Information and Communication Technologies and the COVID-19: From Economic Inequality to Educational Digital Divide in Central and South America

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Abstract

During the pandemic, Information and Communication Technologies (ICT) in education gained significance due to the closure of educational institutions. Therefore, the gap in educational performance between students with access to ICT and those without access to them may have widened. This paper analyzes whether the educational digital divide caused by access to ICT has increased in eight countries in Central and South America. Propensity Score Matching is employed to estimate the effect of access to ICT on educational performance considering students' socioeconomic background, eliminating the effect of other pre-existing inequalities using data from PISA (2018 and 2022 editions). The results indicate that the educational digital divide generated by unequal access to ICT has widened during the pandemic. However, outcomes vary depending on the country and the assessed competence. These findings underline the need to keep debating the impact of unequal access to ICT on educational systems, especially in developing countries.

Keywords: educational digital divide; educational inequalities; COVID-19; academic performance; information and communication technologies; Central and South America

1. Introduction

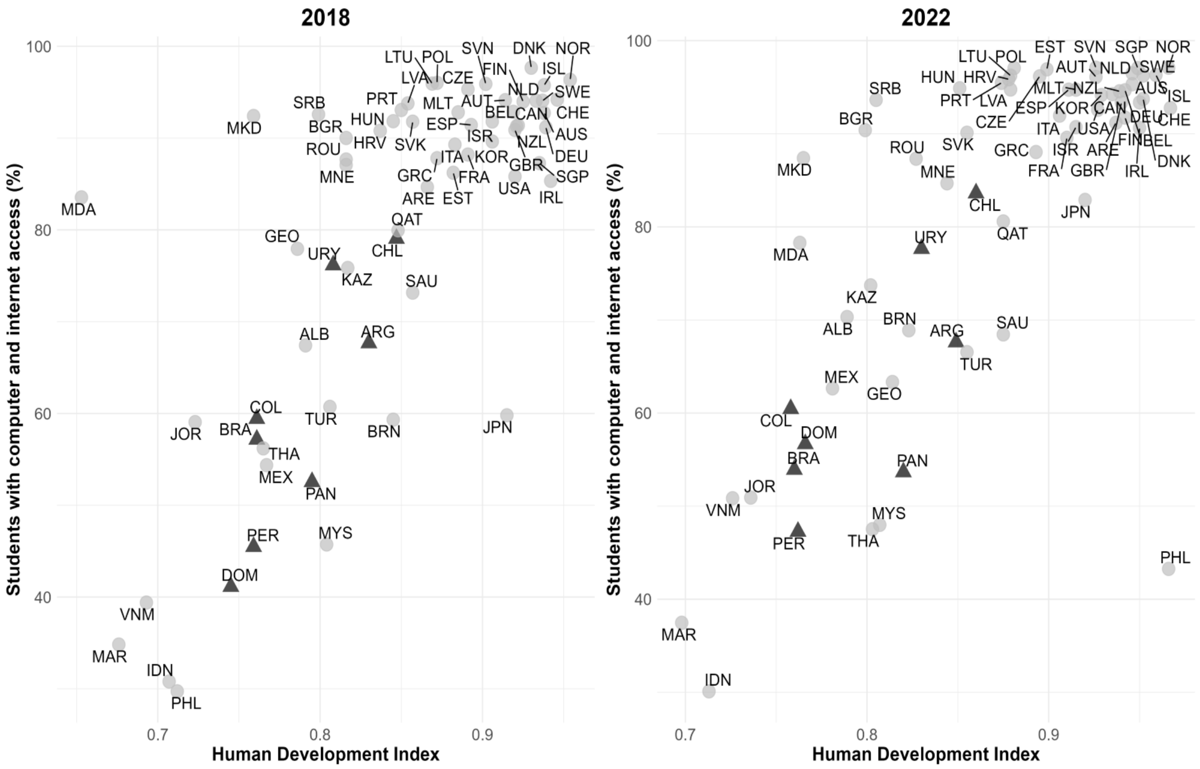
In recent years, the integration of Information and Communication Technology (ICT) in education has significantly transformed the learning landscape. The development of digital competencies has emerged as a pivotal determinant of academic success and, also, on employment opportunities (Alderete & Formichella, 2023). In this context, the role of educational institutions in incorporating digital resources into the teaching process is crucial, as it expands educational opportunities by facilitating access to learning materials and promoting more flexible and self-directed learning methodologies.

The integration of ICT in education has a heterogeneous effect among students, leading to the creation of inequalities and/or the exacerbation of existing ones. On the one hand, the first factor represents material inequality, namely the access—or lack thereof—to digital resources such as hardware or software that are useful for learning. On the other hand, the second factor reflects a gap in students' digital skills or knowledge to use ICT effectively for learning purposes. The digital skills are understood as the safe, critical and responsible use of digital technologies for learning, work and social participation, including skills in information literacy, communication, content creation, security and digital citizenship (World Economic Forum, 2023). They are particularly relevant considering that the mere availability of these resources does not inherently ensure their effective utilization or the development of advanced technological skills (Vaquero, 2020).

The abrupt shift to online learning, compelled by the pandemic, has underscored the critical role of ICT in education while simultaneously highlighting the existing inequalities in digital access and technology (Alderete & Formichella, 2023; Bormann et al., 2021; Cabrera, 2020). Digital distance learning was a key approach during this period but may have contributed to widening social divides in education. It could be argued that the pandemic provided the ideal conditions for the emergence of an educational digital divide, with ICT playing an important role for learning at that time.

The relative importance of these factors depends on the context. On the one hand, in developed countries where ICT access is widespread, digital skills may be more relevant, as only a small segment of the population lacks access. On the other hand, in developing countries where ICT access remains limited, the material gap continues to be significant and may have played a key role during the pandemic. Figure 1 shows the proportion of the population in developing countries lacks access to ICT compared to more developed countries. For example, in regions such as Latin America, access to resources is important. According to the BID (2020), more than a third of 15-year-old students in the region were in a situation of technological material vulnerability. Another relevant aspect is the regional heterogeneity of access to material resources, which shows significant disparities between and within countries according to their level of development, with a particular impact on the most socio-economically disadvantaged sectors (Chancel et al, 2022).

Figure 1. ICT access and Human Development Index by country in 2018 and 2022



Source: The authors based on OECD (2019, 2023) and UNDP (2019, 2022)

This research aims to analyze the evolution of the educational digital divide caused by unequal access to ICT during the COVID-19 in eight Central and South American countries. The hypothesis to be tested posits that the educational digital divide caused by unequal access to ICT generated a gap in academic performance in the analyzed countries during the COVID-19 pandemic. To conduct the empirical analysis, the two most recent editions of PISA (OECD, 2019; 2023) are used (i.e., 2018, the last edition before the pandemic, and 2022, the first edition after the pandemic), applying the Propensity Score Matching (PSM) methodology.

