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# Unequal literacy development and access to online education in public versus private Panamanian schools during COVID-19 pandemic

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National and international tests have yielded low reading comprehension results for education in Panama, although there is limited information regarding literacy development and performance. There are wide gaps in social inequality, access to technology, and public versus private school achievement. Considering this, after a year off from regular face-to-face classes and a partial transition to online education due to the COVID-19 pandemic, the present study utilizes existing data to carry out a pre-post comparison of the reading performance of fourth ( $n=167$ ) and sixth ( $n=164$ ) grade students in the province of Panama employing a subsample stratified by educational system for comparability (Mann-Whitney  $U$  test,  $\alpha=0.05$ ). The pre-post comparison was also carried out independently in both the public ( $n=235$ ) and private ( $n=106$ ) systems, as well as an additional comparison of the average weekly hours of online academic engagement in both systems during the pandemic in fourth ( $n=117$ ) and sixth grade ( $n=109$ ). The results support a significant decrease in reading performance. Based on the comparative analysis, findings indicate that public school students interacted online with their teachers significantly less than their private schools' counterparts; and that, in the same sample, only the public-school students exhibited a significant decrease in reading speed by phonological and lexical route with a medium effect size compared to pre-pandemic standards, greater than those reported in other contexts. This highlights the need to develop effective strategies to narrow the existing educational gaps in the country, which seem to have widened due to the pandemic, with particular emphasis on reading performance in primary school.

## KEYWORDS

online education, social inequality, public and private schools, Panama, literacy development, reading performance, literacy achievement, COVID-19 pandemic

## 1. Introduction

There was a crisis in literacy skills in the country and the region even before the pandemic. According to PISA 2019 results, the average learning achievements of students in the Latin American region in mathematics, science and language were considerably below the average for OECD member countries, as well as countries in Asia, Eastern Europe, and the Middle East and North Africa (OECD, 2019). In Panama, 5 out of 10 children in third grade did not achieve the minimum level in reading, according to the CRECER 2018 national tests (Spencer, 2019). The tests of the

Comparative and Explanatory Regional Studies carried out by the Latin American Laboratory for the Evaluation of Educational Quality (LLECE), SERCE 2006, TERCE 2013 and ERCE 2019, indicate that by the end of primary school, most Panamanian students are not meeting minimum standards in literacy, math, or science. Panama's results are often below the regional average and among the lowest of the participating countries (UNESCO, 2014; LLECE, 2015, 2022a). Already in 2015, this crisis led the country to set goals to improve education quality in terms of measurable achievements in student learning (Unidos por la Educación, 2015).

Panama is a Central-American country with an estimated population of 4.2 million as of 2020, of which 2.2 million lived in the province of Panama (INEC, 2013a). The population density nationwide was estimated at 57.7 people per km<sup>2</sup> as of 2020, while in the province of Panama it was 200.4 (INEC, 2013b). According to the most recent data, in 2010 approximately 29% of the Panamanian population lived in rural areas nationwide (INEC, 2007a); whereas in the province of Panama the population was almost exclusively urban, with only approximately 0.9% of the population living in rural areas (INEC, 2007b). Despite a successful economy, Panama presents a Human Development Index of 0.815 (2019), 57th position worldwide, largely due to high socioeconomic inequality (UNDP, 2020). The pandemic has served to highlight many of the existing inequalities. According to the results of TERCE 2013, PISA 2018 and ERCE 2019, Panama is one of the countries in which the socioeconomic index of students and schools has the greatest impact on student learning outcomes. It is also a country with very wide learning differences between schools—as well as between public and private schools, and indigenous and non-indigenous regions— all which are largely explained by socioeconomic gaps (MEDUCA (Ministerio de Educación de Panamá), & OCDE (Organización para la Cooperación y el Desarrollo Económicos), 2019; LLECE, 2022b). A hierarchical linear model analysis of factors associated with TERCE scores carried out in Panama also supports these findings (Villaba et al., 2018).

In this context, students with access to an internet connection and an electronic device at their homes enjoyed the greatest ease to continue their education during the period of closed schools. According to a report by the Centro de Investigación Educativa de Panamá (Center of Educational Research of Panama, CIEDU) utilizing data from the National Institute of Statistics and Census of 2017, a large part of the population does not have internet or data connection from home, nor a computer. In fact, there are still many who do not even have electricity in their communities. Only about 40% of households with children in schools in the public system have access to the internet and only 30% have a computer, compared to around 90 and 80%, respectively, in the private system (De León Sautú and González, 2020). Similarly, the Inter-American Development Bank (IDB, 2020) indicated, using data from PISA 2018, that 96% of Panamanian students in the quintile with the highest socioeconomic index have access to a computer at home for schoolwork; in contrast to only 17% in the lowest quintile.

Besides the inequity that already existed in the country at the beginning of the pandemic in relation to learning achievements, as well as access to devices and connectivity for distance education, we should also consider how interactions with parents and teachers as well as family context have an impact on student learning. For example, the results of ERCE 2019 associated factors analysis highlight some relevant variables that are significantly associated with the learning of Panamanian students, including the number of hours of study (days a week that students study at home outside of school hours) and the

involvement of parents in learning activities at home (for example, support with homework, showing interest in grades). This association is present, even after controlling for socioeconomic index, but it decreases when doing so (LLECE, 2022b). In other words, the effect of the number of days of study and the involvement of parents in learning does not seem to be the same for students who come from families with different socioeconomic and cultural contexts.

