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# What happens when schools shut down? Investigating inequality in students' reading behavior during Covid-19 in Denmark

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## ABSTRACT

The outbreak of Covid-19 in spring 2020 shut down schools around the world and placed parents in charge of their children's schooling. Research from the lockdown period documents that families differ in their responses to their new responsibility for their children's homeschooling by socioeconomic status and that the Covid-19 crisis has increased educational inequality. The aim of this paper is to examine inequality in children's reading behavior before, during and after the lockdown of schools in Denmark by analyzing new digital data from a widely used reading app combined with administrative data. Our results show, first, that students' online reading behavior increased significantly as a consequence of the lockdown of schools, second, that there is a socioeconomic gradient in students' reading behavior both before and during the lockdown, and, third, that inequality in reading behavior during Covid-19 increased exclusively during the first lockdown period in which schools were closed and students were taught online. Consequently, our results support the findings from previous research documenting a SES gradient in learning opportunities in homeschooling activities during the Covid-19 induced lockdown. Yet, contrary to prior research, we find only a short-term increase in inequality on children's actual reading activity during Covid-19.

## 1. Introduction

The Covid-19 outbreak in the spring 2020 completely changed education overnight, in Denmark, as in many other countries. On March 16th, schools in Denmark were closed and homes were transformed into schooling environments, with parents responsible for informal learning activities, and formally for making sure that their children followed the curriculum. In addition, although schools provided online teaching or guidance during the lockdown, the school day was shortened significantly, which - combined with the shutdown of most other organized activities - meant that children now had substantially more leisure time at home. These Covid-19 induced changes have led researchers to anticipate that social inequality in student learning could increase due to differences in children's opportunities to learn at home (Bol, 2020).

Studies from the initial phases of Covid-19 have supported the concern of a socioeconomic gradient in parents' responses to their children's new schooling reality. Accordingly, children from disadvantaged families received much less academic support from their parents and were less likely to have access to necessary physical resources such as a computer or tablet (Andrew et al., 2020; Bol, 2020). Furthermore,

research based on population data of families' takeout of children's books from libraries shows that social inequality clearly increased during the lockdown (Jæger & Blaabæk, 2020). This paper extends previous research by investigating children's reading activity during the initial phase of the Covid-19 crisis. Specifically, we examine children's actual academic behavior (as opposed to parental resources and investments) during the initial phase of Covid-19 and the fostering of reading ability - an essential human capital skill (Ritchie & Bates, 2013). Accordingly, differences in children's reading activities during Covid-19 might accelerate preexisting social differences in children's cognitive skills. The lockdown of schools in Denmark is particularly interesting in an educational inequality perspective because it consisted of two qualitatively different phases. In the first lockdown phase there was a complete physical lockdown of schools and all instruction took place online. In the second lockdown phase schools reopened, however, only partially under a so-called "emergency teaching" scheme, which implied that the school day was significantly shortened and curricular goals were suspended or downgraded. Consequently, the different lockdown phases imposed very different responsibilities on families in terms of their children's schooling, which most likely affect social inequalities across the

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lockdown phases.

We make three contributions to previous research on inequality in home schooling activities during the Covid-19 crisis. First, unlike existing research, we focus on inequality in actual student behavior as opposed to inequality in resources. This is important because children need to respond to the exposure of unequal homeschooling environments in order for educational inequality to occur. For instance, while families' library takeout (Jæger & Blaabæk, 2020) is undoubtedly relevant for children's home schooling, it does not necessarily foster skills in itself. Children need to read the books their families take out in order to capitalize on the takeout in terms of skills. Similarly, parents' reported homeschooling activities (Bol, 2020) are not equivalent with their children's actual learning at home. Second, unlike previous research, which rely on administrative data or parents' self-reports to describe families' homeschooling activities, we measure children's schooling-related behavior directly by exploiting digital data on reading activity. Specifically, we use new data from a Danish digital reading app, BookBites (BB), which includes time-varying data on children's reading activity before, during and after the lockdown of schools, which we link to detailed administrative data on children's demographic characteristics. While the reading of physical books generally poses a challenge to the use of digital reading data, it is less of a concern during Covid-19 because children's access to physical books was limited due to the closure of schools and libraries. One shortcoming of the data is, however, that we cannot distinguish between reading of books that are part of the curriculum and reading of books for leisure. Nonetheless, we argue that both types of reading are important for investigating a social gradient in students' reading activity. Third, due to our empirical design in which we study within-student differences, we are able to take into account unobserved differences between teachers and classrooms.

