaps in digital literacy. In countries with higher gender equality—measured by indicators such as the Global Gender Gap Index or female labor force participation—girls are more likely to access digital resources and receive encouragement to develop digital skills. These contexts may see narrower or even reversed gender gaps in digital literacy, as supportive policies and cultural norms promote equal opportunities for both boys and girls (Gui, Fasoli, and Carradore 2023). Conversely, in countries with persistent gender disparities, girls may face additional barriers to digital engagement, resulting in lower digital literacy outcomes.

# 3. Hypotheses

**Level 1 Hypotheses**

: A better performance in digital literacy is associated to family socio-economic status.

Girls outperform boys in digital literacy scores.

: The more online learning-related tasks the student performs at school, the higher their digital literacy score.

: Students with higher self-efficacy exhibit a better performance in digital literacy.

**Level 2 Hypotheses**

: Students of more affluent countries (as measured by GDP) show higher scores in digital literacy

: Countries with a larger investment in education perform better in digital literacy

: In countries with less gender inequalities, girls achieve better scores than boys in digital literacy

: The positive association between family status and digital literacy is negatively moderated by educational investment

# 4. Methods

The present study uses the database from the 2023 cycle of International Computer and Information Literacy Study (N = 135.615), which was applied in 35 countries. Oman, Taiwan, Kosovo and Germany (North Rhine-Westphalia) were excluded due to have missing information in some country level variables, leaving 96.887 students nested in 31 countries. Level two variables such as PIB and context gender indicators were collected from external resources as the World Bank and the Quality of Government database.

The hypotheses are tested in a multi-level (random effects) framework. Level one variables were centered to the country-group (CMC) (Enders and Tofighi 2007). We estimate a series of models:

where:

* is the digital literacy score for student in country .
* is the grand mean intercept.
* is the random effect for country .
* is the residual error for student in country .
* and are proxies for family socio-economic status.
* is a binary indicator for student gender.
* measures the frequency of online learning-related tasks at school.
* is the student’s self-reported digital self-efficacy.
* is the GDP per capita for country .
* is a country-level indicator of gender inequality.
* is the share of GDP invested in education for country .
* is a measure of national digital infrastructure or e-government development.

Each model incrementally adds predictors at the individual and country levels to test the hypotheses regarding digital literacy inequalities.

# 5. Results

The null model reports a intra-class correlation of 19%, corresponding to the variance in digital literacy due to country belonging. In addition, is statistically significant (p < 0.001), justifying the use of multilevel models to understand differences in digital literacy scores between countries.

Regarding the individuals hypotheses, there is evidence in favor of , meaning that having at least one of the parents with an university degree increases the digital literacy score by 18.69 — compared to those students without university-educated parents. Individual gender is also significant (), whereby girls score 12.27 points higher than boys in digital literacy. Regarding the impact of school ICT tasks (), there is a positive small effect ( = 0.07; p < 0.05), whereas for each additional unit in digital self-efficacy () the digital literacy score increases in 0.04.

Regarding country-level hypotheses, the preliminary analysis so far shows that children in countries with higher GDP scores 25.34 more than children in countries with less GDP. Also, a country with the major gender inequalities scores -202.99 than a country with lowest gender inequalities. Countries investment in education has no significant effect.

Further steps involve testing the interaction hypotheses as well as estimating three-level models, considering students, schools, and countries, in order to thoroughly analyze the factors that affect differences in digital literacy among students. To this regard, further models will include variables at the school level such as gender and socioeconomic classroom composition.

The code and preliminary results are available in our open repository in Github: https://github.com/tomasurzuam/icils\_multilevel.

# 6. References

Barroso, J., and J. Cabero. 2011. *La Investigación Educativa En TIC*. Madrid: Síntesis.

Cabero, Julio. 2016. *Tendencias educativas para el siglo XXI*.

Caponera, Elisa, Francesco Annunziata, and Laura Palmerio. 2025. “Exploring Gender Differences in ICT Skills: Insights from Italian Results in ICILS 2023.” Italy.

Dijk, Jan van. 2020. *The Digital Divide*. Cambridge Medford: Polity.

Enders, C. K., and D. Tofighi. 2007. “Centering Predictor Variables in Cross-Sectional Multilevel Models: A New Look at an Old Issue.” *Psychological Methods* 12 (2): 121.

Fraillon, Julian, John Ainley, Wolfram Schulz, Tim Friedman, and Daniel Duckworth. 2020. *Preparing for Life in a Digital World: IEA International Computer and Information Literacy Study 2018 International Report*. Springer Nature. <https://doi.org/10.1007/978-3-030-38781-5>.

Fraillon, Julian, Wolfram Schulz, Tim Friedman, John Ainley, and Eveline Gebhardt. 2013. *ICILS 2013: Technical Report*. Amsterdam Netherlands: IEA Secretariat.

García-Ávila, Susana. 2017. “Alfabetización Digital.” *Razón y Palabra* 21 (3\_98): 66–81.