Traditionally, the initial findings on the relationship between language and family socioeconomic index in the literature were, at least in part, biased. This bias was based on racism, class prejudice, and methodological flaws. However, there is a well-established complex relationship between family socioeconomic index and early academic learning achievement. In order not to “pathologize” the cultural context of families living in poverty, it is important to point out that these differences are related to systemic inequities, and not to ethnic or cultural variations, or to decisions that family members make by choice (Gorski, 2008; Dudley-Marling and Lucas, 2009; Avineri et al., 2015). Differences in socioeconomic index between families are related to access to nutrition, health, safety, and many other key determinants of child development (Bruner, 2017), in addition to vocabulary (Hart and Risley, 1995) and academic achievement (Thomson, 2018). However, it is important to cognize the findings of relevant studies. For example, the level of oral language of children at the beginning of kindergarten can help to explain the effect that a family's socioeconomic index has on a child's process of learning reading, writing, and mathematics in second through fourth grade (Durham, et al., 2007). These conclusions suggest that the extreme socioeconomic inequity in Panama could result in children starting their schooling with a wide gap in their prior preparation. Regarding inequality during the suspension of face-to-face teaching during the pandemic, Cabrera et al. (2020) describes the situation in Spain for families from vulnerable socioeconomic contexts in relation to the lower level of education of the parents, less familiarity with digital technology and single-parent households with fewer resources who were facing the challenge of becoming *de facto* teachers to accompany distance education.

Globally, more than 800 million boys and girls saw their education interrupted in 2020 and 2021 (UNESCO, 2021a). Panama was one of the countries with the longest school closure in the world, with 81 weeks of irregular schooling (UNESCO, 2022; UNICEF, 2022). This means that the access and quality of education of approximately 900,000 students were negatively affected during the COVID-19 pandemic.

In June 2021, the majority of students in the country reported receiving some type of distance education, with notable differences according to socioeconomic index. In higher-income households, students used interactive platforms, such as Microsoft Teams, utilizing one computer per student; but in lower-income households, students sent messages to teachers *via* WhatsApp using a shared cell phone; while in the indigenous regions, students had to manage with printed handouts due to the difficulty of communication. In private schools, 87% of students dedicated at least 3 h a day to school, 100% received instruction at least 3 days a week, and 7/10 interacted several times a day with their teachers. On the other hand, in public schools, the figures dropped to 52 and 75% respectively, and only 3/10 of students interacted as often with their teachers (UNICEF, 2021a). At the start of 2021, the Panamanian government regulated blended learning in Panamanian schools (Government of the Republic of Panama, 2021a, 2021b). There is no public data available to date in this regard, but by mid-2021 in many private schools, a hybrid virtual/in-person system was in place, which allowed students to have tutoring sessions with their teachers or attend

in-person classes in subgroups on certain days of the week. Meanwhile, the difficult and uneven gradual integration of only some official schools into this modality generated discontent (Almanza, 2021; Echeverría, 2021). See Table 1 for a timeline of the closing of schools and transition to distance, blended and finally face-to-face education in Panama.

At the same time, it is important to note the ways in which the pandemic also affected teachers, who unexpectedly found themselves in need of teaching remotely. In a diagnostic study on teacher professional development in Panama utilizing data collected in 2020 and 2021, which included a survey sent out to all public school teachers as well as interviews, one of the most requested topics for training turned out to be technology. The interviewed teachers explicitly requested continuous professional training in technology that would improve their skills in the use of technology in general, their pedagogical skills for the use of technology as a teaching tool, as well as their knowledge to be able to teach their students the technological skills that they will, in turn, need in the future (De León Sautú et al., 2022). In fact, previous research has presented evidence that facilitating changes in teachers' attitudes and beliefs may be a feasible path towards achieving further adoption of educational technology by teachers (Ertmer et al., 2012).

During the pandemic, learning losses were documented and/or estimated in Latin America. At the end of 2020, reading proficiency in the early grades of primary school was weak, with only 51% of children reading proficiently; 79% in the last grades of primary school; and just 42% in high school. However, in 2019, 70, 79, and 55% achieved it, respectively (UNESCO, 2021a). On the other hand, belonging to low socioeconomic backgrounds has been described as a risk factor for learning during recently experienced periods of confinement (Hammerstein et al., 2021). A study in Mexico estimated that the loss of reading competence among children aged 10–15 years ranged from 0.34 to 0.45 standard deviations according to their socioeconomic index (Hevia et al., 2022).

In terms of literacy development, specific losses in reading performance in primary school students have also been reported during the pandemic in various studies carried out in countries with a high level of development (Engzell et al., 2021; Tomasik et al., 2021; Maldonado and De Witte, 2022). In such studies, the amplitude of the loss was estimated to be between 0.09 and 0.37 standard deviations (Hammerstein et al., 2021). In South Africa, studies have documented reading literacy losses between 57 and 70% (Ardington et al., 2021). In Latin America and the Caribbean, however, the impact of the pandemic on learning of reading, whether decoding or fluency, has not been quantified.

