

Article

Did the COVID-19 Pandemic Lockdown Harm Pre-Schoolers Learning in Portugal? Yes, but with Variations Depending on Socio-Economic Status

Pedro Bem-Haja ^{1,*} , Paulo Nossa ² , Diogo Simões Pereira ³ and Carlos F. Silva ⁴¹ CINTESIS@RISE, Department of Education and Psychology, University of Aveiro, 3810-193 Aveiro, Portugal² CEGOT, Department of Geography and Tourism, Faculty of Arts and Humanities, University of Coimbra, 3004-531 Coimbra, Portugal³ Empresários Pela Inclusão Social (Associação EPIS), 1649-038 Lisboa, Portugal⁴ William James Center for Research, Department of Education and Psychology, University of Aveiro, 3810-193 Aveiro, Portugal

* Correspondence: pedro.bem-haja@ua.pt

Abstract: The literature has shown that the COVID-19 pandemic has indelibly affected student performance. However, this deterioration is not the same for all students, with students of a lower socio-economic status (SES) being the most affected. The present study aims to understand if the pandemic lockdown in the last year of pre-school impacted the learning skills considered crucial for the transition to primary school, and whether this impact was moderated by SES or a quiet place to study (QPS). A total of 11,158 students belonging to 318 Portuguese schools underwent an assessment protocol composed of writing skills, maths, and motor-control tasks. A pandemic effect was observed for writing skills, especially during the first lockdown. Said effects were found to be potentiated by SES. Regarding maths, the fall in skills was only observed to be significant for less economically advantaged children. Motor tasks suffered; however, this was without any significant effect for SES or QPS. Thus, a detrimental effect of the pandemic lockdown was found on pre-school skills, particularly pre-literary abilities, and especially during the first lockdown. SES appeared to potentiate some inequalities. In other words, skills differences between individuals with higher and lower SES increased during the pandemic, particularly in the first lockdown, due to novelty, unpredictability, and the need for quick adaptation.

Keywords: COVID-19; lockdown; pre-schoolers; educational skills; socio-economic status

Citation: Bem-Haja, P.; Nossa, P.; Pereira, D.S.; Silva, C.F. Did the COVID-19 Pandemic Lockdown Harm Pre-Schoolers Learning in Portugal? Yes, but with Variations Depending on Socio-Economic Status. *Educ. Sci.* **2022**, *12*, 710. <https://doi.org/10.3390/educsci12100710>

Academic Editor: James Albright

Received: 13 September 2022

Accepted: 11 October 2022

Published: 14 October 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Most scientific evidence has suggested that the COVID-19 pandemic has had a negative impact on student learning, disrupting the normal functioning of schools and leading to learning losses as yet to be assessed, with the potential to increase inequality in education [1–3]. The COVID-19 pandemic caused strong disruption in the educational setting that affected 95% of school-age children around the world, according to the United Nations, 2020. It caught schools and parents off guard, with both children and families being exposed to a completely new fully-online educational model.

1.1. Pandemic Measures School Achievement and Socio-Economic Status

According to [4], the pandemic containment measures built a sudden wall of social isolation for children and adolescents, representing a serious risk for their mental health and academic skills. A study carried out by [5] showed that losses in reading learning ranged between 32 and 37%, while mathematics learning fell between 50 and 63%.

However, the literature seems to demonstrate that negative pandemic effects on academic results are not the same for all students, with students of low socio-economic status

seeming to have suffered the most (e.g., [1,4]). According to [6] estimated that socio-economic inequality in school performance increased by up to 30% during the pandemic. One of the most studied causes to explain this effect is related to the containment measures (lockdown) and consequent school closures that forced students to stay at home and study at a distance without pedagogical support or with lesser quality assistance, such as that provided by family members [7]. Specifically, parents seem to play an important role in helping children through lockdown [8]. A recent study has shown that, in addition to direct assistance, more educated parents promote greater access to literacy and good quality resources [9]. Some data have shown that lockdown learning losses were as much as 60% higher among students from less-educated homes [10] and poorer families [11]. Some studies showed that even if low socio-economic status (SES) students were able to access remote classes, they were less likely to have the same quality of remote learning or supportive atmosphere (e.g., parental supervision, space without distraction) [12]. According to [12] postulated that low SES students would experience 12.4 months of learning loss compared to 6.8 months of a global sample, aggravating existing opportunities by 15% to 20%. Another study showed that COVID-19 lockdown school interruptions had different impacts on the training of social and reasoning skills, contributing to delays in the acquisition of expected school skills, and that these delays were more severe in students of a lower socio-economic status [13]. This effect of potentiating inequalities caused by the absence of school does not seem to be new, since studies on summer learning loss have already shown that less-advantaged students lose more academic skills over the summer break (e.g., [14]). The authors hypothesized that this effect might be explained by the fact that higher SES families invest during this period in activities that are beneficial to academic performance, such as reading, traveling to foreign countries, visiting museums, or even participating in mixed leisure and learning programs that are adapted to the age group (e.g., [1]). Alexander and colleagues focused on the reasons that led to lockdown and the consequent online learning to increase socio-school inequality [14]. This theoretically oriented article states that this inequality originates in three distinct domains: (1) the inequality of access and digital skills; (2) socio-cultural differences; (3) structural and economic. One such variables raised by the authors was access to study space. Regarding socio-cultural variables, the authors state that middle and high social classes are more familiar with academic knowledge and the skills that are expected and valued in the educational setting. Regarding the effect of the pandemic lockdown on the learning commitment of the poorest, the authors of [11] postulated that in primary education this effect may mainly be explained by differences in the physical resources that are available for learning at home, such as a space for study. They argued that if the pandemic were to force schools to close again, it would continue to deprive the poorest students of the protective and equalizing role in their learning and development that school time can play. Along the same line, [7] showed that students made very little progress at home, more dramatically, students with less-educated parents, or those living in countries with weaker infrastructure and longer school closures. Another impediment weighing more heavily on lower SES students was less access to additional means of home and family support [12]. Interestingly, a study that analysed the school effect [3] found that schools with more underprivileged pupil populations registered less-robust learning gains. On the other hand, in addition to parental influence, studies have shown that the study habits of students with low socio-economic status also have an impact on performance. For example, [15] showed that students from more underprivileged families spent fewer hours learning at home during the lockdown.

The largest study carried out in this domain had an $n = 4.4$ million students and showed that decrements during the confinement were larger for mathematics scores than for English scores, but above all, it showed that these delays were greater in lower grades [16].

1.2. Early Child Education and Its Importance

The International Standard Classification of Education [17] stipulates that pre-schoolers should acquire social, language, and reasoning and logic skills, in addition to alphabetical

and mathematical concepts, and that they are encouraged to explore the surrounding world and environment. Additionally, supervised gross motor activities and play-based activities can be used as learning opportunities to promote peer social interaction and to foster skills, autonomy, and school readiness. Thus, recognition is growing that quality pre-school educational environments have a strong impact on children's learning, development, and well-being [18]. More than 85% of G20 country children participate in Early Childhood Education (ECE) programs before primary school, and in countries such as Australia and the United Kingdom, most children are in school by the age of 5 [19]. In Portugal, pre-school education was named as the first stage of basic education in 1997, a move which became a fundamental pillar in efforts toward social inclusion and human capital development [20].

Pre-school education covers a critical interval of student development and is now seen to be a fundamental, preparatory stage for short- and medium-term educational success, contributing significantly to the acquisition of present and future school and life competences [21]. Indeed, these years are key to the development of social and emotional competence (e.g., [22]) and a crucial phase in developing school skills (e.g., mathematics [23]). Given the importance of this period in students' cognitive, social, and emotional development, any potential obstacles may be prejudicial for their futures. As mentioned above, the pandemic and the consequent lockdowns may have compromised the natural development of pre-school activities. An investigation carried out on pre-schoolers by [24] assessed parental opinion about remote learning and the level of family involvement during the lockdown generated by COVID-19. The results show that parents reported greater support and engagement in literacy-related tasks than in mathematics learning-related tasks. The authors state that this difference seems to be based on the great time consumption that maths tasks demand from parents, compared to others that are less demanding and generate more social interaction with the child. Another relevant datum is associated with the level of satisfaction that the tasks sent remotely generated in the parents. Although most parents considered the tasks easy to understand, only 28% said they were satisfied with their involvement in those tasks, and 35% were dissatisfied with the distance-learning methodology.