This research contributes to the Information and Communication Technologies for Development (ICT4D) field in several ways. Firstly, it contributes to a deeper understanding of the effects of the COVID-19 pandemic on education systems, a recent and underexplored area despite the profound changes that have occurred (OECD, 2023). Secondly, this research provides new insights into the effects of the pandemic on the educational digital divide, specifically regarding the impact of the material gap in ICT access on educational inequality. Thirdly, this study highlights that the effects of the material access gap on education systems remain a significant challenge in Central and South America and have worsened during the COVID-19 pandemic. Specifically, this research points out how the material divide has gained prominence in the context of the countries analyzed during the pandemic and the need to address it as a priority in contrast to approaches that consider the digital skills gap as the most relevant aspect.

This study is structured into four main sections, in addition to this Introduction. Section two provides an in-depth review of the relevant literature on the digitization of education and the digital divide, with particular attention to the impacts of COVID-19 in this context. Section three details the methodological framework and the primary data sources employed. Section four presents and analyses the study's key findings. Finally, Section five summarizes the main conclusions and offers a set of policy recommendations.

2. Literature Review

2.1. Framing the Digital Divide in the Context of ICT4D

The concept of the digital divide, initially centered around access to ICT, has evolved significantly over the years, particularly within the field of ICT4D (Information and Communication Technology for Development). As highlighted by Ganapathy et al. (2024), traditional binary conceptions of the digital divide have increasingly been recognized as inadequate, particularly in addressing deeper, structural inequalities that prevent marginalized groups from fully benefiting from digital technologies. This shift aligns with the growing recognition in the literature that access alone does not equate to meaningful inclusion or development (Heeks, 2022; Aissaoui, 2022).

In the context of ICT4D, the digital divide is often understood as part of broader societal inequalities, with scholars such as Kleine (2009) and Qureshi (2019) emphasizing the need to consider the intersection of technology with political, economic, and social structures. These perspectives argue that focusing solely on access, such as infrastructure provision or economic barriers, risks promoting a techno-deterministic view of development—where technology is seen as a panacea without addressing the underlying causes of exclusion. This narrow framing fails to account for the multifaceted challenges that affect digital inclusion, including issues related to digital literacy, the quality of digital engagement, and the capacity to derive meaningful benefits from technology use (Pleasant & Zhang, 2021).

Saba et al. (2023) and Azmat et al. (2020) emphasize that bridging the digital divide involves more than providing devices and internet connectivity. It also requires ensuring that individuals have the necessary skills to utilize digital resources effectively and that these resources are integrated into broader socio-economic structures in ways that foster equity rather than exacerbating existing inequalities. Heeks (2022) introduces the concept of "adverse digital incorporation" which highlights how access to digital technologies can sometimes deepen inequalities rather than mitigate them, particularly when technological adoption occurs without the requisite support systems.

Building on these discussions, it is also important to recognize that technological access alone does not address the structural dimensions of the digital divide. While critiques of techno-determinism rightly emphasize the importance of digital literacy and integration into socio-economic structures, the material dimension of the divide remains a pressing issue, particularly in underdeveloped contexts. In regions such as Latin America, where technological infrastructure remains unevenly distributed, understanding how material access still shapes digital inequalities is crucial.

2.2.Digitalization in Education: Assessing the Impact of ICT

The digitalization of education has transformed both teaching and learning processes, creating a digital ecosystem for developing essential competencies (Bawack & Kamdjoug, 2020; Ilomäki et al., 2016; Pettersson, 2018). This transformation has profound implications for social and professional development, as labour markets increasingly demand proficiency in emerging technologies (Qureshi, 2021).

Literature extensively examines the impact of ICT on educational outcomes, highlighting benefits such as enhanced interactivity, stimulated creativity, and improved knowledge acquisition. Regular access to ICT, both inside and outside educational settings, facilitates the effective integration of digital tools into daily learning activities (Ertl et al., 2020; Gorjón et al., 2021). Alderete & Formichella (2023) highlight that access to both a computer and reliable internet at home significantly improves academic performance. In this line, insufficient ICT investments, often stemming from socioeconomic inequalities, can negatively impact student performance (Ben Youssef et al., 2022).

Other studies suggest that the mere possession of technology is not enough; its effective use is crucial (Pagani et al., 2016; Vargas-Montoya et al., 2023). Désiron & Petko (2023) warn that misuse of ICT (e.g., social media overuse) can negatively impact student outcomes and Gorjón & Osés (2023) report that harm is caused by excessive use of technology, with a more pronounced effect on students from lower socio-economic backgrounds. Agasisti et al. (2020, 2023) found that students from higher socioeconomic backgrounds are more likely to use ICT for educational purposes rather than for leisure. Navarro-Martinez & Peña-Acuña (2022) also note that early ICT use among boys is associated with lower performance, especially due to social media overuse.

2.3. COVID-19 on Educational Access and Digital Divide

The closure of schools during the COVID-19 pandemic and the monitoring of remote education highlighted the need for online resources and the use of ICT in education (Bormann et al., 2021; Jack et al., 2023; Babinčáková & Bernard, 2020). The generalization of online teaching ocurred suddenly, due to the exceptional circumstances, without prior preparation for the groups involved (students, teachers, family). Moreover, for certain groups, such as the most vulnerable, it was their first contact with digital media for educational purposes in a context of necessity, without being aware of the opportunities and risks.

The BID (2020) highlighted the problem of school closures, warning that a third of students lacked access to computers to carry out their homework in Latin America countries. This lack of resources not only hindered participation in remote learning but also exposed deep pre-existing inequalities in digital access. While technological solutions were promoted as a response to educational disruption, access alone was not enough to guarantee effective learning experiences.

This situation brings into focus the debate between ICT4D perspectives and the limitations of technodeterminism. Although ICT4D frameworks emphasize the role of digital tools in fostering development, they also stress that simply expanding access to technology does not automatically translate into better educational outcomes. The evolution of ICT adoption across Latin American countries shows a trend toward greater digital coverage (Ganapathy et al., 2024). However, this positive trend is still limited compared to developed countries, where access to ICT is more universal, although there are still challenges in terms of access to new technologies for the low-income population, which has also been proved to have an impact on educational performance (Wagg, Vannini, Zammani, Klyshbekova, & Aylward, 2024; Wagg, Vannini, Zammani, Klyshbekova, Aylward, et al., 2024). The pandemic revealed that disparities in digital access continue to shape educational inequalities emphasising that this is an inherent issue.

While the impact of ICT on education during the pandemic is well understood, the role of the material gap in the education systems of developing countries has also gained particular relevance (Herath, 2021; Qureshi, 2021). Despite the novelty of the pandemic, most studies have focused more on the digital skills gap than on the effects of the material gap (Bormann et al., 2021). This becomes even more significant considering that during the pandemic, access to ICT was essential for remote learning, and social isolation increased the importance of resources provided by the home over those provided by the school.

The pandemic revealed that access to digital tools was not enough to ensure equitable educational outcomes, particularly in the absence of adequate training and infrastructure, which disproportionately affected marginalized groups. Thus, while equitable access to ICT does not guarantee egalitarian effects, it is a first step towards discussing the role of access. Families with limited resources and digital skills face greater challenges in supporting students, which exacerbates stress in the educational environment. These pre-existing disparities contributed to a further decline in learning outcomes as they lacked not only the necessary tools but also digital literacy (García & Weiss, 2017; Neidhöfer et al., 2018).