Measuring reading performance in Spanish necessarily implies evaluating its effectiveness (the quality of text comprehension), but also the decoding process that leads to literacy and enables reading

comprehension, as they are closely related (Caravolas et al., 2019). According to the double route model (Coltheart and Rastle, 1994), the reader uses two different strategies to decode a text: the sublexical (or indirect) route and the lexical (or direct) route. In the first, the reader breaks the word into sublexical units (phonemes, syllables, or monemes) to subsequently decode and assemble them to form a recognizable word. The second involves a recognition of the orthographic form of the word already stored in the visual lexicon. As both routes are used in a complementary manner, the evaluation of decoding performance must necessarily include measures of ability to use the direct and indirect routes, for which word and pseudoword reading tasks have traditionally been used, respectively. Additionally, it is convenient to evaluate decoding in its two aspects, accuracy and speed, due to its differential contribution to reading comprehension (Álvarez-Cañizo et al., 2015).

Therefore, this study proposes to answer the following research questions:

1. Are there significant differences ( $\alpha=0.05$ ) pre-post pandemic in reading performance of students in the second half of primary school (fourth and sixth grade) in the province of Panama?
2. Is there a differential effect of the pandemic on the literacy development of students between public and private schools in the province of Panama?
- 2a. Are there significant differences ( $\alpha=0.05$ ) between the pre-and post-pandemic reading performance results in the public system?
- 2b. Are there significant differences ( $\alpha=0.05$ ) between the pre-and post-pandemic reading performance results in the private system?
3. Are there differences in access to education during the pandemic for students in public and private schools in the province of Panama?
- 3a. Is there significant differences ( $\alpha=0.05$ ) between the public and private system students in terms of the time dedicated by adults to schoolwork at home?
- 3b. Is there significant differences ( $\alpha=0.05$ ) between the public and private system students in terms of the time of online interaction with teachers?

## 2. Materials and methods

### 2.1. Participants

1. Prior to the data collection for this study, and therefore to the pandemic, there was no data source that evaluated the reading performance of Panamanian students representatively. The official Panamanian education system does not regularly assess its students for the purpose of collecting data on this competency in a way that could represent a baseline that would allow a pre-and post-pandemic comparison in order to estimate its effects. Therefore, in order to identify whether there are significant differences pre-post pandemic in reading performance, this study uses comparison data sets of student performance that had been obtained before and after the pandemic utilizing the same measurement instruments each time ( $n=331$ ).

The post-pandemic data is from 2021 and comes from a study with a random sample of nine public and six private schools from the five

TABLE 1 Timeline of education during the pandemic in Panama.

Event	Date
All schools closed	March 12, 2020
Private schools begin virtual classes	March 27, 2020
Distance education begins in public schools	June 20, 2020
Blended-learning begins in private schools	January 14, 2021
Blended-learning begins in some public schools	May 31, 2021
Face-to-face classes begin in most private schools	August 18, 2021
Face-to-face classes began in all public schools	February 7, 2022

educational districts of the province of Panama, including and surrounding Panama City (Central Panama, Western Panama, Eastern Panama, Northern Panama, and San Miguelito), from which a convenience sample was obtained of 339 participating programs school students from second, fourth, and sixth grades whose legal guardians chose to give consent for their participation (Cubilla-Bonnetier and Sánchez-Vincitore, unpublished manuscript). The sample of this study had been stratified by sex, educational district, public/private system, and grade level, so that it was representative of the population; and the data had been collected by applying the instruments virtually during lock-downs, with the consent of the parents. For the analysis of this study, the data pertaining to 2nd grade participants was discarded due to the lack of pre-pandemic data for comparison. Therefore, the 2021 subsample for this study consists only of fourth grade students ( $n = 117$ ) and sixth grade ( $n = 109$ ).

The pre-pandemic data is from 2019 and comes from a non-probabilistic study carried out with 216 fourth, 5th and sixth grade students from three public and three private schools in the same geographical area in 2019 (Cubilla-Bonnetier et al., 2020, 2021). Since the 2021 sample did not include 5th grade, only fourth grade, and sixth grade students were utilized to generate a 2019 subsample for the purpose of this study. Additionally, since the 2019 sample did not have the same proportion of students by education system as that of the 2021 subsample, participants from the private education system were randomly selected for elimination, in order to generate a 2019 subsample with the same proportion of public and private systems as the 2021 subsample for the pre-post pandemic comparison. This process was carried out with the IBM SPSS 25 Random Sample of Cases tool. Therefore, the 2019 subsample for this study consists only of fourth grade students ( $n = 50$ ) and sixth grade ( $n = 55$ ).

The composition of the pre-post samples utilized to answer the first research question is described in Table 2.

- To carry out the differentiated analysis on the impact of the pandemic on public and private educational systems, we worked with the 2021 subsample and with the 2019 subsample of the fourth and sixth grades without discarding participants, given that it was not necessary to stratify by public and private system since the effect of the pandemic was to be studied separately in the sample of participants from each system separately with data from a total 265 public school students (fourth grade  $n = 131$ , sixth  $n = 134$ ) and 106 private school students (fourth grade  $n = 60$ , sixth grade  $n = 46$ ).
- To report the differences in terms of the time of online interaction between teacher and students, and the time dedicated by adults to schoolwork at home, only the 2021 subsample was used, since

this information was not collected, nor did it apply, in 2019. This resulted in a total sample of 220 public and private school students (fourth grade  $n = 117$ , sixth grade  $n = 109$ ).