1.3. The Lockdowns in Portugal

During the first COVID-19 wave, the Portuguese school system officially closed on 16 March 2020, and the educational system transitioned to a mixed system of television broadcasting and online home-schooling until June 2020 [25], although many Portuguese parents kept their children at home longer due to health uncertainty. This unexpected emergency led to both students [26] and teachers [27] having to quickly adapt to online teaching. This unpredictability, which was exacerbated by pre-school characteristics such as low child autonomy and curricular flexibility, reduced school–child interaction to almost negligible levels. The second Portuguese lockdown, from 22 January to 15 March 2021 [28], saw online teaching returning to the daily lives of teachers and students, but this time with higher, yet not universal, levels of preparation.

1.4. Purpose

To the best of our knowledge, no study to date has investigated the impact of pre-school lockdowns by evaluating the cognitive and educational skills that are necessary for the transition to primary education, while also investigating the moderating impact of SES and a quiet place to study (QPS). This work aims to study whether the pandemic confinement during the last year of pre-school negatively impacted children's command of those learning skills considered fundamental for the transition to primary education, and whether this impact was moderated either by students and families' SES, as evaluated by the Graffar Index (GI), and/or by the access or not to a quiet place to study at home. We used the GI because it is a multifactorial instrument that has proven to be very robust in assessing household SES [29]. This article introduced to the literature an assessment of the pandemic lockdown's impact on pre-school students' skills that represent pre-school

curricular goals (skills that the student should master when finishing pre-school). This aspect is extremely important because these goals are significant predictors of academic achievement in subsequent years. Another point that renders the present study novel is that the skills assessment was carried out at the entrance of primary school (beginning of grade 1) and not during it, avoiding learning biases of a temporal nature. It also evaluated whether there is an interaction between these skills and the SES and QPS. This study also sought to detail whether there are skills that are more or less affected by the lockdown, with the type of skill as a within-subject factor, where the same participant performs all the tasks. In addition, the analytical approach, using the school as a cluster and controlling its variability, is also a novelty in the literature. This last point is crucial considering the existence of several studies that showed a strong variability among schools in how much their students had suffered during the lockdown (see [3]).

2. Materials and Methods

2.1. Study Sample

Data were collected over four consecutive years (2018–2022) from a sample of 11,158 students (5504 female) enrolled in the first year of formal schooling (primary). The mean age was 6.13 (SD = 0.45) and the age distribution appears in Table 1.

Table 1. Frequencies of students by age.

Levels	<i>n</i>	% of Total	% Accumulated
4 years	5	0%	0%
5 years	352	3%	3%
6 years	9077	81%	85%
7 years	1622	15%	99%
8 years	88	1%	100%
9 years	10	0%	100%
10 years	4	0%	100%

These students attended 318 schools in 41 municipalities in Portugal and were evaluated by the EPIS educational program—Entrepreneurs for Social Inclusion tool, which is described below.

Regarding SES, the distribution of GI scores (see Materials Section 2.2.2 for a detailed description) appears in Figure 1.

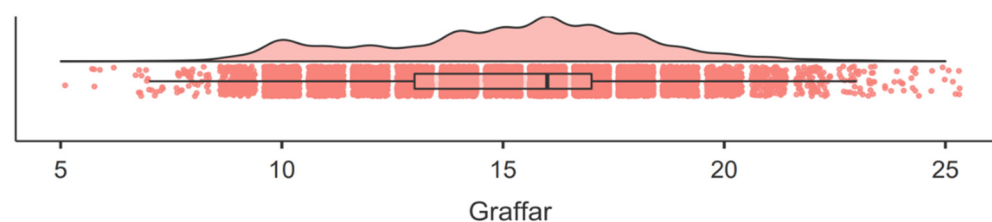


Figure 1. Graffar Index score distribution (2018–2022).

The average GI was 15.11 (Md = 16, SD = 3.0) and ranged between 5 and 25. Due to the variable's continuous nature, it was entered as a covariate into the models using the $M \pm 1$ SD criterion. The distribution of students who reported YES and NO to having a quiet place to study appears in Table 2.

Table 2. Student attendance due to availability of a room or a quiet place to study.

Levels	<i>n</i>	% of Total	% Accumulated
No	1248	11%	11%
Yes	9910	89%	89%

Interestingly, almost 90% of students reported having a quiet place to study.

2.2. Materials

2.2.1. Assessment Protocol and Performance Tasks

The research protocol was drawn up in advance, and informed parental consent was obtained before the assessment of children's skills. The screening, carried out by teachers or psychologists with specific training, took place between October and December of each year with students enrolling in the first year for the first time. The results were shared with both parents and the head teacher of the class. Both informed consent and collection documents included a GDPR—data protection statement.

In the screening, students were evaluated at the beginning of primary school using a protocol that evaluated the Curriculum Guidelines for Preschool Education (OCEP [30]). These guidelines indicate learning contents regarding: (i) mathematics, (ii) oral and written language, and (iii) physical and artistic education. Based on these criteria, an assessment tool composed of writing, mathematics, and motor-control tasks was drawn up, bearing in mind the goals and competencies expected at the end of this educational cycle. The following skills were evaluated: (a) vowel identification, (b) linguistic perception and planning (story sorting), (c) ranking, (d) counting, (e) picture copying, and (f) physical balance (materials and tasks can be shared by authors through a collaboration protocol).

The pre-literacy skills tested included whether children could draw and distinguish some vowels on a card with a set of twenty randomly distributed capital letters.

The linguistic perception and planning task was divided into two stages. The children first listened to a short story (112 words) and were then asked to retell the story by placing cards with images representing the story into a coherent sequence.

The ranking task comprised a card with four elephants of clearly differentiated sizes and the children had to link the elephants with a pencil in order from the smallest to the largest.

The children demonstrated their counting abilities by naming the number of blackberries in an image. Next, they were asked to copy figures in the correct orientation from a card with four simple and well-defined figures (circle, square, triangle, and a cross). The child had to copy the figures onto a sheet of paper, respecting the approximate shape and position so that the figures were recognizable.

The motor skill task required children to walk a straight line drawn on the floor (approx. 120 cm long, 5 cm wide), without significantly deviating or needing adult support.

2.2.2. Other Measures—Graffar Index (GI) and Quiet Space to Study

The GI is commonly employed in the literature as a simple and consistent instrument for assessing household SES [29]. It assessed families' socio-economic status based on the following categories: (1) profession; (2) education level; (3) family income sources; (4) the comfort of the accommodation; and (5) the urban quality of the neighbourhood. In this study, the family member with the highest level of profession, education, and income completed this self-report.

The students answered a question enquiring whether they spent the lockdown in a dwelling with a quiet space to study or read.

2.3. Data Analysis

We analysed four years of evaluations of students in the first year of primary education and compared the results from years 2018 to 2019, 2019 to 2020, 2020 to 2021, and 2021 to 2022. As these evaluations were carried out at the beginning of primary school, years 2018–2019 and 2019–2020 were defined as pre-pandemic years. The 2020–2021 evaluation took place only in the last quarter of 2020, since the first lockdown had prevented students from attending pre-school at least between March and June. This meant that they lost the last year of pre-school, as no online pre-school activities took place. Evaluations also occurred in the last quarter of 2021 due to the February and March lockdown, although

greater school–family integration allowed educators to organize remote activities using either a computer, tablet, or smartphone.

To verify whether the student results varied over the four-year period, a longitudinal analysis was performed for each dependent variable using the school as the clustering vector. Growth models analysed the longitudinal fluctuation of the results over the period. These models are the most suitable for this data set, as they focus on the school (controlling for possible differences between schools); correct eventual lack of data in certain years (schools that did not evaluate the entire quadrennium); and correct for any timing differences (e.g., a school where most tests were implemented in one year is October and in the following year in November). The growth models were estimated within a framework of generalized mixed models (GMM), which was adjusted by REML. The *t*-test calculations used Satterthwaite’s method. For the growth models, a 2-step sequential method was used: 1—unconditional growth model and 2—conditional growth model. The unconditional growth model was produced with the variable YEAR to assess the existence of a significant fluctuation over time (year) without restricting other variables. This model allowed intercepts (scores in 2018–2019) and slopes (slope of the lines) to vary between schools. The unconditional growth model was expressed using the following Equation (1):

$$Y_{ys} = \beta_0 + \beta_1(YEAR) + b_{0s} + b_{1y}(YEAR_{ys}) + \varepsilon_{ys} \quad (1)$$

where Y_{ys} is the dependent variable in year y for school; β_0 is the average of the intercept (result in 2018–2019); β_1 is the average rate of fluctuation (YEAR); b_{0y} and b_{1y} are random effects and allow intercepts (result in 2018/2019) and slopes (fluctuation rates) to vary between schools; and ε_{ys} is the year-specific residual.