In developing countries, the situation is further complicated by limited infrastructure and resources, where the challenges go beyond technology provision to include the capacity to integrate digital tools into everyday learning processes. Disparities in access and usage patterns continue to reflect deeper societal inequalities, emphasizing the need for context-specific strategies that consider local barriers to digital adoption (Brunello, 2010; Gudmundsdottir, 2010). The lack of understanding about the role of the material gap in ICT access during the pandemic hinders a deeper analysis of the factors underlying the observed dynamics in this unprecedented situation. Consequently, it limits the ability to draw lessons on how to respond to future crises and to guide public policies aimed at mitigating negative effects.

3. Data and Methodology

In this research paper, the evolution of the digital divide during the pandemic is addressed in eight Central and South American countries[1] (Argentina, Brazil, Chile, Colombia, the Dominican Republic, Panama, Peru, and Uruguay). For this purpose, data from the two most recent editions of PISA conducted in the years 2018 and 2022 are utilized. This allows for an analysis of the changes between both years. The PISA report focuses on assessing the essential knowledge and competencies of 15-year-old students in participating countries. PISA conducts assessments in the areas of mathematics, reading, and science. The report uses a 6-level performance scale, where each level of competencies demonstrates the development of knowledge, skills, and information management; and this is reflected in the fact that lower scores reveal less effective educational systems. The data and results obtained provide insights into what can be achieved in education, from the perspective of both high-performing students and the effective practices of educational systems (Wang et al., 2023).

In addition, it is fundamental to the contribution of the PISA Report of the socioeconomic and cultural index (ESCS), which is a proxy measure of family wealth. It reflects the professional occupation and educational level of the parents, as well as the resources available in the home. The index is standardized so that it has a mean of 0 and a standard deviation of 1 across the OECD. Hence, students with characteristics above the OECD

[1] These eight countries are the only ones in Central and South America that participated in both edition of PISA included in this study.

average will have positive values, while negative values represent more vulnerable groups than the OECD average (Blanco-Varela et al, 2024).

Drawing on the data from the aforementioned PISA editions, this research adopts the PSM methodology to analyze the impact of the digital divide on academic performance. This methodology facilitates the creation of cohorts with comparable attributes, enabling a contrast between the responses of statistical units (i.e., students) impacted by a specific occurrence (treated units) and those unaffected (control units) (Rosenbaum & Rubin, 1983; Stuart et al., 2011). Its aim is to create a treatment group (students without access to ICT resources) and a control group (students with access to ICT resources) that are comparable in terms of observable characteristics, thereby enabling a more precise estimation of the causal effect of interest (Blanco-Varela et al., 2024).

The treatment group comprises students who have access to the Internet and a personal computer at home. In contrast, the control group consists of students with characteristics similar to those in the treatment group (see control variables in Table 1) but without access to these digital and technological resources.

Table 1. Treatment, control, and academic performance (result) variables

Group	Variable	PISA 2018 code	PISA 2022 code	Paper code	Values
Treatment variables	Computer at home for schoolwork (PC)	ST011Q04TA	ST250Q02JA	PC	No (0) / Yes (1)
	Link to Internet at home (no cell phones) (INTERNET)	ST011Q06TA	ST250Q05JA	INTERNET	No (0) / Yes (1)
	Computer desktop and Internet access (PC*INTERNET)	-	-	PC_INTERNET	No (0) / Yes (1)
Control variables	Student age	AGE	AGE	AGE	Continuous: 15 to 16
	Student standardized sex	ST004D01T	ST004D01T	SEX	Male (0) / Female (1)
	Grade repetition	REPEAT	REPEAT	REPEAT	No (0) / Yes (1)
	How old were you when you started ISCED0	ST125Q01NA	ST125Q01NA	STU_BEGIN	1 y/o to 6 y/o (1-6)
	Origin background	IMMIG	IMMIG	ORIGIN	Native (1), 2º generation immigrant (2), and 1º generation immigrant (3)
	Student index of economic, social, and cultural status	ESCS	ESCS	ESCS	Continuous: -5.94 to 2.48
	Own room for student in home	ST011Q02TA	ST250Q01JA	ROOM	No (0) / Yes (1)
	School type	SCHLTYPE	SCHLTYPE	SCHLTYPE	Public (1), Charter (2), and Private (3)

	School community size (inhabitants)	SC001Q01TA	SC001Q01TA	SCHLCOMSIZE	Less than 15,000 (0), 15,000-100,000 (1), and over 100,000 (2)
	School size (students)	SCHSIZE	SCHSIZE	SCHSIZE	Continuous: -10 to 4,711
	Class size (test language class)	CLSIZE	CLSIZE	CLSIZE	7.5, 18, 23, 28, 33, 38, 43, 48, and 50 (Interval midpoint)
	Student-teacher ratio	STRATIO	STRATIO	STRATIO	Continuous: 1 to 82
	Ability grouping use in the school	SC042Q01TA	SC042Q01TA	ABGROUPING	No (0) / Yes (1)
Academic performance indicators	Average plausible values in Science	PV1SCIE-PV10SCIE	PV1SCIE-PV10SCIE	SCIENCE	Continuous: 177 to 700
	Average plausible values in Reading	PV1READ-PV10READ	PV1READ-PV10READ	READING	Continuous: 120 to 723
	Average plausible values in Mathematics	PV1MATH-PV10MATH	PV1MATH-PV10MATH	MATHEMATICS	Continuous: 140 to 686

Source: Authors from OECD 2019 & 2023

This allows to address endogeneity issues arising from the relationship between the digital divide and other factors influencing students' academic performance. Among these factors, notable considerations include the student's own characteristics, socioeconomic environment, and school characteristics. Specifically, Nearest Neighbor Matching (NNM) is used in combination with Exact matching (for SEX, REPEAT, ORIGIN and SCHLTYPE variables) to obtain exact balance in key variables[2] (1). Using four different alternatives[3] of NNM 1:k (with k=1, 3, 5, and 10) and selecting, for each country and each year, the matching with the best balance measures (see Table 2). Additionally, when estimating the propensity score for individual i (2), the methodology involves Generalized Linear Model (GLM).

[2] The combination of these two matching methodologies facilitates a dual adjustment, allowing for an exact match on certain characteristics –meaning individuals who are precisely identical in these aspects through exact matching– and simultaneously employing matching of the most similar individuals, those with a more similar propensity score, via Nearest Neighbor Matching.

[3] The k ratio refers to the number of control individuals assigned to each treatment individual in the NNM.

Furthermore, replacement and re-estimation are employed. For more information, refer to Stuart (2010).

$$\min_{T',C'} \sum_{i \in T'} \sum_{1}^{k} \left| PS_i - PS_{j(i)} \right| \ if \ X_i = X_{j(i)} \ \forall X \in (SEX, REPEAT, ORIGIN, SCHLTYPE) \quad (1)$$

$$\begin{aligned} PS_i &= logit\big(P(PC\_INTERNET_i = 1)\big) \\ &= \beta_1 AGE_i + \beta_2 STU\_BEGIN_i + \beta_3 ESCS_i + \beta_4 ROOM_i \\ &+ \beta_5 SCHLCOMSIZE_i + \beta_6 SCHSIZE_i + \beta_7 STRATIO_i \\ &+ \beta_8 ABGROUPING_i \end{aligned} \quad (2)$$

Where i refers to the treated individual and in question, and $j(i)$ refers to the individual or individuals from the control group assigned to this treated individual, and T' and C', to the treatment and control group respectively.