## 2.2. Instruments

During the data gathering for both studies, each student was given a test that uses multiple tasks. Different variables were obtained from the results of said tasks. The “Name or Sound of Letters,” “Word Reading,” “Pseudoword Reading” and “Text Comprehension” tasks belong to the PROLEC-R test (Cuetos et al., 2014), whose validity is based on the model of the double route explained above and which has demonstrated acceptable reliability (Cronbach’s alpha of 0.79). The following variables were obtained: letter recognition accuracy (LRA), word reading accuracy (WRA), and pseudoword reading accuracy (PRA), reported as a percentage of correct items over the total; letter recognition speed (LRS), word reading speed (WRS) and pseudoword reading speed (PRS), reported as the number of items read per minute; and percentage of correct answers to questions about the texts read, as a text comprehension index (TC). Finally, an average text reading speed (S) was obtained, measured in words read per minute, although only in the case of the 2021 sample. The instrument can be obtained from TEA Ediciones.

All two studies included an evaluation team that was composed of final-year students of speech-language pathology and psychology degrees trained in the use and scoring of the PROLEC-R test by the principal investigator, who is highly experienced in its use in the clinical context. Training processes were carried out in the interpretation of responses until a high degree of harmonization of criteria between evaluators was achieved. In the case of the evaluation during the pandemic, the researchers carried out a previous pilot study to test the entire process of the virtual application of the test.

Furthermore, in the study carried out in 2021, an online questionnaire was additionally administered to the legal guardians of the participants in which they were asked to quantify how many weekly hours of direct virtual interaction had taken place on average between student and teacher(s), utilizing an interval scale; as well as the average time dedicated by adults in the household to carry out supervised homework during the period of suspension of face-to-face education. The questions from the instrument are attached in the original Spanish language in the supplementary materials, as well as an English translation.

## 2.3. Data analysis

Statistical analysis was performed using IBM SPSS Statistics 25.

TABLE 2 Stratification of the samples to obtain their comparability.

Stratification variables	Values	Fourth grade		Sixth grade	
		Sub2019 <sup>1</sup>	Sub2021 <sup>2</sup>	Sub2019 <sup>1</sup>	Sub2021 <sup>2</sup>
Sex	Female	26 (52%)	60 (51.3%)	28 (50.9)	56 (51.4%)
	Male	24 (48%)	57 (48.7)	27 (49.1%)	53 (48.6%)
System	Public	39 (78%)	92 (78.6%)	45 (81.8%)	89 (82.6%)
	Private	11 (22%)	25 (21.4%)	10 (18.2%)	20 (18.4)
Total		50	117	55	109

<sup>1</sup>Subsample drawn from Cubilla-Bonnetier et al. (2020, 2021), stratified by sex and educational system.

<sup>2</sup>Subsample drawn from Cubilla-Bonnetier and Sánchez-Vincitore (unpublished manuscript).



To identify the effect of the pandemic on the literacy development of fourth or sixth grade students in the province of Panama, and to compare this effect between the public and private systems, an analysis was carried out to identify whether there were significant differences ( $\alpha=0.05$ ) between the pre and post-reading performance measures, first taking both systems into account, and then analyzing them separately. We also compared both systems for significant differences in the time of interaction with teachers and parents. Since data from the post-pandemic sample was not normally distributed, the Mann–Whitney  $U$  test, a non-parametric technique, was used to compare group medians in continuous reading performance variables. This test was also used to study group differences in terms of interaction time with parents and teachers during the confinement period, which were ordinal variables (Rivas-Ruiz et al., 2013). The effect size of the differences was calculated *a posteriori* using:

$$r = \frac{Z}{\sqrt{n}}$$

where  $Z$  is the standardized value of the  $U$  statistic (Tomczak and Tomczak, 2014). When interpreting the magnitude of the effect size, the indications of Cohen (1988, p. 82) were followed, which considers small values of  $r$  between 0.1 and 0.3, medium values between 0.3 and 0.5, and large values greater than 0.5.

## 3. Results

### 3.1. Effects of the pandemic on literacy development

The contrast between the 2019 subsample and the 2021 subsample allowed comparisons of literacy development to be made based on reading performance measures from before and after the suspension of face-to-face education in grades fourth and sixth. As can be seen in Tables 3, 4, there is a significant reduction in the decoding speed of letters ( $U=2275.5$ ;  $p<0.05$ ), words ( $U=2022$ ;  $p<0.01$ ), and pseudowords ( $U=1880.5$ ;  $p<0.001$ ) in fourth grade ( $n=167$ ); and in the decoding speed of words ( $U=2085.5$ ;  $p<0.01$ ) and pseudowords ( $U=1719.5$ ;  $p<0.001$ ) in sixth grade ( $n=164$ ); all with small effect sizes, except for the pseudoword reading in sixth which was medium-sized ( $r=-0.35$ ). These subsamples include both public and private school students and are stratified to be representative of the student population of the province of Panama in terms of sex, educational district, public/private system, and grade level. These findings support concluding that there were significant differences ( $\alpha=0.05$ ), that is a reduction in the pre-post reading performance of students in the second half of primary school in the province of Panama pre-post pandemic.