To ascertain whether the progression of the dependent variable over time depended on either SES or QPS, a conditional growth model was produced with the QPS as a factor and the GI as a covariate factor using the following Equation (2):

$$Y_{ti} = \beta_0 + \beta_1(YEAR) + \beta_2(SPACE) + \beta_3(GRAFFAR) + \beta_4(YEAR)(SPACE) + \beta_5(YEAR)(GRAFFAR) + \beta_6(SPACE)(GRAFFAR) + \beta_7(SPACE)(GRAFFAR)(YEAR) + b_{0s} + b_{1y}(YEAR_{ys}) + \varepsilon_{ys} \quad (2)$$

where β_2 is the effect of space; β_3 is the effect of Graffar ($M \pm 1$ DP); β_4 , β_5 e β_6 are the double interactions; and β_7 is a triple interaction.

Statistical analyses were conducted using R (<https://www.r-project.org/>, accessed on 10 March 2022) with the GAMLj package.

Variables Systematization

Independents:

- Time (4 years of assessment 2018–2022, 1 each year at the beginning of the grade 1).
- SES (measured by Graffar Index).
- QPS (presence or absence of a quiet place to study).

Dependents:

Pre-literacy

- Vowel Identification (drawing and distinguishing some vowels on a card with a set of twenty randomly distributed capital letters).
- Story Sort (listening to a short story—112 words—and retelling the story by placing cards with images representing the story into a coherent sequence).

Maths

- Ranking Task (a card with four elephants of differentiated sizes and the children had to link the elephants in order from the smallest to the largest).
- Counting (naming the number of blackberries in an image).

Motor Skills

- Figure Copying (copying the figures onto a sheet of paper, respecting the approximate shape and position so that the figures were recognizable).

- Balance (walking along a straight line drawn on the floor without significantly deviating or needing adult support).

3. Results

For a better understanding of the results, these are divided by pre-school domain.

3.1. Pre-Literacy

3.1.1. Vowel Identification

The unconditional growth model shows the existence of a significant effect of year, $\chi^2(3) = 184.23, p < .001$. Figure 2 reveals a fluctuation in vowel identification over time, with a higher score (more errors). Repeated contrasts show that this vowel identification fluctuation seems to be explained by the significant rise in the score between 2019/2020 and 2020/2021 ($z = -6.45, p < 0.001$). No other variations were found to be significant (all p values > 0.202). The most conceptually important finding was that the 2021/2022 vowel identification value did not return to pre-pandemic values.

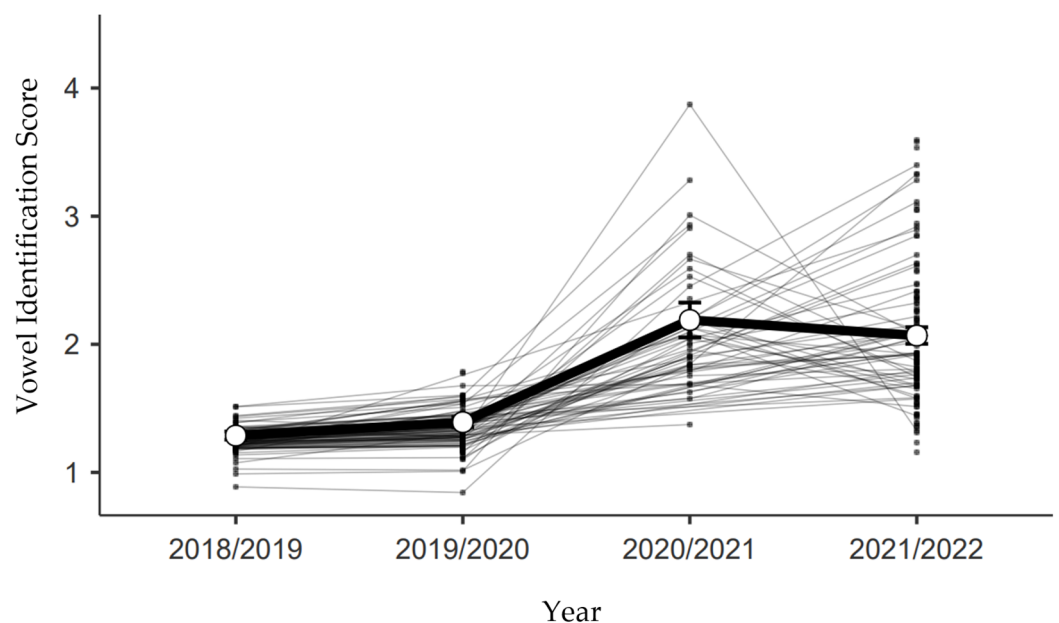


Figure 2. Fluctuation of vowel identification score over four years (2018–2022); error bars represent standard error of the mean.

The graph demonstrates the high level of variability in the last two years. It was, therefore, decided to produce a growth model that might condition the fluctuation by SES and QPS. The conditional growth model showed a significant effect of GI $\chi^2(2) = 197.79, p < 0.001$ and of QPS $\chi^2(2) = 19.89, p < 0.001$ with higher scores (worse results) obtained by students with lower SES and those with no QPS. Interestingly, a significant interaction $\chi^2(3) = 27.12, p < 0.001$, appeared between SES and year. These data show that the effect of the year depends on the GI. Figure 3 illustrates that during the pandemic years, not only did vowel identification levels fall, but the differences between the SES levels fell as well. To better explore this interaction, the simple main effects of time were performed with GI as a moderator. Although the significant effects of time were recorded for all GI levels (all $p < 0.01$), the greater the GI values, the greater the effects ($M - 1\text{ SD} = -3.88, p < 0.001$; $M + 1\text{ SD} = -7.56, p < 0.001$).

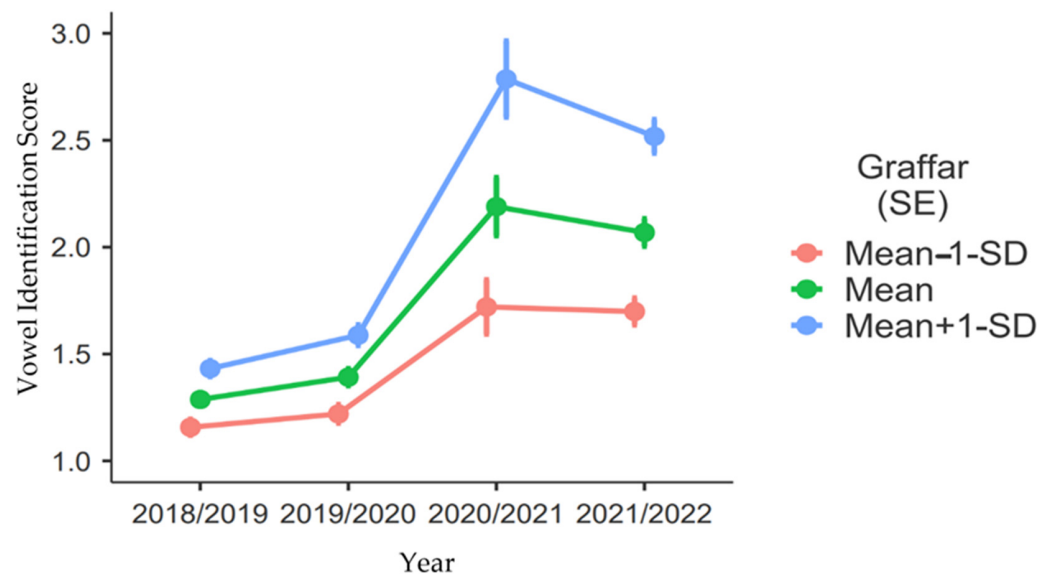


Figure 3. Fluctuation of vowel identification score over four years (2018–2022) by Graffar (GI) levels (mean $\pm$ 1 standard deviation); error bars represent standard error of the mean.