Table 2. Balance measures by country and year

Country	Year	Matching option	Average standardized bias		Pseudo-R²		Treatment students		Control students	
			Before matching	After matching	Before matching	After matching	Before matching	After matching	Before matching	After matching
Argentina	2018	NNM 1:3	29.28%	2.34%	0.262	0.0029	5,059	4,939	2,295	1,815
	2022	NNM 1:5	28.10%	3.27%	0.241	0.0060	6,554	6,526	3,003	2,856
Brazil	2018	NNM 1:10	28.35%	1.27%	0.303	0.002	3,683	3,589	2,653	2,376
	2022	NNM 1:5	27.79%	1.92%	0.277	0.0024	3,629	3,427	2,697	2,361
Chile	2018	NNM 1:10	24.48%	1.44%	0.184	0.0025	3,453	3,235	870	847
	2022	NNM 1:1	28.56%	2.53%	0.159	0.0027	4,488	4,345	855	646
Colombia	2018	NNM 1:1	36.55%	2.00%	0.383	0.0019	3,449	3,106	2,425	914
	2022	NNM 1:1	35.63%	3.32%	0.34	0.0067	3,827	3,612	2,415	1,031
Dominican Republic	2018	NNM 1:10	24.31%	2.85%	0.251	0.0073	1,345	1,277	2,051	1,743
	2022	NNM 1:3	19.80%	1.20%	0.16	0.0014	2,289	2,200	1,568	1,348
Panama	2018	NNM 1:10	33.90%	4.42%	0.377	0.02307	1,624	1,516	1,571	1,243
	2022	NNM 1:1	36.28%	1.33%	0.332	0.0012	1,279	1,163	1,000	416
Peru	2018	NNM 1:3	40.31%	3.09%	0.431	0.0115	2,405	2,33	2,908	1,347
	2022	NNM 1:10	33.17%	2.43%	0.397	0.0032	3,066	2,747	3,341	2,617
Uruguay	2018	NNM 1:3	25.40%	2.97%	0.228	0.0058	3,229	3,183	991	864
	2022	NNM 1:3	26.03%	2.04%	0.178	0.0035	4,625	4,465	1,279	1,218

Source: Authors from OECD 2019 & 2023

Following the matching, the digital divide (DD) is calculated as the difference between the weighted means of the treatment group[4] (students with a computer and Internet access) and the control group (students without a computer and/or link to the Internet) in the three academic performance variables (Science, Reading, and Mathematics) for both years (3).

$$DD_{ik} = \left(\frac{\overline{PT_{ik}} - \overline{PC_{ik}}}{\overline{PC_{ik}}}\right) * 100 \quad (3)$$

where $\overline{PT}$ refers to the weighted average of academic performance in country i and knowledge area k for the treatment group, and $\overline{PC}$ refers to the control group, respectively.

This enables the observation of whether access to these resources has gained greater significance during the pandemic in explaining academic performance, and consequently, whether the digital divide has increased. To verify if the observed gap for each year is statistically significant the t-test is employed. This allows to check if the difference in performance between students with access to a computer and internet connection and those without access to at least one of the two is relevant. Additionally, the t-test is employed to determine if there has been a significant change in the average performance of both groups between the two years.

4. Results and Discussion

4.1. Descriptive Statistics: Digitalization in the Face of a Pandemic

This section begins with a presentation of descriptive statistics, aimed at illustrating the context in which changes in access to technological resources are occurring. This includes a detailed examination of the evolution of computer and Internet access, the distribution of these resources among students in relation to their economic, social, and cultural status, and their

[4] The weights used correspond to those generated in the matching process.

academic performance.

The effects of the pandemic on the level and inequality of academic performance in the countries analyzed is remarkable (see Table 3). Although there is some heterogeneity among them, the decline in average performance is lower than that of more developed countries. This is mainly concentrated in reading and mathematics skills, with slight increases in science. This observation must be contextualized by considering the generally higher scores of more developed countries. On average, countries in the OECD and Europe scored around 500 points in the 2018 edition and 480 points in the 2022 edition (OECD, 2023). However, it is significant to note that Central and South American countries did not exhibit such a marked decline in average scores, with some even improving.

No significant increase in inequality was found between 2018 and 2022 (as shown by the Gini coefficient), and no significant differences were observed among the Central and South American countries (Table 3). Nevertheless, two clarifications are necessary. Firstly, these outcomes were derived prior to the application of statistical matching, implying that no particular variables were considered for evaluating performance variances between students, such as socioeconomic background or access to educational and digital resources, as investigated in this study. Secondly, the comparatively lower average results of countries in the region also implies a narrower gap between the individual scores of each student.

Table 3. Average and inequality academic performance by country, 2018 and 2022

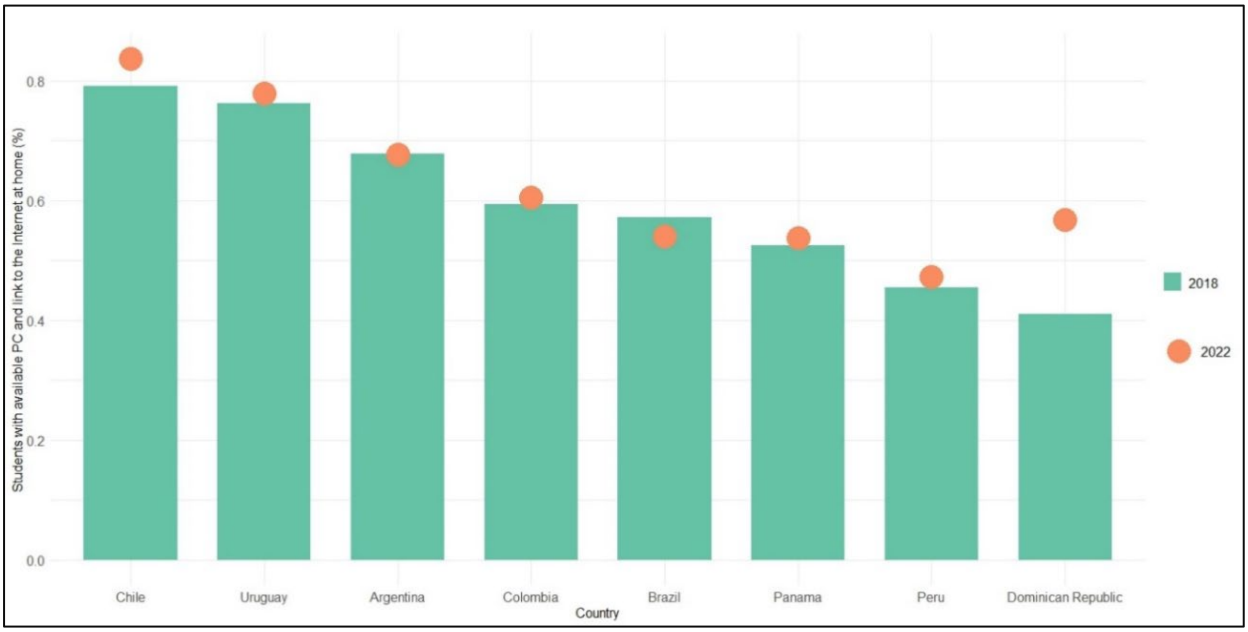
	Knowledge area	Argentina		Brazil		Chile		Colombia		Dominican Republic		Panama		Peru		Uruguay	
		2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022
Average academic performance	Science	416	417	405	406	460	462	422	420	338	362	366	383	406	411	426	436
	Reading	415	413	416	413	469	465	422	419	345	353	378	387	403	411	427	430
	Mathematics	392	389	385	381	435	429	400	391	328	340	355	353	402	394	418	409
Gini coefficient	Science	0.11	0.11	0.12	0.12	0.10	0.11	0.10	0.11	0.11	0.10	0.12	0.12	0.10	0.11	0.11	0.11
	Reading	0.13	0.12	0.13	0.13	0.11	0.11	0.12	0.12	0.13	0.12	0.13	0.12	0.12	0.12	0.12	0.12