### 3.2. Differential effects of the pandemic on literacy development between educational systems

During 2020 and early 2021, schools in Panama implemented online education to varying degrees of success, with marked differential access between private and public systems. In such a system with unequal

access to online education, it was important to study the effect of the suspension of face-to-face education in each of the educational systems (public and private) independently. Thus, the results in the 2019 and 2021 samples were compared again, this time separately. The pre and post-analysis compared students only within each of the systems, therefore there was no need for stratification of samples. In public education, there is a significant loss of speed in letter recognition ( $U=1397.5$ ,  $p<0.05$ ) in fourth grade with a small effect size; and a significant loss in speed in reading words ( $U=1207.5$ ;  $p<0.01$  in fourth grade,  $U=1,273$ ;  $p<0.01$  in sixth grade) and pseudowords ( $U=1,124$ ;  $p<0.01$  in fourth grade,  $U=1,037$ ;  $p<0.001$  in sixth grade), with effect sizes close to or greater than the medium size cut-off point ( $r=0.3$ ) which are larger in sixth grade. However, in private education, there is no significant decrease in reading performance. On the contrary, in fourth grade there is a significant improvement in the accuracy of reading words ( $U=567.5$ ;  $p<0.05$ ) and pseudowords ( $U=631$ ;  $p<0.01$ ), with small and medium effect sizes, respectively. These findings support concluding that there was a significant reduction in reading performance ( $\alpha=0.05$ ) between the pre and post-pandemic results of public school students, but not private school students (see Tables 5, 6).

### 3.3. Differences in access to education during the pandemic between public vs. private systems

Finally, a comparison was carried out on the number of hours of distance education received by participating students throughout the first year of school closure (as stated by legal guardians in a survey). As can be seen in Table 7, there are no significant differences between the public and private systems in terms of the time dedicated by adults to schoolwork at home. However, there is a significant difference in the time of online interaction between teachers and students in favor of participants in the private education system, with a medium-large effect size in fourth grade ( $U=416.5$ ;  $p<0.001$ ;  $r=0.48$ ;  $n=117$ ) and medium effect size in sixth grade ( $U=316$ ;  $p<0.001$ ;  $r=0.43$ ;  $n=109$ ). These findings lead us to conclude that there were differences in access to education: although there is no significant difference ( $\alpha=0.05$ ) in the amount of time parents were spending with their children in schoolwork during the pandemic, children in public schools interacted online with their teachers significantly less ( $\alpha=0.05$ ).

## 4. Discussion

### 4.1. Interpretation

When comparing the results of Panamanian elementary students in fourth and sixth grades in reading performance from samples taken before and after the pandemic, we found a significant loss in letter recognition speed and reading speed, both through the sub lexical route (reading pseudowords) and through the lexical route (reading words). This result confirms the impact of the pandemic on the learning of reading that has been documented in other contexts (Engzell et al., 2021; Tomasik et al., 2021; Maldonado and De Witte, 2022). In such reports, the loss has been estimated to be between  $-0.09$  and  $-0.37$  standard deviations. However, if we apply that standard to this study, the size of the loss would be between  $-0.39$  and  $-0.65$  SD in fourth grade and between  $-0.56$  and  $-0.87$  SD in sixth. On the other hand, the size of the

TABLE 3 Results in reading performance variables in fourth grade, pre- and post-pandemic.

Variable	Sub2019 (n =50)		2021 (n =117)		Difference size effect <i>r</i>	Difference in $\sigma$
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$		
Letter Recognition Accuracy	94.40	8.90	95.30	11.19		
Letter Recognition Speed	62.92*	23.08	53.87	22.38	<b>-0.18</b>	<b>-0.39</b>
Word Reading Accuracy	91.35	11.87	90.90	17.40		
Word Reading Speed	47.76**	17.01	38.43	17.90	<b>-0.24</b>	<b>-0.55</b>
Pseudowords Reading Accuracy	82.10	16.42	84.87	17.51		
Pseudowords Reading Speed	34.89***	10.75	27.90	11.35	<b>-0.28</b>	<b>-0.65</b>
Text Reading Speed	-	-	88.21	38.48		
Reading Comprehension	73.75	23.86	72.22	21.34		

\*Significant difference in favor of this group in the Mann–Whitney *U* test  $p < 0.05$ ; \*\*Significant difference in favor of this group in the Mann–Whitney *U* test  $p < 0.01$ ; \*\*\*Significant difference in favor of this group in the Mann–Whitney *U* test  $< 0.001$ . Aggregated values, such as effect sizes, differences in standard deviations, and medians, are presented in bold text.

TABLE 4 Results in reading performance variables in sixth grade, pre- and post-pandemic.

Variable	Sub2019 (n =55)		2021 (n =109)		Difference size effect <i>r</i>	Difference in $\sigma$
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$		
Letter Recognition Accuracy	96.45	4.58	96.15	4.00		
Letter Recognition Speed	75.52	23.52	74.02	23.65		
Word Reading Accuracy	94.41	7.68	96.44	7.39		
Word Reading Speed	63.10**	18.11	52.91	20.74	<b>-0.25</b>	<b>-0.56</b>
Pseudowords Reading Accuracy	85.73	14.76	86.97	11.02		
Pseudowords Reading Speed	44.86***	9.61	36.54	12.77	<b>-0.35</b>	<b>-0.87</b>
Text Reading Speed	-	-	119.26	37.52		
Reading Comprehension	83.41	15.60	78.33	17.81		

\*\*Significant difference in favor of this group in the Mann–Whitney *U* test  $p < 0.01$ ; \*\*\*Significant difference in favor of this group in the Mann–Whitney *U* test  $< 0.001$ . Aggregated values, such as effect sizes, differences in standard deviations, and medians, are presented in bold text.