3.1.2. Story Sort

The unconditional growth model revealed no significant effect of year, $\chi^2(3) = 4.73$, $p = 0.192$. Descriptively, as demonstrated in Figure 4, sorting performance fluctuated (with higher scores representing worse performance). In fact, although no significant differences were recorded, a pandemic effect did appear in 2020–2021, followed by a return to pre-pandemic levels in 2021–2022, contrary to what happened with vowel identification.

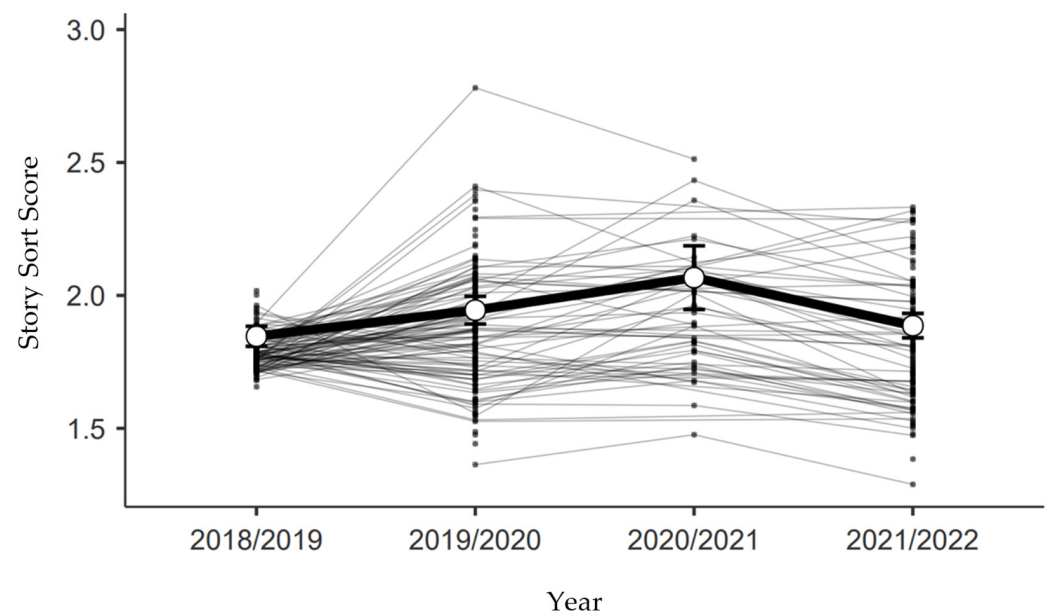


Figure 4. Fluctuation of story sort score over four years (2018–2022); error bars represent standard error of the mean.

Despite the absence of year effect, considering the exploratory nature of this study, it was decided to condition the fluctuation to SES and QPS. The conditional growth model showed a significant effect of GI $\chi^2(2) = 130.78$, $p < 0.001$ and of QPS $\chi^2(1) = 10.59$, $p < 0.001$, with higher scores obtained by lower SES students and those without QPS. However, no significant interactions were recorded. Nevertheless, exploratory analyses were performed

with the simple main effects of time with the variables GI and QPS as moderators. The results revealed that the only significant results were those for GI, which emphasises the importance of GI on the time effect. In fact, the only significant variation over time was that obtained for the mean +1 standard deviation ($\chi^2 = 8.08$, $p = 0.044$; see Figure 5). In other words, the only score that increased during the first pandemic year was that for the children of a lower socio-economic status.

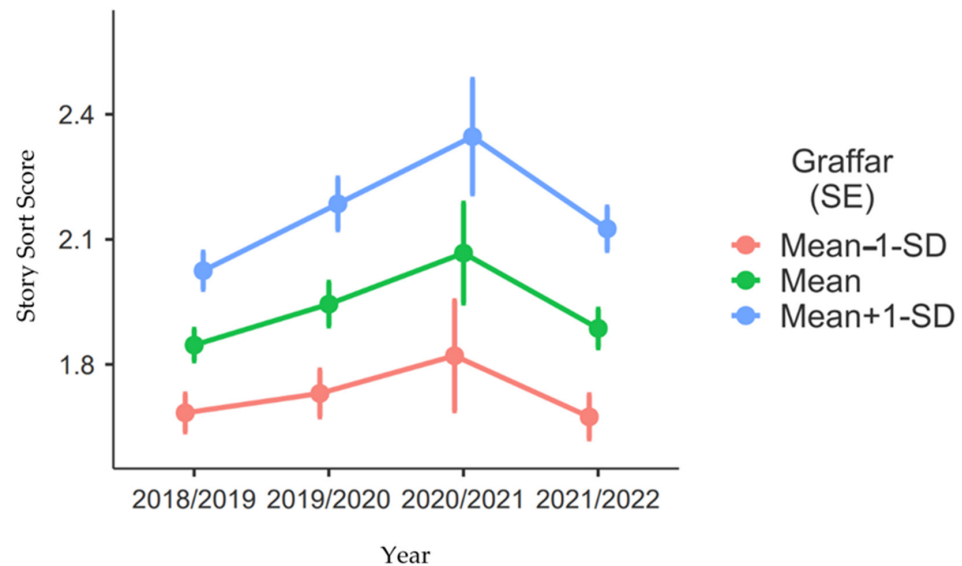


Figure 5. Fluctuation of story sort score over four years (2018–2022) by Graffar (GI) levels (mean $\pm$ 1 standard deviation); error bars represent standard error of the mean.

3.2. Maths

3.2.1. Ranking Task

The unconditional growth model uncovered the existence of a significant effect of year, $\chi^2(3) = 17.45$, $p < 0.001$. Figure 6 shows a fluctuation in ranking performance over time, with higher scores implying worse performance. Repeated contrasts show that this ranking fluctuation over time seems to be explained by the score increase between 2019–2020 and 2020–2021 (first lockdown) and by the fall in the score in 2021/2022 ($z = 2.50$, $p = 0.012$).

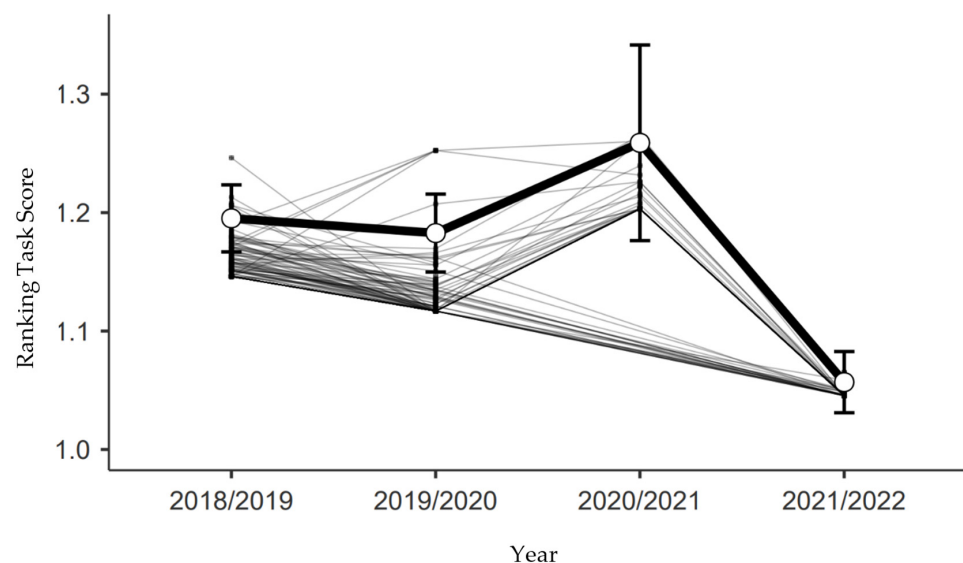


Figure 6. Fluctuation of ranking task score over four years (2018–2022); error bars represent standard error of the mean.

The conditional growth model showed a significant effect of GI, $\chi^2(2) = 17.59, p < 0.001$ and a marginal one for QPS $\chi^2(1) = 3.82, p < 0.001$, with worse results being reported by lower SES students and those without a QPS. However, no significant interactions were revealed. Once again, exploratory analyses were performed with simple main effects of time with the variables GI and QPS as moderators. The results showed that only the GI manifested significant results. In fact, over time, the only significant variation was that obtained for the mean ($\chi^2 = 17.46, p < 0.001$) and for the mean +1 standard deviation ($\chi^2 = 24.84, p < 0.001$; see Figure 7). In other words, the increase in the score in the first year and the decrease in the second lockdown year was only found to be significant for the lowest and medium SES students. Lower GI scores (higher SES) seemed to protect the children from pandemic ranking impact, which is a very important skill for mathematics.