Mathematics	0.11	0.10	0.12	0.11	0.11	0.10	0.11	0.10	0.11	0.08	0.11	0.09	0.11	0.11	0.11	0.11

Source: Authors from OECD 2019 & 2023

In terms of access to a PC and Internet connectivity (PC_INTERNET), the proportion of students possessing both resources at home increased between 2018 and 2022. However, the percentage of students without access to either or both resources remain significantly high in 2022 (see Figure 2).

Figure 2. Students with computer and link to the Internet at home by country, 2018 and 2022



Source: Authors from OECD 2019 & 2023

Table 4 represents the percentage of students who have access to the Internet and a computer for their studies according to their economic, social, and cultural status. The results are segmented by ESCS quintiles. Broadly defined, no specific patterns are observed according to country and ESCS level.

Table 4. PC availability and link to the Internet by ESCS quintiles by country (%)

Country	Q1		Q2		Q3		Q4		Q5	
	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022
Argentina	67.36	65.72	67.21	65.54	68.35	67.75	68.35	70.12	67.66	69.18
Brazil	56.48	54.63	55.85	54.40	57.10	54.73	57.57	52.88	59.10	53.36
Chile	79.01	83.63	78.33	85.02	78.25	85.42	80.57	83.96	79.69	80.29
Colombia	58.68	61.99	58.23	57.26	59.42	61.31	61.11	61.35	59.63	60.63
Dominican Republic	40.29	57.45	40.68	55.18	43.59	54.67	39.61	57.72	41.46	58.85
Panama	52.00	51.94	54.47	54.73	51.77	56.09	54.28	53.96	50.37	52.20
Peru	42.68	47.29	47.28	45.99	45.06	49.18	44.69	44.18	47.78	49.78
Uruguay	74.87	75.60	77.55	76.95	74.25	80.54	76.93	77.51	77.45	78.95

Source: Authors from OECD 2019 & 2023

In countries such as Chile and Argentina, access to digital tools was concentrated in wealthier groups, reinforcing the argument that the digital divide is rooted in socioeconomic disparities (Alderete & Formichella, 2023; Ganapathy et al., 2024). Belonging to a higher quintile correlates with increased access to the Internet and PCs, with Brazil representing an exception to this trend.

However, within these quintiles, there is still considerable heterogeneity among students. This is reflected in the lower average socioeconomic status of students without access to these resources. Table 5 shows the ESCS according to whether the students have a PC and Internet connection. The results show an improvement in the average of both groups (with and without access to ICT), except in the case of Peru, where both worsen, and in Panama, where the group with access to digitalization worsens. However, despite the overall improvement in economic conditions, there are still socioeconomic disparities as students without access to technology come from more disadvantaged backgrounds. This reinforces that the digital divide is socioeconomic in nature.

Table 5. ESCS by country for students with and without PC and link to the Internet, 2018 and 2020

Students group	Argentina		Brazil		Chile		Colombia		Dominican Republic		Panama		Peru		Uruguay	
	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022
Without PC and/or link to the Internet	-1.67	-1.43	-1.86	-1.55	-1.19	-1.10	-1.94	-1.77	-1.51	-1.13	-1.80	-1.66	-1.76	-1.82	-1.91	-1.64
With PC and link to the Internet	-0.37	-0.27	-0.56	-0.45	-0.08	-0.07	-0.44	-0.43	-0.37	-0.37	-0.21	-0.28	-0.29	-0.33	-0.66	-0.55

Source: Authors from PISA 2018 & 2022

Table 6 presents an overview of the average academic performance for students with and without a PC and link to the Internet. This provides a preliminary understanding of the substantial gap that exists between students with access to digital resources and those without. However, these differences are due to multiple factors, and the impact of ICT must be considered through a specific exploratory study. The difference between the averages increased among different countries in general terms in science and reading, with more irregular behavior in mathematics. This increase in the averages does not necessarily have to be due to the ICT gap.

Furthermore, it is noteworthy that individuals lacking access from more vulnerable households may experience a greater pronounced impact on their performance as a result. However, this disparity is not solely attributable to digital access; it reflects deeper socioeconomic inequalities. To isolate the effect of digital access, PSM was applied, offering a clearer picture of how the digital divide impacts academic outcomes. This methodology helps separate the effect of digital resources from other socioeconomic variables, providing a more nuanced understanding of the relationship between digital access and academic performance (Qureshi, 2021; Ertl et al., 2020).

Table 6. Average academic performance for students with and without PC and link to the Internet

Knowledge area	Students group	Argentina		Brazil		Chile		Colombia		Dominican Republic		Panama		Peru		Uruguay	
		2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022	2018	2022
Science	With PC and link to the Internet	437.70	435.51	432.11	437.27	469.59	474.04	443.35	448.18	363.24	377.35	399.83	419.24	438.29	444.26	439.81	452.65
	Without PC and/or link to the Internet	379.81	390.70	378.69	380.07	427.25	417.58	395.06	386.24	329.00	353.13	349.36	354.40	382.00	384.92	392.99	398.04
	Gap	57.89	44.81	53.42	57.19	42.35	56.46	48.29	61.94	34.24	24.22	50.47	64.83	56.30	59.33	46.82	54.61
Reading	With PC and link to the Internet	437.40	434.51	444.38	446.19	480.09	476.45	448.33	450.07	371.14	373.74	414.47	426.32	441.68	449.54	443.03	448.19
	Without PC and/or link to the Internet	377.98	379.94	387.11	385.87	434.43	424.11	388.37	380.30	335.92	340.64	359.03	360.16	373.11	381.62	390.53	389.11
	Gap	59.42	54.57	57.27	60.32	45.65	52.35	59.95	69.78	35.22	33.10	55.45	66.16	68.57	67.93	52.50	59.08
Mathematics	With PC and link to the Internet	412.95	406.10	411.50	407.82	445.78	438.94	422.87	414.72	350.95	352.75	384.99	380.69	436.50	427.25	431.15	424.84
	Without PC and/or link to the Internet	354.27	362.45	358.28	358.11	396.90	389.89	370.91	360.21	319.83	332.45	338.30	332.83	376.33	368.63	386.79	372.27
	Gap	58.68	43.65	53.23	49.71	48.88	49.05	51.97	54.51	31.12	20.30	46.69	47.86	60.18	58.61	44.36	52.58

Source: Authors from OECD 2019 & 2023

The findings reinforce that the digital divide, particularly in education, is not just a matter of technological access but also of broader socioeconomic inequalities that are compounded during crises like the COVID-19 pandemic. As noted by Ganapathy et al. (2024), closing this divide requires more than providing devices; it demands structural reforms to ensure digital resources are accessible and usable by all students, regardless of their socioeconomic background.