## 2. Data

We use new data from a Danish digital reading app, BB, which is one of few reading apps available to schoolchildren. The school or the municipality pay the cost of using the app, granting children unlimited access to books. Every turn of a page generates a data point containing information on the number of words on the page and the time spent on the page. We link the reading app data to administrative data on children's sociodemographic background. Our sample includes data from seven municipalities with a high proportion of schools that provide their students with access to the app. The municipalities are located around the country and schools within the municipalities vary in terms of urbanization, size, and socioeconomic composition. We restricted our sample to *active* BB users in 4th and 5th grade (average age 11.5) because there is most reading activity at these grade levels. We define active users as students that have spent more than 0 minutes reading (many students flip through pages, generating data without actually reading) during the period of analysis from February 4th to May 20th 2020.

Our analytical sample of active users is quite heterogeneous and includes municipalities with both relatively high and low average levels of parental income and education (see Table A3). In order to assess the representativeness of our data, we compare the socioeconomic background of students in our pooled analytical sample to all students in the seven municipalities as well to the entire population of all 4th and 5th grade students in Denmark (see Table A2). Parents of active users are slightly better educated and have slightly higher incomes compared to all students in the selected municipalities. Compared to the general population, parents in the seven municipalities on average have markedly higher levels of education and incomes, though. Overall, the relatively high level of variation in terms of parental socioeconomic status allows for a robust assessment of the SES gradient in reading activity, even if the sample deviates somewhat from the population average. Yet, results should be read in the context of the limited sample of seven diverse municipalities.

## 2.1. Variables

Our dependent variable is students' reading activity in minutes per day. Pages that students spent more than ten minutes reading are excluded from the analysis as they are likely generated by the screen being idle. We measure children's socioeconomic status using register data on parents' education and income. Specifically, we use information from the parent with the highest education and measure parents' education using a dummy indicating if this parent has a college degree (a degree from either a university college (3–4 years) or from a university (5 years)). We measure income using a dummy indicating if the parents' total net income is above the population median.

We control for weekday and the national winter holiday to account for differences in reading activity induced by time out of school. Finally, we include two additional measures to assess group heterogeneity: use of the reading app prior to Covid-19 and gender. Descriptive statistics for the variables included in the analysis are reported in the appendix (Table A1).

## 2.2. COVID-19 in Denmark

Like Jæger and Blaabæk (2020), we differentiate between four phases of the initial Covid-19 crisis, however as previously mentioned, we consider the two lockdown phases as qualitatively different. These are: (1) the "pre-lockdown" from February 1st until March 15th. (2) The first lockdown from March 16th to April 3rd which is characterized by school closures and online instruction. (3) The "Easter Holiday" phase from April 4th to April 15th. Finally, (4) the second lockdown from April 16th to May 20th when students attended schools under the aforementioned "emergency teaching" scheme. The cutoff date of May 20th is due to data availability given that phase four lasted until the summer holiday break starting June 26th.

## 3. Empirical strategy

The empirical analysis aims at examining the development of the SES gradient in children's reading behavior during the lockdown of schools and involves three parts. First, similar to Jæger and Blaabæk (2020), we use graphical illustrations to examine the SES gradient in children's reading activity before, during and after the lockdown of schools. Second, we use student fixed effects models to analyze if children's reading activity varies with socioeconomic status net of unobserved time-invariant factors that (self-) select children into different types of online teaching at the classroom level. Third, we investigate heterogeneous effects across different subgroups of students.

## 4. Results

We present results in three sections corresponding to our empirical approach. First, we summarize students' reading activity in the reading app by parental education across the different phases of the lockdown. Second, we employ student fixed effects models to more rigorously examine how inequality developed during the lockdown. Third, we analyze the extent to which the impact of Covid-19 differs across different subgroups of students.