TABLE 5 Averages and pre-post pandemic differences in fourth grade (public vs. private).

Variable	Public				<i>r</i>	Dif. $\sigma$	Private				<i>r</i>	Dif. $\sigma$
	2019 (n =39)		2021 (n =92)				2019 (n =35)		2021 (n =25)			
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$			$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$		
LRA	93.33	9.76	95.33	12.29			96.25	4.44	95.20	5.68		
LRS	60.90*	21.84	53.04	23.05	<b>-0.17</b>	<b>-0.36</b>	64.13	24.09	56.95	19.87		
WRA	90.13	13.12	89.24	19.21			95.14	5.25	97.00*	3.82	<b>0.26</b>	<b>0.35</b>
WRS	46.33**	17.03	36.48	18.24	<b>-0.26</b>	<b>-0.58</b>	46.72	17.94	45.62	14.82		
PRA	79.74	17.68	82.64	18.81			86.71	10.12	93.10**	7.04	<b>0.38</b>	<b>0.63</b>
PRS	34.09***	10.89	26.65	11.60	<b>-0.29</b>	<b>-0.68</b>	33.61	9.88	32.51	9.16		
TRS	-	-	82.08	38.46			-	-	110.77	29.59	-	-
RC	72.76	25.14	70.38	22.45			78.93	17.09	79.00	15.19		

\* Significant difference in favor of this group in the Mann–Whitney *U* test  $p < 0.05$ ; \*\* Significant difference in favor of this group in the Mann–Whitney *U* test  $p < 0.01$ ; \*\*\* Significant difference in favor of this group in the Mann–Whitney *U* test  $< 0.001$ . Aggregated values, such as effect sizes, differences in standard deviations, and medians, are presented in bold text.

pre-post lock-down differences tends to grow from fourth to sixth grade. This seems to contradict emerging evidence that the impact of the loss of face-to-face school attendance has been greater in younger rather than older students (Hammerstein et al., 2021). These seemingly divergent findings may turn out to be characteristic of environments with low reading performance prior to the pandemic, such as Panama; given that the studies considered in Hammerstein’s systematic review

were carried out in more developed countries. However, such interpretations need to take into account that this study is limited by the absences of students in the first grades of primary school in the sample.

After analyzing the differential impact of remote education in the public and private education systems, it appears that the decrease in reading performance documented in this study only takes place in the public schools, with small to medium effect sizes, and only in regard to

TABLE 6 Averages and pre-post pandemic differences in sixth grade (public vs. private).

Variable	Public				<i>r</i>	Dif. $\sigma$	Private				<i>r</i>	Dif. $\sigma$
	2019 ( <i>n</i> =45)		2021 ( <i>n</i> =89)				2019 ( <i>n</i> =26)		2021 ( <i>n</i> =20)			
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$			$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$		
LRA	96.11	4.75	96.12	4.11			98.08	3.19	96.25	3.58		
LRS	75.95	24.75	71.49	22.75			72.42	16.92	85.29	24.91		
WRA	93.56	8.20	96.10	8.00			97.60	3.71	98.00	3.20		
WRS	62.76**	17.93	50.95	19.80	<b>-0.28</b>	<b>-0.66</b>	60.89	20.23	61.67	23.03		
PRA	84.06	15.71	86.40	11.45			91.06	6.75	89.50	8.65		
PRS	45.03***	10.10	35.39	11.98	<b>-0.38</b>	<b>-0.95</b>	41.89	10.66	41.65	15.11		
TRS	-	-	114.79	36.35			-	-	139.12	37.09		
RC	81.94	15.44	76.83	18.32			85.58	15.69	85.00	13.81		

\*Significant difference in favor of this group in the Mann–Whitney U test  $p < 0.05$ ; \*\*Significant difference in favor of this group in the Mann–Whitney U test  $p < 0.01$ . Aggregated values, such as effect sizes, differences in standard deviations, and medians, are presented in bold text.

TABLE 7 Relative and median frequency of academic stimulation time by the teacher and adults at home, by type of schooling and grade.