4.2.Digital Divide and COVID-19 pandemic

This section analyzes the impact of the digital divide on academic performance through the PSM methodology outlined in Section 3. Tables 7, 8, and 9 delineate the gaps in academic outcomes attributable to the digital divide across the three study areas.

These tables include various indicators: the means of the treatment and control groups and the percentage difference between them (percentage difference between students not exposed to the digital divide and those exposed to it), the standard deviations of both groups and the significance tests of the gap in each year (B/ groups), the significance of the difference between both years in the treatment group (B/ periods (treatment)) and in the control group (B/ between (control)). This allows to observe whether there is a significant gap in both years and whether there have been significant changes within each group between the two years analyzed.

As shown in Table 7, access to digital resources has gained relevance explaining the differences in science academic performance between 2018 and 2022. Regarding the Dominican Republic, the digital divide is diminishing, whereas in Argentina, the value remains relatively stable. However, in Colombia, the gap has widened significantly, nearly by 25 points, which is equivalent to more than one entire academic year[5]. This case is particularly significant because it coincides with an increase in the average performance of non-exposed students and a decrease in the performance of those who are exposed. However, in most cases where we observe an increase in the digital divide, it is due to a smaller increase in the average performance of students exposed to digital divides. This is the case in Brazil, Panama, and Uruguay. Meanwhile, in Chile and Peru, where we observe an increase in the gap, there do not appear to have been significant changes in the average performance of the groups. This stark difference highlights the varying impacts of digital access across different countries, with Colombia experiencing a substantial increase in the digital divide, potentially affecting students' academic progress and access to educational resources.

Table 7. Digital divide and Science academic performance gap by country, 2018 and 2022

Country	Year	Means		Difference	Standard deviation		T-test		
		Treatment	Control		Treatment	Control	B/ groups	B/ periods (treatment)	B/ periods (control)
ARG	2018	440.81	425.92	14.89	78.23	84.28	6.56***	-1.34	-1.18
	2022	438.83	423.08	15.76	87.16	91.32	9.27***		
BRA	2018	437.18	417.28	19.89	81.76	78.14	9.45***	2.92***	0.45
	2022	442.96	418.30	24.66	92.59	87.66	11.44***		
CHL	2018	470.69	460.94	9.75	78.31	76.91	3.27***	1.14	-0.76
	2022	472.84	457.60	15.24	84.78	89.25	4.05***		
COL	2018	436.78	431.02	5.76	76.15	72.13	2.10**	4.48***	-3.74***
	2022	445.22	418.25	26.97	77.73	78.39	9.76***		
DOM	2018	360.15	347.53	12.62	67.02	59.99	5.34***	9.55***	11.38***
	2022	382.18	371.90	10.28	63.06	58.28	4.94***		
PAN	2018	395.80	385.90	9.90	74.86	73.23	3.50***	8.34***	4.20***
	2022	420.47	402.82	17.65	76.7	69.22	4.29***		
PER	2018	439.09	425.51	13.58	71.73	71.66	5.53***	0.64	-1.59
	2022	440.42	421.63	18.79	75.76	74.51	9.16***		
URY	2018	443.00	434.61	8.38	81.03	79.06	2.75***	5.55***	1.98**

[5] The 25-30 points are approximately equivalent to the typical annual learning gain by students around the age of 15 (OECD, 2023; Woessmann, 2016).

	2022	453.39	441.68	11.71	80.52	79.61	4.43***		

Note 1: “*”, “**, and “***” indicate significance at 10%, 5% and 1% respectively

Note 2: “B/groups” t-test between groups, “B/ periods (t)” t-test between years for treatment group, and “B/ periods (c)” t-test between years for control group

Source: Authors from OECD 2019 & 2023

In terms of basic reading literacy the digital divide has become more relevant in the Central and South America American economies analyzed, exceeding 25 points in countries such as Brazil, Peru, and Panama (see Table 8). This notable increase suggests that access to digital resources has become a more critical factor in reading literacy in these countries. This trend may be attributed to the substantial conversion of academic resources into digital formats during and after the pandemic. The widening gap in these countries means that students without access to digital resources are increasingly disadvantaged, which may affect their overall educational outcomes and future opportunities.

Table 8. Digital divide and Reading academic performance gap by country, 2018 and 2022

Country	Year	Means		Difference	Standard deviation		T-test		
		Treatment	Control		Treatment	Control	B/ groups	B/ periods (treatment)	B/ periods (control)
ARG	2018	441.65	426.52	15.12	72.19	76.88	6.11***	-2.14**	-3.99***
	2022	438.16	415.96	22.21	79.28	74.14	11.87***		
BRA	2018	450.11	428.41	21.70	77.36	75.2	9.15***	1.52	-0.36
	2022	453.37	427.51	25.86	84.18	78.08	11.37***		
CHL	2018	483.16	472.44	10.72	86.5	85.89	3.23***	-3.33***	-1.63
	2022	476.55	464.98	11.56	84.15	89.01	3.10***		
COL	2018	440.91	429.15	11.76	83.05	78.11	3.94***	3.03***	-1.62
	2022	446.95	423.08	23.87	79.51	87.15	7.91***		
DOM	2018	367.43	356.27	11.16	79.9	72.52	3.94***	5.15***	4.01***
	2022	381.80	366.80	14.99	78.44	72.32	5.80***		
PAN	2018	411.07	399.19	11.88	77.26	78.14	3.99***	6.75***	1.67*
	2022	431.85	405.83	26.02	80.35	70.79	6.42***		
PER	2018	442.25	424.53	17.71	83.32	82.99	6.23***	1.79*	-1.43

	2022	446.28	420.65	25.62	76.16	77.43	12.21***		
URY	2018	446.70	441.53	5.18	90.55	86.38	1.55	1.43	-1.84*
	2022	449.63	434.53	15.10	84.99	81.85	5.52***		

Note 1: "*", "**, and "***" indicate significance at 10%, 5% and 1% respectively

Note 2: "B/groups" t-test between groups, "B/ periods (t)" t-test between years for treatment group, and "B/ periods (c)" t-test between years for control group

Source: Authors from OECD 2019 & 2023

The results from Table 8 show how the pandemic has widened the gap in most countries. However, this is due to different reasons. On one hand, Argentina saw a decrease in the average performance in both groups, but it was more pronounced among students exposed to the digital gap. In Chile, the average performance of non-exposed students dropped significantly; however, this does not seem to have reduced the gap between groups. In Uruguay, one of the most notable cases, the digital gap was not statistically significant in 2018, but a decrease in the average performance of students exposed to the digital gap has made it significant in 2022, exceeding 15%. On the other hand, Colombia and Peru have seen an increase in the average performance of non-exposed students between 2018 and 2022, while the average performance of exposed students has not changed significantly. This has resulted in an increase in the digital gap. Similar cases are those of the Dominican Republic and Panama, where the average performance of both types of students increased, but to a greater extent among the non-exposed. This also resulted in an increase in the gap. In the case of Brazil, there are no significant variations in the average performance of both groups; however, this seems to have translated into a wider gap.