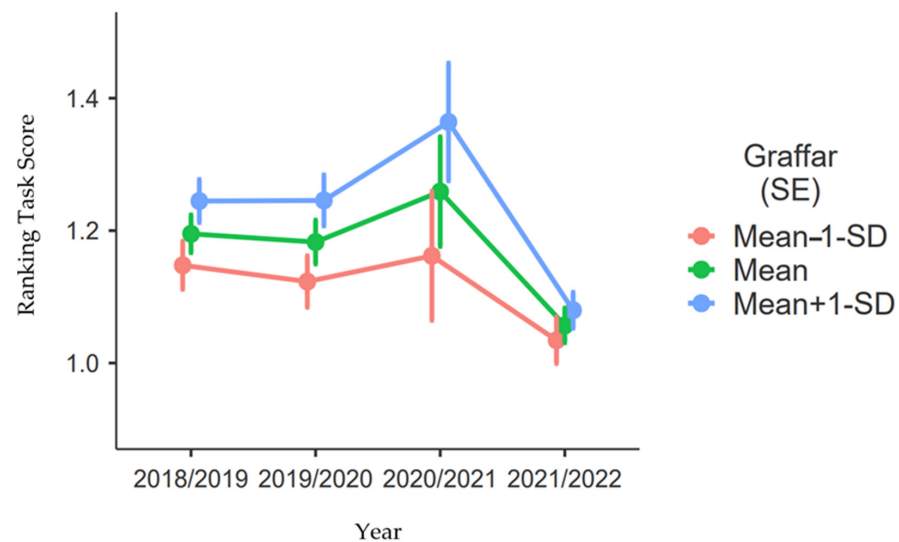


Figure 7. Fluctuation of ranking task score over four years (2018–2022) by Graffar (GI) levels (mean $\pm$ 1 standard deviation); error bars represent standard error of the mean.

3.2.2. Counting

Figure 8 shows counting performance fluctuation over time. A higher average value in 2020–2021 stands out; however, the unconditional growth model revealed that variation in counting task scores was not significant over time, $\chi^2(3) = 0.59, p = 0.900$.

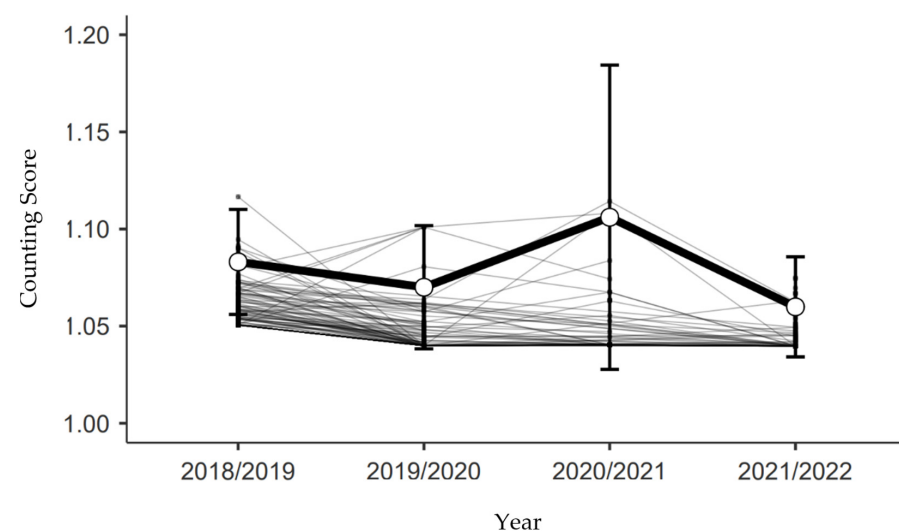


Figure 8. Fluctuation of counting score over four years (2018–2022); error bars represent standard error of the mean.

The conditional growth model showed a significant effect of GI $\chi^2(1) = 9.40, p < 0.001$ but not of QPS, $\chi^2(1) = 2.67, p < 0.001$, with worse results obtained by lower SES students. No significant interactions were recorded, however. Exploratory analyses with simple main effects of time with GI and QPS were not found to be significant.

3.3. Motor Skills

3.3.1. Figure Copying

The unconditional growth model revealed a significant effect of year, $\chi^2(3) = 134.78, p < 0.001$, and Figure 9 displays a copying fluctuation over time, with higher scores indicating worse performance. This fluctuation over time seems to be explained by the significant rise in the score between 2019/2020 and 2020/2021 ($z = -3.99, p < 0.001$). No other variations were found to be significant (all p values > 0.344). The most important finding was the unchanged error value for figure-copying in 2021/2022, which failed to return to pre-pandemic values.

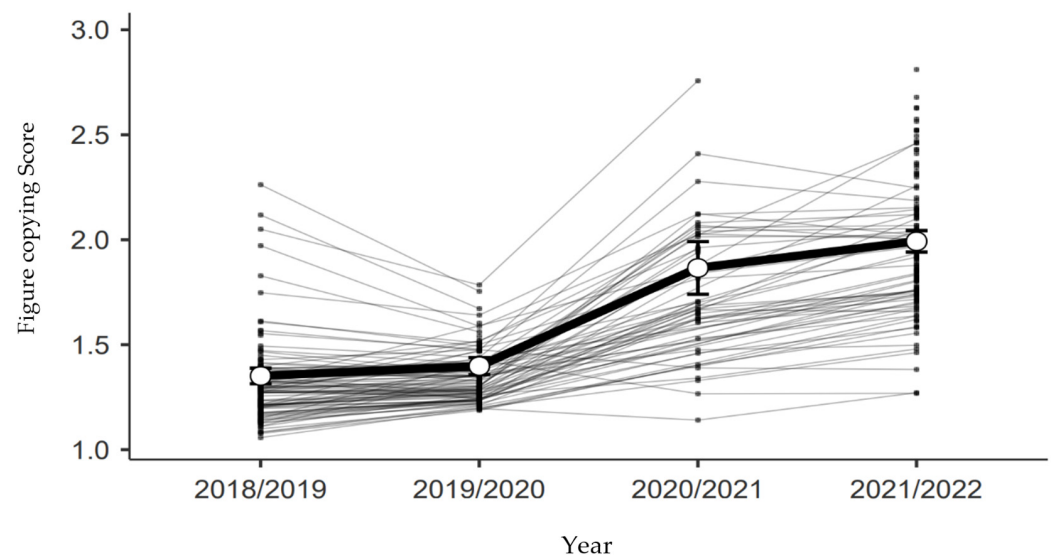


Figure 9. Fluctuation of figure-copying score over four years (2018–2022); error bars represent standard error of the mean.

The graph illustrates a high rate of variability in the last two years and, therefore, a growth model was produced to condition the fluctuations to SES and QPS. The conditional growth model showed a significant effect of GI $\chi^2(1) = 49.60, p < 0.001$ and of QPS, $\chi^2(2) = 6.73, p < 0.001$, with worse scores characterizing lower SES students and those with no QPS. No significant interactions were obtained, however. Figure 10 shows that although lower GI (higher status students) always reported better results, the ratio between SES levels remained unchanged over the four years. In fact, exploratory analyses with the simple main effects of time with GI and QPS revealed no significant results.