Gui, Marco, Marcella Fasoli, and Riccardo Carradore. 2023. “Digital Parenting and Digital Literacy: How Family Context Shapes Children’s Digital Skills.” *New Media & Society* 25 (2): 389–407.

Guillén-Rascón, Gladys, Gerardo Ascensio-Baca, and Javier Tarango. 2016. “Alfabetización digital: una perspectiva sociológica.” *e-Ciencias de la Información*, June, 1–21. <https://doi.org/10.15517/eci.v6i2.23938>.

Hatlevik, Ove Edvard, Gréta Björk Gumundsdóttir, and Massimo Loi. 2015. “Digital Diversity Among Upper Secondary Students: A Multilevel Analysis of the Relationship Between Cultural Capital, Self-Efficacy, Strategic Use of Information and Digital Competence.” *Computers & Education* 81 (February): 345–53. <https://doi.org/10.1016/j.compedu.2014.10.019>.

Nand, Ravneil, and Anuraganand Sharma. 2019. “Meta-Heuristic Approaches to Tackle Skill Based Group Allocation of Students in Project Based Learning Courses.” In *2019 IEEE Congress on Evolutionary Computation (CEC)*, 1782–89. <https://doi.org/10.1109/CEC.2019.8789987>.

Pojani, Dorina, and Dominic Stead. 2015. “Sustainable Urban Transport in the Developing World: Beyond Megacities.” *Sustainability* 7 (6): 7784–7805. <https://doi.org/10.3390/su7067784>.

Reddy, Pritika, Bibhya Sharma, and Shaneel Chandra. 2020. “Student Readiness and Perception of Tablet Learning in Higher Education in the Pacific- A Case Study of Fiji and Tuvalu: Tablet Learning at USP.” *Journal of Cases on Information Technology (JCIT)* 22 (2): 52–69. <https://doi.org/10.4018/JCIT.2020040104>.

Reddy, P., B. Sharma, and S. Chandra. 2017. “Tablet Learning and Its Perceived Usage at a Higher Education Institute in Fiji.” *Fijian Studies: A Journal of Contemporary Fiji*, 131–42.

Robinson, Laura, Cotten, Ono, Quan-Haase, Mesch, Chen, Schulz, Hale, and Michael J. and Stern. 2015. “Digital Inequalities and Why They Matter.” *Information, Communication & Society* 18 (5): 569–82. <https://doi.org/10.1080/1369118X.2015.1012532>.

Scherer, Ronny, Fazilat Siddiq, Sarah K. Howard, and Jo Tondeur. 2023. “Gender Divides in Teachers’ Readiness for Online Teaching and Learning in Higher Education: Do Women and Men Consider Themselves Equally Prepared?” *Computers & Education* 199 (July): 104774. <https://doi.org/10.1016/j.compedu.2023.104774>.

Sharma, Bibhya Nand, Ravneil Nand, Mohammed Naseem, Emmenual Reddy, Swasti Shubha Narayan, and Karuna Reddy. 2018. “Smart Learning in the Pacific: Design of New Pedagogical Tools.” In *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 573–80. <https://doi.org/10.1109/TALE.2018.8615269>.

Sharma, Bibhya N., Anjeela D. Jokhan, Raneel Kumar, Rona W. Finiasi, Sanjeet Chand, and Varunesh Rao. 2015. “Use of Short Message Service for Learning and Student Support in the Pacific Region.” In, edited by Y. Zhang, 199–220. Berlin: Springer.

Siddiq, Fazilat, Ronny Scherer, and Jo Tondeur. 2016. “Gender Differences in Students’ Digital Competence: A Cross-National Study.” *Computers in Human Behavior* 63: 91–98.

Tinmaz, Hasan, Mina Fanea-Ivanovici, and Hasnan Baber. 2022. “A Snapshot of Digital Literacy.” *Library Hi Tech News* 40 (1): 20–23. <https://doi.org/10.1108/LHTN-12-2021-0095>.

Tinmaz, Hasan, Yoo-Taek Lee, Mina Fanea-Ivanovici, and Hasnan Baber. 2022. “A Systematic Review on Digital Literacy.” *Smart Learning Environments* 9 (1): 21. <https://doi.org/10.1186/s40561-022-00204-y>.

Trucco, Daniela, and Guillermo Sunkel. 2010. “Nuevas Tecnologías de La Información y La Comunicación Para La Educación En America Latina: Riesgos y Oportunidades.” *Políticas Sociales*, no. 6174 (November).

Tsai, Meng-Jung, and Chin-Chung Tsai. 2010. “Junior High School Students’ Internet Usage and Self-Efficacy: A Re-Examination of the Gender Gap.” *Computers & Education* 54 (4): 1182–92. <https://doi.org/10.1016/j.compedu.2009.11.004>.

Vandenbulck, Jan, and Lieven De Marez. 2022. “Digital Inequalities in the Classroom: Socio-economic Status, Digital Skills, and Educational Outcomes.” *Learning, Media and Technology* 47 (1): 1–17.