In terms of mathematics, as depicted in Table 9, there is also an increase in the gap within these economies, though with more moderate effects in countries like Brazil, Panama, or the Dominican Republic. Interestingly, small decreases in the gap are observed in Argentina and Chile. The findings imply that the significance of access to digital resources varies across different domains of knowledge. However, the negative impact of the digital divide on mathematics performance should not be underestimated. The varied effects across different countries indicate that the relationship between digital access and academic performance in mathematics may be influenced by other factors, including curriculum design, teaching methods, and the availability of digital resources specifically tailored for mathematics education. In this regard, the cases of Colombia, Peru, and Uruguay are the three countries where the gap has widened the most. This is due in all cases to the greater decrease in the average performance of students exposed to the digital gap.

Table 9. Digital divide and Mathematics academic performance gap by country, 2018 and 2022

Country	Year	Means		Difference	Standard deviation		T-test		
		Treatment	Control		Treatment	Control	B/ groups	B/ periods (treatment)	B/ periods (control)
ARG	2018	414.41	397.74	16.66	84.71	82.82	8.03***	-3.83***	-1.65*
	2022	409.21	394.14	15.07	71.39	66.2	9.91***		
BRA	2018	416.49	395.23	21.26	87.41	83.43	10.88***	-2.94***	-3.06***
	2022	411.28	389.04	22.23	71.3	63.24	12.47***		
CHL	2018	446.47	431.80	14.67	77.32	77.35	4.92***	-4.93***	-1.39
	2022	437.81	426.30	11.51	73.41	74.29	3.68***		
COL	2018	417.20	403.83	13.36	72.24	69.66	5.06***	-3.36***	-4.46***
	2022	411.51	389.81	21.70	65.5	68.69	9.04***		
DOM	2018	348.36	338.47	9.89	64.43	58.19	4.34***	4.12***	4.05***
	2022	356.97	345.92	11.05	49.57	43.96	6.92***		
PAN	2018	381.98	368.79	13.19	63.07	65.58	5.35***	-0.76	-1.03
	2022	380.23	365.76	14.47	55.33	45.6	5.18***		
PER	2018	437.35	425.02	12.34	72.17	73.68	4.93***	-7.03***	-9.06***
	2022	423.34	403.10	20.24	69.13	68.98	10.73***		
URY	2018	434.35	431.54	2.81	77.36	75.92	0.96	-5.32***	-5.37***
	2022	424.97	413.42	11.55	74.21	73.58	4.73***		

Note 1: “*”, “**, and “***” indicate significance at 10%, 5% and 1% respectively

Note 2: “B/groups” t-test between groups, “B/ periods (t)” t-test between years for treatment group, and “B/ periods (c)” t-test between years for control group

Source: Authors from OECD 2019 & 2023

The overall results of the above tables demonstrate that during the COVID-19 pandemic, the digital divide has increased significantly. Which demonstrates that the initial hypothesis of this research (the pandemic has increased the importance of ICT in education, leading to an escalation in inequality between students with and without access to them) is accurate. Specifically, in a significant number of cases, the gap has increased by more than 10 points, approximately equivalent to almost half an academic year. In some instances, this increase reaches 15 points (more than half of an academic year), and even 20 points in the case of the science competency in Colombia (about a full academic year). Nonetheless there are some exceptions in certain areas of knowledge, such as Argentina and Chile in mathematics. Regarding the comparison between competencies, the digital divide has increased to a greater extent in reading, followed by science and mathematics.

A particularly interesting case is that of Uruguay, where the educational digital divide in 2018 is not statistically significant for reading and mathematics competencies compared to 2022, where it is. This demonstrates that before the pandemic, there was no digital educational divide in these competencies, but after the pandemic it emerges. Furthermore, the findings indicate that there are notable differences in academic performance between 2018 and 2022 for both the treatment and control groups. These discrepancies underscore the significant influence of COVID-19 on student achievement, an effect that was exacerbated by the widening digital divide. It is also worth noting the case of the Dominican Republic, where the scores obtained by the treatment group increased in all competencies between 2018 and 2022. In this sense, it would be interesting to analyze in future research the development policies, especially the educational ones, implemented in the country in relation to ICT.

The analysis highlights certain needs in Central and South America education systems. The findings reveal significant barriers in educational equity, particularly regarding digitalization, measured as access to computers for homework and internet connectivity. Digital divides have widened, underscoring the growing importance of ICT in education and human capital development. Furthermore, the consequences of digitalization extend beyond education. Digitalization in the labor market demands greater ICT training (Bührer & Hagist, 2017; Eberhard et al., 2017; Vaquero, 2020). This approach would not only benefit the employability of current youth but also professional development in general, initially, and the economic development of Central countries. Implementing measures could also reverse the vicious cycle of inequality, where a vulnerable student's environment translates into poor educational achievements and limited intergenerational mobility.

4.3.Methodological limitations

This study has some methodological limitations that should be acknowledged, as they affect the strength of the conclusions drawn. Methodologically, PSM requires a proper balance across all covariates that influence both the treatment variable and the outcome variables. Although PISA provides rich information on students and their background, this data may be incomplete. Furthermore, since these factors cannot be accounted for the analysis, their potential influence remains unknown. However, as noted in the literature reviewed in the second section, the main determinants of educational performance have been included in this study.

Another methodological limitation concerns the measurement of the material digital divide: some students may have had access to the internet and a computer during the pandemic but not during the year the survey was conducted. This implies that a student classified in this study as lacking access to ICT may, in fact, have had such access during the pandemic period. The opposite situation could also occur, where a student did not have access during the pandemic but now has access in present.

The limitations previously mentioned constrain the conclusions drawn in this study, but they are manageable given the sample size and the fact that the digital divide is a complex concept that should not be understood exclusively as an invariant and dual situation.

5. Conclusions

Digitization has facilitated access to a wide range of online educational resources, transforming teaching and learning processes. Moreover, the use of technological tools promotes the development of critical skills that are highly correlated with improved academic performance (Ben Youssef et al., 2022; Falck et al., 2015). However, while digitization can improve academic outcomes, it also has a downside: it can exacerbate existing inequalities. This phenomenon is consistent with global trends highlighted in the ICT4D literature, where technological interventions, if not accompanied by appropriate inclusive policies, tend to reinforce socioeconomic divisions (Ganapathy et al., 2024; Heeks, 2022).