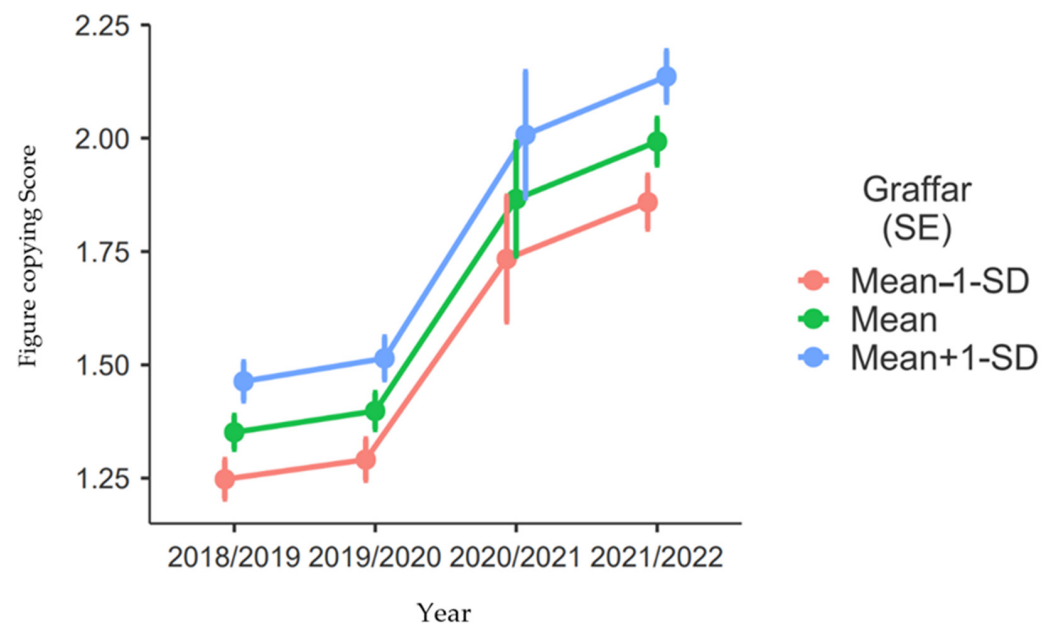


Figure 10. Fluctuation of figure-copying score over four years (2018–2022) by Graffar (GI) level (mean $\pm$ 1 standard deviation); error bars represent standard error of the mean.

3.3.2. Balance

Figure 11 illustrates balance fluctuation over time, where higher scores represent better performance. A lower average clearly appears in 2020–2021; this was reinforced by the unconditional growth model, which revealed that this measure varied significantly over time, $\chi^2(3) = 14.43$, $p < 0.001$. Repeated contrasts show that this fluctuation over time appears to be explained by the decrease in the score between 2019–2020 and 2020–2021 (first lockdown) and by the increase in 2021/2022 ($z = -2.46$, $p = 0.001$).

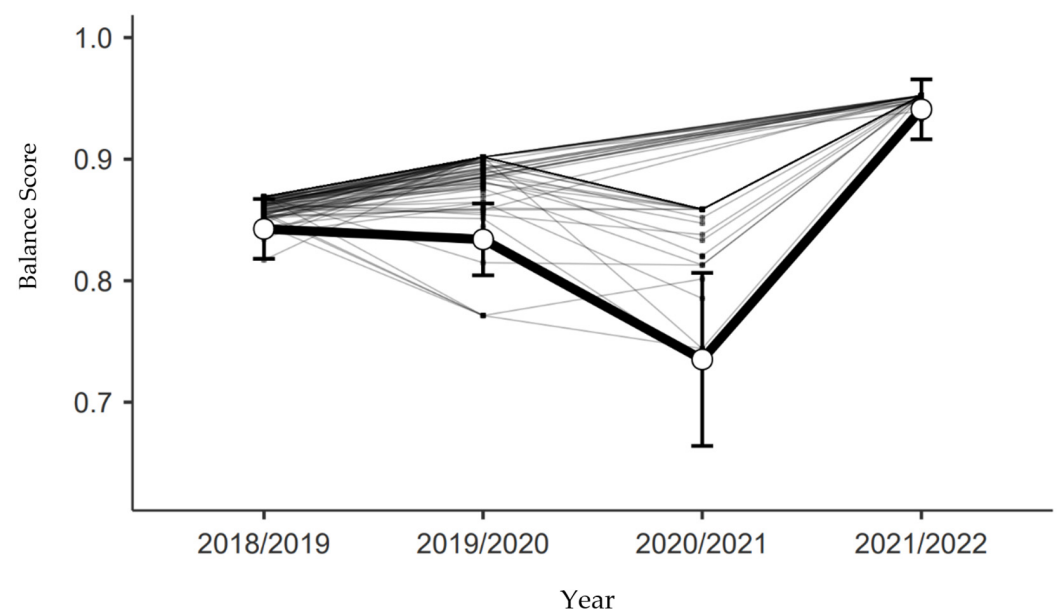


Figure 11. Fluctuation of balance score over four years (2018–2022); error bars represent standard error of the mean.

In contrast to what was found in all previous models, this conditional growth model only showed a significant effect of QPS $\chi^2(1) = 6.16$, $p < 0.001$, with better scores being reported by students without a QPS. Nevertheless, no significant interactions were obtained

and none of the simple effects were found to be significant. Even so, and despite the variability in 2020–2021, Figure 12 illustrates that children without QPS had lower balance scores.

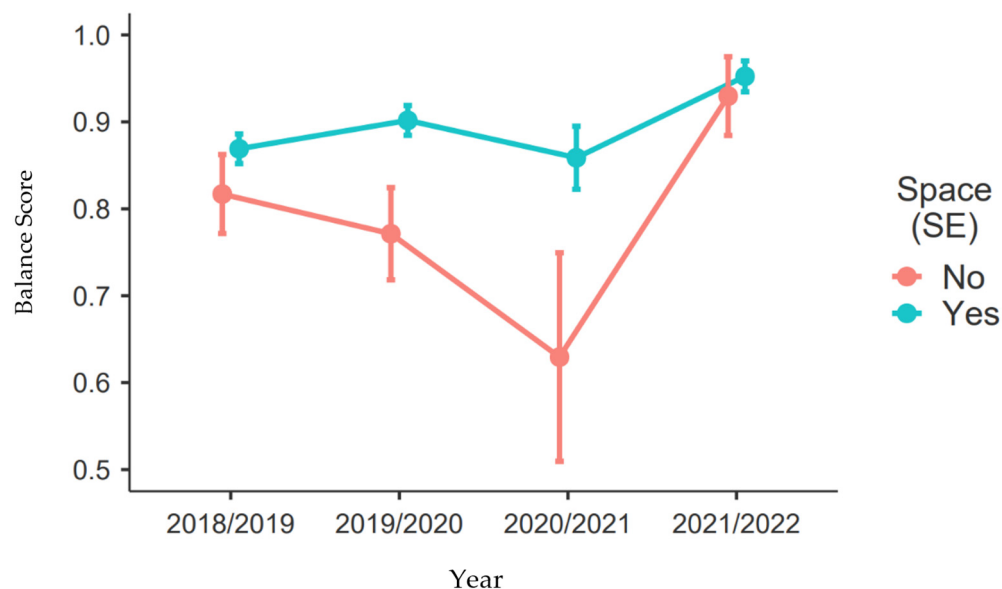


Figure 12. Fluctuation of balance score over four years (2018–2022) as a function of QPS (space); error bars represent standard error of the mean.

4. Discussion

The impact of COVID-19 lockdowns on student academic performance has been documented by [6]. However, to the best of our knowledge, no studies have examined the lockdown impact on last-year pre-school students on a key set of skills supporting children’s transition to primary school. Writing skills, vowel identification, and story sorting witnessed a pandemic effect, particularly so following the first lockdown. Both effects depended on SES, with less-advantaged children showing greater functional impairment during the pandemic confinement, a fact which distanced them even further from higher SES students. This effect was even more relevant because we controlled for school variability. Despite the importance of QPS for schooling performance, this variable did not significantly increase its importance during the pandemic lockdown when measured against pre-school writing skills. Thus, the pandemic asserts itself as a potentiator of inequalities between various student SES levels and preliteracy skills. These data are in line with what was predicted based on published results, such as those of [10]. Interestingly, the results obtained in our study give more strength to this effect because objective performance measures were used, rather than inference attributed to lost study time. The literature has explained the SES effect using several explanations. In [15], this effect is said to occur because students from more underprivileged families spent fewer hours learning at home during the lockdown. On the other hand, [9] postulates that students of a lower socio-economic status have less access to literacy and consume low-quality educational resources. Additionally, a possible explanation for the potentiation of these inequalities is related to the fact that parents of a lower socio-economic status will find it more difficult to help their children and give less constructive feedback [31]. This feedback influences the continuity of the task and promotes the early abandonment of its execution (see [31]). Interestingly, pre-pandemic studies have already reported that children with difficulties in carrying out homework already activated the help of parents; however, they were not necessarily able to help them [9]. Additionally, a study with teachers as participants shows that the use of distance education is not suitable for teaching reading and writing skills in general [32]. In this study, the teachers state that this inadequacy is related to four major problems of distance learning: those related to parents, technical issues, the learning–teaching process,

and the learning environment. Nevertheless, they signalled that parental influence is the most important.