Stimulation type	Weekly stimulation hours	Fourth grade		Sixth grade		Sample set	
		Public ( <i>n</i> =92)	Private ( <i>n</i> =25)	Public ( <i>n</i> =89)	Private ( <i>n</i> =20)	Public ( <i>n</i> =181)	Private ( <i>n</i> =45)
Teacher	None	3.3%	4%	4.5%	0%	3.9%	2.2%
	1–5	52.2%	8%	41.6%	5.3%	47.0%	6.7%
	6–10	30.4%	24%	38.2%	36.8%	34.3%	28.9%
	11–15	8.7%	4%	5.6%	0%	7.2%	2.2%
	16–20	4.3%	28%	9%	31.6%	6.6%	31.1%
	More than 20	1.1%	32%	1.1%	26.3%	1.1%	28.9%
	<b>Median</b>	<b>1–5</b>	<b>16–20***</b>	<b>6–10</b>	<b>16–20***</b>	<b>1–5</b>	<b>16–20***</b>
Adults in home	None	6.5%	20%	7.9%	0%	7.2%	11.1%
	1–5	34.8%	24%	30.3%	31.6%	32.6%	26.7%
	6–10	29.3%	44%	29.2%	31.6%	29.3%	40.0%
	11–15	10.9%	8%	15.7%	15.8%	13.3%	11.1%
	16–20	3.3%	4%	9%	15.8%	6.1%	8.9%
	More than 20	15.2%	0%	7.9%	5.3%	11.6%	2.2%
	<b>Median</b>	<b>6–10</b>	<b>6–10</b>	<b>6–10</b>	<b>6–10</b>	<b>6–10</b>	<b>6–10</b>

\*\*\*Median difference in Mann–Whitney U test significant in favor of this group,  $p < 0.001$ . Aggregated values, such as effect sizes, differences in standard deviations, and medians, are presented in bold text.

variables related to letter recognition speed and reading speed (sixth graders reduced their pseudoword reading speed by nearly one standard deviation). Although the difference was not statistically significant, sixth grade students also registered a loss of reading comprehension of 5 percentage points, which represents a noticeable impact on a population that already had poor levels of reading comprehension before the pandemic. These results confirm the findings to date in emerging literature, which have also demonstrated a greater impact of the pandemic on the most socioeconomically vulnerable sectors in other countries (Hammerstein et al., 2021; Hevia et al., 2022). In contrast, in the private schools, there was even a significant improvement in reading accuracy in fourth grade and in letter recognition speed in sixth grade during the pandemic. Similarly, in a country with a high level of development (Australia), a previous study also reported an increase in reading ability after a short period of confinement (Gore et al., 2021).

The significant disparity found between the two educational systems in terms of the amount of virtual interaction between

students and their teachers (joint median of 6–10 h per week in the public system and 16–20 in the private system) could explain, at least partially, the differential impact that a year of suspension of face-to-face schooling has had on the reading performance of the students. These results support similar findings in other studies, which have documented a marked difference in terms of hours of access to education and interaction with teachers between the public and private systems during the pandemic in Panama (UNICEF, 2021a).

In fact, the Technology, Pedagogical, and Content Knowledge (TPACK) framework states that, in order to carry out their responsibilities, teachers require initial and continuing training in all three types of competencies, which form a complex system with significant overlaps with each other (Mishra and Koehler, 2006). Differences between the teachers of both systems in terms of knowledge and skills, but also in terms of attitudes related to technology (De León Sautú et al., 2022), may also be an important factor that affects the

significantly lower number of hours of interaction that the students of the public system received in comparison with their peers, since not liking or fearing technology have been identified as some of the strongest barriers that prevent the use of technology by teachers (Ertmer et al., 2012).

In addition to the scarce remote pedagogical stimulation received by students in the public system during the pandemic described in this study and previously (UNICEF, 2021b), we must consider the possibility that the parental engagement (reported of similar intensity in the two systems) has been less effective in the homes of participants in public education due to a higher proportion of families with lower education levels, and sociocultural and socioeconomic capital, as reported by Cabrera et al. (2020). This effect could be a risk factor of critical importance, considering that reading is a prerequisite for equalizing educational opportunities. On top of that, we must take into account the differences in reading performance between students from both systems that existed prior to the pandemic, already described (Villaba et al., 2018; MEDUCA (Ministerio de Educación de Panamá), & OCDE (Organización para la Cooperación y el Desarrollo Económicos), 2019; Cubilla-Bonnetier et al., 2021; LLECE, 2022b). These differences are related to multiple sources of systemic inequity that range from school characteristics, including infrastructure and teacher attendance; to characteristics of the socioeconomic level of students and their families, including access to health, nutrition (Torres-Lista et al., 2019), and housing. Such characteristics vary significantly by school, region, and official or public system (Gorski, 2008; Dudley-Marling and Lucas, 2009; Avineri et al., 2015; Villaba et al., 2018).

## 4.2. Limitations and future research

The main limitation of this study is its limited sample size, which is only representative of one province in Panama, which is almost exclusively urban and sub-urban. The inclusion of schools in rural areas, as well as areas of difficult and very difficult access, with much less access to electricity and internet, would have resulted in largely different findings. Additionally, there is a limitation due to the use of a 2019 data set with a non-random sample, unlike the 2021 data set which comes from a study with random sampling procedures, which decreases the possible representativeness of the first sample compared to the second.

Future studies should aim to calculate the impact on reading performance among early elementary students, which was not possible due to the lack of a baseline with which to compare the 2nd grade reading performance reported in Cubilla-Bonnetier and Sánchez-Vincitore (unpublished manuscript). The reading performance of students at a national level, including indigenous regions, should also be carried out to expand the focus of this study. Furthermore, although the samples were stratified by sex to secure parity, this study did not include a comparative analysis by sex. Future research should look into possible significant differences between boys and girls. It is necessary to remember that this data collection was carried out 1 year after the suspension of face-to-face education, so a newly updated evaluation of the effects of the pandemic overall should be carried out, given that Panamanian public schools remained in a remote or blended-learning mode for 2 years. Finally, this study does not include classroom observations to provide understanding of the teaching and learning processes in which the children in the sample were participating. Certainly, the quality of reading instruction a child receives has an impact on their literacy development, therefore future studies should focus on describing this aspect and its effects.