During the COVID-19 pandemic, online learning remained the main alternative to face-to-face education due to school closures. Through digital platforms and online learning materials, ICT was essential to maintain educational continuity. However, two problematic issues have arisen in this context. Firstly, not all students had access to these resources, with those from the most vulnerable backgrounds being the most affected. Secondly, despite having access to digital tools (Internet and computers), both students and teachers did not always have the necessary skills to adequately engage in the digital learning process (NU-CEPAL, 2020, 2021). Specifically for students, the lack of family support to adapt to new technologies and the need to share technological resources within the household were additional barriers. In addition, the role of schools in bridging the digital divide has been limited, particularly in low-income countries where educational institutions themselves lack adequate resources and digital literacy among teachers (Gudmundsdottir, 2010).

While several studies have analyzed the impact of ICT access on education (Alderete & Formichella, 2023; Agasisti et al., 2020), few have explored how inequalities in access to these technologies widened specifically during the pandemic, and even fewer have focused on the Latin American context, where socioeconomic disparities are particularly acute.

The aim of this paper is to analyze the impact of the COVID-19 pandemic on the digital divide due to unequal access to ICT resources in Argentina, Brazil, Chile, Colombia, the Dominican Republic, Panama, Peru and Uruguay, based on PISA data. The study examines how unequal access to ICT during the pandemic affected academic performance in science, reading, and mathematics. It also examines how pre-existing socio-economic contexts influenced access to and effective use of ICT, and how this affected students differently according to their economic and social backgrounds.

This research contributes to a deeper understanding of the pandemic's impact on education systems by providing empirical evidence on how the COVID-19 crisis has affected educational structures and practices in under-researched contexts. It makes several contributions to the field of ICT4D. First, it advances knowledge about the impact of the pandemic on education systems, addressing a critical but under-researched territory. Second, it provides new insights into the impact of the pandemic on the educational digital divide, in particular the role of disparities in material access to ICT in exacerbating educational inequality. Finally, in the countries studied, it shows that the material divide became more pronounced during the pandemic, highlighting the importance of addressing it as a policy priority, particularly in contrast to approaches that focus primarily on digital skills.

In this sense, the results show a substantial and widespread increase in the digital educational divide generated by the gap in access to digital resources (Computer and Internet) between 2018 and 2022, as the management of ICT for learning became more relevant in explaining educational performance. This empirically confirms that ICT became more important in education during the pandemic. However, two important considerations need to be made. On the one hand, access to digital resources has expanded, while, in general, academic performance has shown a slightly negative or stable trend in several areas and countries. This fact shows that digitization alone does not contribute to a systematic improvement in learning, in line with the evidence of ADI. On the other hand, the decline in performance was greater for students with limited access to ICT, and, given the unequal and regressive distribution of access to ICT, this seems to have negatively affected students from vulnerable backgrounds.

Another notable conclusion is the uneven impact across three competencies. Specifically, the results show that the widening gap is more pronounced in reading, followed by science, and significantly smaller in mathematics. This suggests a greater benefit from the use of ICT in the first two competencies than in the third. The adaptation of curricular content to online learning has been uneven, as the results seem to indicate greater difficulties in learning mathematics, highlighting the challenges posed by the physical distance between students and teachers. According to Barlovits et al. (2021), online mathematics instruction during the pandemic was affected by the lack of direct personal interaction, which hindered immediate feedback and monitoring of student progress, especially in an environment where many teachers lacked the technical competence to effectively manage these tools. Moreover, distance learning increased students' cognitive load as they had to adapt to a higher level of autonomous learning, coupled with teachers' difficulties in adapting content (Saadati et al., 2023). This situation led to lower student participation in synchronous and asynchronous activities and difficulties in motivating those who already found the subject challenging.

Regarding the impact by countries, it is worth noting that the increase in the educational digital gap is heterogeneous. The most affected countries are Colombia, Panama, Peru, and Uruguay compared to Argentina, Chile, Brazil, and the Dominican Republic. This pattern does not seem to correlate with either the average performance of the different educational systems or the level of economic development of the analysed countries. This indicates a potential avenue for future research to explore the factors contributing to this uneven impact in the different countries.

For policy recommendations to be effective in the Central and South American context, it is essential to consider regional specificities and the side effects that the integration of ICT can have. The arrival of the 4.0 industrial revolution and new technologies further accentuates these issues, especially in socioeconomically vulnerable areas, leading to material inequality and restricted resource access. To address these issues, it's recommended that governments implement policies and scholarship systems aimed at providing technological resources to underprivileged households, thereby narrowing the educational gap (dos Santos Tavares et al., 2023). The expansion of digital media is not enough, and other issues such as the quality of digital services, the training of teachers, and the capacity of the schools themselves are gaining in importance. The simple implementation of scholarship schemes or the provision of technological resources has not always had the expected impact. For instance, in countries like Argentina and Colombia, government initiatives to provide computers to lower-income children (e.g., Argentina's "Conectar Igualdad") did not substantially reduce the digital divide due to issues like insufficient infrastructure, poor maintenance of devices, and lack of technological training for teachers (Matozo, 2019). It is frequently the case that such initiatives are not incorporated into established teaching methodologies (Okoye et al., 2023). Additional problems are related to differences in the optimal teaching methodology for different disciplines, some of which require a more hands-on approach that cannot be easily replaced by digital tools (Okoye et al, 2024).

Likewise, the training of teachers in the use of ICT faces significant obstacles in many countries of the region. UNICEF (2022) highlights that many teacher training programs are hindered by lack of funding, inadequate technological infrastructure in schools, and resistance to change on the part of some teachers. In line with our findings, the specificities of subjects and the adaptation of curricular content to online learning are also highlighted. It is crucial that any policy aimed at improving teacher training takes these factors into account and develops mechanisms for ongoing support and training incentives for teachers to improve their teaching.

A further issue in the Latin American context is the disconnection between education policies and the actual training requirements of the population. Access to education has expanded remarkably in recent decades (Chiroleu & Marquina, 2017), nevertheless, this rapid development has resulted in trained human capital that subsequently fails to find employment in accordance with its training. This is further compounded by a subsequent disconnection with the labour market. The most effective strategies to address these imbalances would be the appointment of highly qualified personnel, the development of training and assessment mechanisms tailored to the desired skills, and the establishment of mechanisms to connect the training system with the labour market (Bassi et al., 2012; Okoye et al., 2023). This problem has a consequential impact on the region's economic performance. Despite the increase in the number of educational institutions, improvements in enrolment rates and investment in digitalisation at all levels of education, neither productivity nor employability levels have improved significantly (Rosario et al., 2021).

From this study, three main lines of future research can be identified. First, following some studies, such as those by Agasisti et al. (2020) and Gorjón & Osés (2023) we propose to analyze the differences in the use of ICT according to the socioeconomic background of the students. Second, it is suggested to compare Central and South American countries with European economies to understand how ICT impact in different regional contexts. This comparison is relevant because it allows for an exploration of how varying socio-economic structures, public policies, and educational systems influence the effectiveness of ICT integration in education. While European countries generally have more established digital infrastructures and policies aimed at reducing the digital divide, Central and South American countries face more significant challenges, including widespread socio-economic disparities and limited technological access. Third, it is suggested to analyze how ICT affect higher education in Central and South America and to what extent they facilitate integration into the labour market and the improvement of employability. This approach could include the study of the effectiveness of online teaching, the availability of digital educational resources, and how digital competence acquired through higher education impacts the job opportunities of graduates

Declaration of interest statement

None

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