The losses in math skills were less robust than in pre-literacy skills. Nevertheless, the ranking results did fluctuate during the pandemic, although the only significant change was for lower SES children. The counting results fell after the first confinement; however, these fluctuations were not significant in relation to either SES or QPS. Once again, QPS, despite being important for performance, did not significantly increase its importance during the pandemic regarding maths skills. This result is in line with those reported by [10]. However, the slightest deterioration in maths compared to writing skills was not expected, considering the vast body of literature that shows that learning losses were larger for maths than reading (for example, [10,16,33]). Additionally, our results contrast with evidence that parents were less comfortable with helping their children with maths tasks [24]. Nevertheless, there is also evidence that this effect depends on the difficulty of the tasks (see [34]). Indeed, a recent study showed that children in early grades are still learning to read and need regular tutoring from their teachers [9]. Furthermore, according to [34], the parents of younger students were more self-confident about their overall home-learning involvement in maths. Although most studies show a larger decline in mathematics during the pandemic lockdown, both [7,35] showed stronger decrements in reading comprehension than in mathematics after the school closures. These mixed results need further investigation, perhaps with standardized tests and in longitudinal studies to assess the stability of the learning losses.

Our pandemic effect regarding motor skills echoes those reported by [25]. Specifically, significantly worse figure-copying results were obtained in the first and second pandemic lockdown years. Nevertheless, these differences were not potentiated by either SES or QPS. In fact, in all years, higher SES students obtained better results and the score differential did not increase during the pandemic. Regarding the issue of balance and despite a non-significant effect, worse performances were obtained in the first lockdown year. Curiously, balance was the only dimension where QPS achieved a more relevant result than status. Balance differences between those who did or did not have a QPS increased for pre-school children during the first lockdown. Although there is literature showing a highly negative impact of lockdown on the motor skills of primary school students [36], the result obtained for the QPS is not intelligible and may be an artifact. Targeted studies must be carried out to disentangle this result.

Regarding limitations, the present study was carried out with a non-probabilistic sample, and despite a generous population size distributed across the country, the sample is not representative of the population. We did not control for the psychological variables that the literature indicates affect task performance, and which were highly unusual. This constitutes a confounding variable in our study. Additionally, we were unable to control the exact time that each child was at home with their parents, and whether their interaction at home was with their parents, grandparents, or if they were part of single-parent families. Another issue is related to the result's degree of "far transfer"; however, we did not have access to school results in order to evaluate this transfer between task performance and academic classifications. More research is needed to replicate uncovered effect, particularly, to assess its stability over time, i.e., if the pandemic effects are fully reversed in the following years. For example, it would be particularly worthwhile to compare the fourth-year academic performance of a sample who completed the fourth year in the pre-pandemic period to those finishing the fourth year in the post-pandemic period and who attend the last year of pre-school in COVID-19 lockdown (class of 2019 and class of 2024).

5. Conclusions and Recommendations

Globally, we have verified a detrimental effect of the lockdown on pre-school skills, particularly on pre-literacy abilities, and which affected to a much greater degree those children in their last year of pre-school. On the other hand, SES appears to have potentiated

some inequalities. In other words, individual performance differences between higher and lower GI students increased during the pandemic, especially so during the first lockdown due to novelty, unpredictability, and the need for quick adaptation. In [37], it was reported that learning loss in grade 3 would accumulate and result in students performing 1 to 1.5 years lower in grade 10. According to [37], short-term remediation efforts (e.g., teachers covering 1/2 of grade 3 curriculum in grade 4 and reverting to the pre-pandemic curriculum and instructional levels by grade 5) were also estimated to potentially reduce long-term learning loss to half of a school year.

The results obtained in the present study draw the attention of all educational stakeholders to a significant delay in students' competence caused by the pandemic lockdown, namely, in students with a lower socio-economic status and greater deterioration of pre-writing skills. Educational stakeholders must give special emphasis to low SES students, designing educational interventions with students and parents to enhance underdevelopment (for example, [31,37]). This parental intervention, specifically in the modelling of educational feedback, is crucial [38], because as we have seen in several studies, they are the ones that support the educational accomplishment at home. On the other hand, there is also a need for greater investment in more effective distance education. Studies in more advanced schools in terms of technological structure and which had dedicated software at their disposal promoted less delay in competences [39]. Some educational software already have feedback systems that have been shown to be very efficient in educational guidance [40]. However, in addition to strengthening the technological structure, the digital skills of teachers must be fostered [41] and all technological support must be provided so that the negative image of distance learning disappears, particularly in disadvantaged students and families [42].

Whether on the side of a more effective distance education, or through the creation of programs of educational empowerment in parents, we cannot leave these children without intervention, especially because at these ages the brain is highly plastic and receptive to transformation [43].

Author Contributions: Conceptualization, P.B.-H., P.N., D.S.P. and C.F.S.; methodology, P.B.-H., P.N. and C.F.S.; formal analysis, P.B.-H. and P.N.; writing—original draft preparation, P.B.-H. and P.N.; writing—review and editing, P.B.-H., P.N., D.S.P. and C.F.S.; project administration, D.S.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to legal issues.

Acknowledgments: We would like to thank EPIS programs director Andreia Jaqueta Ferreira; the entire team of EPIS coordinators: Marcelo Formosinho, Isabel Duarte, Margarida Brandão, Goreti Moreira, and Nuno Palma; and all the mediators. We also want to thank all the students, parents, and teachers who participated or collaborated in this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. George, G.; Dilworth-Bart, J.; Herringa, R. Potential socioeconomic effects of the CoViD-19 pandemic on neural development, mental health, and K-12 educational achievement. *Policy Insights Behav. Brain Sci.* **2021**, *8*, 111–118. [\[CrossRef\]](#)
2. Hammerstein, S.; König, C.; Dreisörner, T.; Frey, A. Effects of COVID-19-Related School Closures on Student Achievement—A Systematic Review. *Front. Psychol.* **2021**, *12*, 746289. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Maldonado, J.E.; De Witte, K. The effect of school closures on standardised student test outcomes. *Br. Educ. Res. J.* **2021**, *48*, 49–94. [\[CrossRef\]](#)