## 4.3. Recommendations

Given that the reading performance outcomes of students in the province of Panama have worsened during the pandemic only for schools in the public system, we conclude that the gap that already existed before the pandemic between the academic learning achievements of students in public and private schools in Panama has increased and will continue to increase without systematic intervention. For this reason, we consider it urgent to prioritize evidence-based efforts for learning recovery, which will allow us to meet the learning needs of students in the public system in terms of reading, and thus reduce a gap that perpetuates inequality in the country. Some effective strategies for learning recovery which have been shown to be successful in improving reading achievement include: applying effective accelerated teaching methods during the entire instructional time, during summer courses, or during additional time throughout the year (Palmer et al., 2008); carrying out diagnostic evaluations and providing the necessary corresponding support to students through individualized or small group instruction (Paepflow et al., 2006); as well as providing tutorials that take place preferably during school hours, and that can be carried out by paraprofessionals and volunteers, such as university students with adequate training (Darling-Hammond et al., 2020; Robinson et al., 2021).

In order to achieve wider implementation of more effective educational approaches to the learning of literacy, it is important to incorporate into public policy the existing evidence on psycholinguistic reading precursors, as well as the evidence generated in Panama on their impact on reading performance. Specifically, it is critical to emphasize the development of phonological awareness and rapid automatized naming speed (RAN), as they have shown an important and persistent impact on the development of decoding in Spanish and in the Panamanian context, even up to fourth grade (Cubilla-Bonnetier and Sánchez-Vincitore, unpublished manuscript). Likewise, schools should also focus on developing the understanding of grammatical structures and receptive vocabulary, due to its direct effects on reading comprehension. This will require curricular changes, and the introduction of best practices for the development of literacy skills into initial and continuous teacher training programs.

In fact, because most of the professional development Panamanian teachers have been receiving seems to be focused on general pedagogical knowledge, teachers are currently already demanding more training that is subject-specific, such as teaching techniques for specific areas (De León Sautú et al., 2022). Teachers have praised programs such as the science-based “Aprendamos Todos a Leer” (Let us All Learn to Read), which focuses on early reading skills by providing teachers with training and follow-up coaching, as well as structured pedagogical materials (including workbooks and storybooks; IDB, 2021; Marinelli et al., 2021). Because there are few professional development programs that are year-long and include coaching in Panama, there is emerging evidence that schools enrolled in such programs generate better learning outcomes for students (De León Sautú, 2017; De León Sautú et al., 2022). Current initiatives should be supported for long-term sustainability, and new training focused on the teaching of literacy should follow best practices to support teachers in transferring evidence-informed teaching techniques for reading skills to the classroom, both face-to-face and online.

The results of this study highlight the need to provide the distance education our students need, in terms of hours of instruction as well as quality. As far as closing inequality gaps, it will be important to further



equalize virtual interaction time between students and teachers in public and private schools in the event of a new suspension of face-to-face schooling. In order to do this, the public system needs to be prepared to facilitate equitable access for both students and teachers to connectivity and devices (Darling-Hammond et al., 2020; IDB, 2020; UNESCO, 2021b).

Continuous professional development regarding technological pedagogical content knowledge (how to teach utilizing technology) and technological knowledge (the use of technology, in its different levels of expertise) should increase in variety and frequency, so that all teachers who need and desire such training are able to find ample opportunities to do so. Furthermore, to achieve an increase and improvement in the use of technology in the classroom that endures in time, special attention must be paid to providing professional development that aims to produce positive teacher attitudes and beliefs toward technology. Training about technology use should be provided at different levels to help all teachers receive training that is adequate for their current ability. There should be a way to track the capacity building that teachers have completed and provide incentives for teachers to complete technology-related professional development at sufficient intervals while tracking if it actually leads to more and better utilization of the technology needed for effective virtual education.

In conclusion, the evidence of this study documents an increased literacy development gap between public and private schools, possibly associated with significant differences in virtual interaction time with teachers. Closing the increased reading performance gap post-pandemic, and addressing the increasing educational inequality in the country will require: the implementation of evidence-based learning recovery with a focus on literacy development; long-term adjustments in curriculum and pedagogical methods that take into account psycholinguistic reading precursors such as phonological awareness; immediate sustained efforts to provide all students and teachers with devices and access to connectivity; and high-quality content, pedagogical and technology professional development with long-term support for implementation in the classrooms.

## Data availability statement

The datasets analyzed for this study can be found in the CIEDU Dataset at: [www.ciedupanama.org](http://www.ciedupanama.org).

## Author contributions

DC-B conceptualized the study, as well as designed it with contributions from NS, MG-B, AO-E, LP, and DC-B collected the data. DC-B analyzed the data and wrote the first draft of the manuscript, with

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contributions from NS, MG-B, AO-E, and LP wrote and contributed sections of the manuscript, including work carried out as part of their unpublished thesis. DC-B and NS revised the final manuscript. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2023.989872/full#supplementary-material>

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