4. Poletti, M. Hey teachers! Do not leave them kids alone! Envisioning schools during and after the coronavirus (COVID-19) pandemic. *Trends Neurosci. Educ.* **2020**, *20*, 100140. [CrossRef] [PubMed]
5. Kuhfeld, M.; Soland, J.; Tarasawa, B.; Johnson, A.; Ruzek, E.; Liu, J. Projecting the Potential Impact of COVID-19 School Closures on Academic Achievement. *Educ. Res.* **2020**, *49*, 549–565. [CrossRef]
6. Haeck, C.; Lefebvre, P. Pandemic school closures may increase inequality in test scores. *Can. Pub. Policy* **2020**, *46*, 82–87. [CrossRef]
7. Engzell, P.; Frey, A.; Verhagen, M.D. Learning loss due to school closures during the COVID-19 pandemic. *Proc. Natl. Acad. Sci. USA* **2021**, *118*, e2022376118. [CrossRef] [PubMed]
8. Van Bakel, H.; Bastiaansen, C.; Hall, R.; Schwabe, I.; Verspeek, E.; Gross, J.J.; Roskam, I. Parental burnout across the globe during the COVID-19 pandemic. *Int. Perspect. Psychol.* **2022**, *11*, 141–152. [CrossRef]
9. Lerkkanen, M.K.; Pakarinen, E.; Salminen, J.; Torppa, M. Reading and math skills development among Finnish primary school children before and after COVID-19 school closure. *Read. Writ.* **2022**. [CrossRef]
10. Engzell, P.; Frey, A.; Verhagen, M.D. *Learning Inequality during the COVID-19 Pandemic*; Center for Open Science: Charlottesville, VI, USA, 2020. [CrossRef]
11. Andrew, A.; Cattán, S.; Costa Dias, M.; Farquharson, C.; Kraftman, L.; Krutikova, S.; Sevilla, A. Inequalities in children's experiences of home learning during the COVID-19 lockdown in England. *Fisc. Stud.* **2020**, *41*, 653–683. [CrossRef]
12. Van Dorn, A.; Cooney, R.; Sabin, M. COVID-19 Exacerbating Inequalities in the US. *Lancet* **2020**, *395*, 1243–1244. [CrossRef]
13. Haelermans, C.; Korthals, R.; Jacobs, M.; de Leeuw, S.; Vermeulen, S.; van Vugt, L.; de Wolf, I.; van Wetten, S.; van der Velden, R.; Prokic-Breuer, T.; et al. Sharp increase in inequality in education in times of the COVID-19-pandemic. *PLoS ONE* **2022**, *17*, e0261114. [CrossRef] [PubMed]
14. Alexander, K.L.; Entwisle, D.R.; Olson, L.S. Lasting consequences of the summer learning gap. *Am. Sociol. Rev.* **2020**, *72*, 167–180. [CrossRef]
15. Pensiero, N.; Kelly, A.; Bokhove, C. *Learning Inequalities during the Covid-19 Pandemic: How Families Cope with Home-Schooling*; University of Southampton Research Report 1; Southampton Education School, University of Southampton: Southampton, UK, 2020.
16. Lewis, K.; Kuhfeld, M.; Ruzek, E.; McEachin, A. Learning during COVID-19: Reading and math achievement in the 2020–21 school year. NWEA Brief 2021. Available online: <https://www.nwea.org/content/uploads/2021/07/Learning-during-COVID-19-Reading-and-math-achievement-in-the-2020-2021-school-year.research-brief-1.pdf> (accessed on 14 July 2021).
17. UNESCO. International Standard Classification of Education (ISCED, 2011). 2012. Available online: <http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf> (accessed on 12 July 2022).
18. Douglass, A. *Leadership for Quality Early Childhood Education and Care*; OECD Education Working Papers, No. 211; OECD Publishing: Berlin, Germany, 2019.
19. OECD. *Early Childhood Education: Equity, Quality and Transitions*; Report for the G20 Education Working Group; OECD: Paris, France, 2020.
20. Vilarinho, E. The Rights of Children to Quality of Public Preschool Education: Critical Analysis of the Implementation of Integrated System of Child Education and care in Portugal. *Rev. Pedagógica* **2013**, *15*, 281–300. [CrossRef]
21. UNICEF. A World Ready to Learn: Prioritizing Quality Early Childhood Education. 2019. Available online: <https://doi.org/www.unicef.org/media/57926/file/A-world-ready-to-learn-advocacy-brief-2019.pdf> (accessed on 14 July 2022).
22. Denham, S.A.; Bassett, H.H.; Zinsner, K.; Wyatt, T.M. How preschoolers' social-emotional learning predicts their early school success: Developing theory-promoting, competency-based assessments. *Infant Child Dev.* **2014**, *23*, 426–454. [CrossRef]
23. Ten Braak, D.; Lenes, R.; Purpura, D.J.; Schmitt, S.A.; Størksen, I. Why do early mathematics skills predict later mathematics and reading achievement? The role of executive function. *J. Exp. Child Psychol.* **2022**, *214*, 105306. [CrossRef]
24. Stites, M.L.; Sonneschein, S.; Galczyk, S.H. Preschool parents' views of distance learning during COVID-19. *Early Educ. Dev.* **2021**, *32*, 923–939. [CrossRef]
25. Pombo, A.; Luz, C.; de Sá, C.; Rodrigues, L.P.; Cordovil, R. Effects of the COVID-19 Lockdown on Portuguese Children's Motor Competence. *Children* **2021**, *8*, 199. [CrossRef] [PubMed]
26. Oliveira, L.; Mesquita, A.; Sequeira, A.; Oliveira, A. Emergency Remote Learning during COVID-19: Socio-educational impacts on Portuguese students. In *International Conference on Interactive Collaborative Learning*; Springer: Cham, Switzerland, 2020; pp. 303–314.
27. Henriques, S.; Correia, J.D.; Dias-Trindade, S. Portuguese Primary and Secondary Education in Times of COVID-19 Pandemic: An Exploratory Study on Teacher Training and Challenges. *Educ. Sci.* **2021**, *11*, 542. [CrossRef]
28. Portuguese Government. Comunicado do Conselho de Ministros de 11 de março de 2021. Available online: <https://www.portugal.gov.pt/pt/gc22/governo/comunicado-de-conselho-de-ministros?i=407> (accessed on 14 July 2022).
29. Von Holle, A.; North, K.E.; Gahagan, S.; Burrows, R.A.; Blanco, E.; Lozoff, B.; Voruganti, V.S. Sociodemographic predictors of early postnatal growth: Evidence from a Chilean infancy cohort. *BMJ Open* **2020**, *10*, e033695. [CrossRef] [PubMed]
30. OCEP. Orientações Curriculares para a Educação Pré-Escola. *Direção Geral de Educação. República Portuguesa* 2016. Available online: <http://www.dge.mec.pt/ocepe/> (accessed on 14 July 2022).
31. Goudeau, S.; Sanrey, C.; Stanczak, A.; Manstead, A.; Darnon, C. Why lockdown and distance learning during the COVID-19 pandemic are likely to increase the social class achievement gap. *Nat. Hum. Behav.* **2021**, *5*, 1273–1281. [CrossRef] [PubMed]

32. Özdemir, S.M.; Gündoğan Önderöz, F. Teachers' Opinions on Teaching Primary Reading and Writing through Distance Education During the COVID-19 Pandemic Period. *J. Teach. Educ. Lifelong Learn.* **2022**, *4*, 34–50. [\[CrossRef\]](#)
33. Schult, J.; Mahler, N.; Fauth, B.; Lindner, M.A. Did students learn less during the COVID-19 pandemic? Reading and mathematics competencies before and after the first pandemic wave. *Sch. Eff. Sch. Improv. International Journal of Research, Policy and Practice Int. J. Res. Policy. Pract.* **2022**, *10*, 1–20. [\[CrossRef\]](#)
34. Darragh, L.; Franke, N. Lessons from Lockdown: Parent Perspectives on Home-learning Mathematics During COVID-19 Lockdown. *Int. J. Sci. Math. Educ.* **2022**, *20*, 1521–1542. [\[CrossRef\]](#)
35. Lek, K.; Feskens, R.; Keuning, J. The effect of distance education on learning results in primary education Cito, Enschede, The Report 2020, Cito, Nov. Available online: https://www.cito.nl/-/media/files/kennis-en-innovatie-onderzoek/201104_cito_onderzoeksrapport-effect-afstandsonderwijs.pdf?la=nl-nl (accessed on 4 November 2020).
36. Chambonnière, C.; Fearnbach, N.; Pelissier, L.; Genin, P.; Fillon, A.; Boscaro, A.; Bonjean, L.; Bailly, M.; Siroux, J.; Guirado, T.; et al. Adverse Collateral Effects of COVID-19 Public Health Restrictions on Physical Fitness and Cognitive Performance in Primary School Children. *Int. J. Environ. Res. Public Health* **2021**, *18*, 11099. [\[CrossRef\]](#) [\[PubMed\]](#)
37. Kaffenberger, M. Modelling the long-run learning impact of the Covid-19 learning shock: Actions to (more than) mitigate loss. *Int. J. Educ. Dev.* **2021**, *81*, 102326. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Neville, H.J.; Stevens, C.; Pakulak, E.; Bell, T.A.; Fanning, J.; Klein, S.; Isbell, E. Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 12138–12143. [\[CrossRef\]](#) [\[PubMed\]](#)
39. Meeter, M. Primary school mathematics during the COVID-19 pandemic: No evidence of learning gaps in adaptive practicing results. *Trends Neurosci. Educ.* **2021**, *25*, 100163. [\[CrossRef\]](#) [\[PubMed\]](#)
40. VanLehn, K. The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educ. Psychol.* **2011**, *46*, 197–221. [\[CrossRef\]](#)
41. Lucas, M.; Bem-Haja, P.; Siddiq, F.; Moreira, A.; Redecker, C. The Relation between In-Service Teachers' Digital Competence and Personal and Contextual Factors: What Matters Most? *Comput. Educ.* **2021**, *160*, 104052. [\[CrossRef\]](#)
42. Gamage, K.A.A.; Gamage, A.; Dehideniya, S.C.P. Online and Hybrid Teaching and Learning: Enhance Effective Student Engagement and Experience. *Educ. Sci.* **2022**, *12*, 651. [\[CrossRef\]](#)
43. Remer, J.; Croteau-Chonka, E.; Dean, D.C., III; D'Arpino, S.; Dirks, H.; Whiley, D.; Deoni, S.C. Quantifying cortical development in typically developing toddlers and young children, 1–6 years of age. *Neuroimage* **2017**, *153*, 246–261. [\[CrossRef\]](#)