### 4.1. Descriptive analysis of students' reading activity during the initial phase of the Covid-19 crisis

In Fig. 1, we plot students' reading activity measured in minutes per day in the four phases. Fig. 1 shows a darker line for children with college-educated parents and a lighter line for children with non-college-educated parents. As it appears from the figure, in the pre-lockdown phase, children of college-educated parents on average read more minutes per day compared to children of non-college-educated parents. Moving to the first lockdown phase, Fig. 1 shows that the

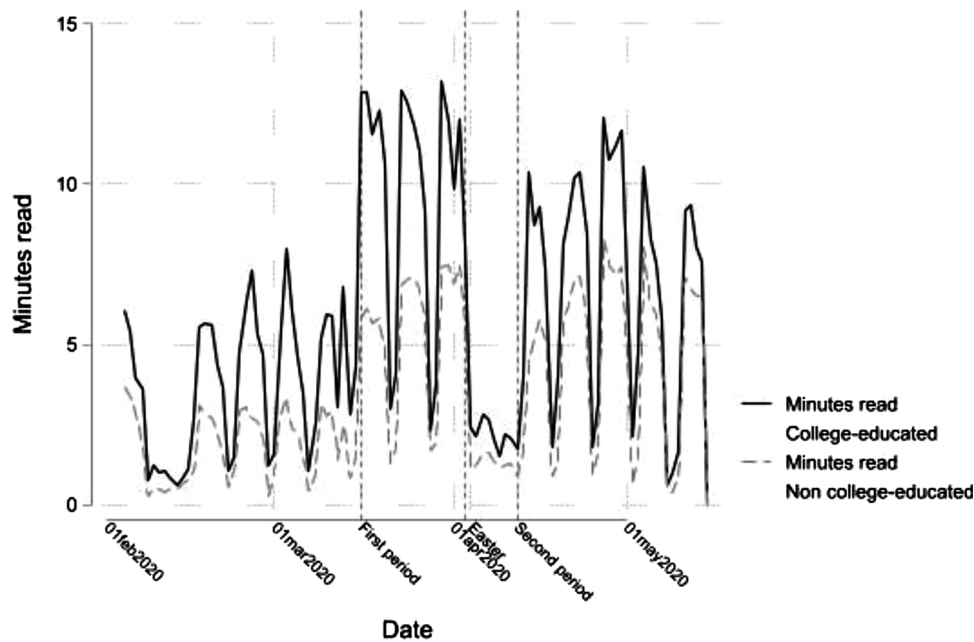


Fig. 1. Minutes per day by parental education.

complete shutdown of schools led to a considerable increase in reading activity across all groups of students, yet the relative increase appears to be higher for children of parents with a college degree. Not surprisingly, there is a considerable drop in reading activity for all students during the Easter holiday.

Finally, in the second lockdown, the phase of emergency teaching in Denmark, students' reading activity has leveled off compared to the first lockdown, but still stabilized at a higher level compared to the pre-lockdown period. Consequently, the results from the descriptive "eyeball" test of students' daily reading activity are consistent with the idea that there is a clear socioeconomic gradient in students' daily reading activity, nevertheless it is not clear whether or not the relative differences across the two socioeconomic groups have increased during the lockdown phases compared to the baseline pre-lockdown period. A corresponding figure, split by parental income, shows highly similar patterns (Fig. A1).

#### 4.2. Student fixed effects models of the SES gradient in students' reading activity

We now investigate the development of social inequality across the two lockdown phases of Covid-19 and the Easter holiday in further detail. Table 1 summarizes the results from fixed effects regressions of students' daily reading activity. We present the results as minutes read in the reading app per day and include a dummy variable for each phase in the lockdown period.

Model 1 shows differences in average reading activity across the first lockdown, Easter holiday and second lockdown in comparison to the baseline pre-lockdown phase.

The dummy variable for the first lockdown phase in which schools were completely closed shows that students on average read four additional minutes per day compared to pre-lockdown. Reading activity decreased significantly during the Easter holiday indicating that the reading app is mostly connected to school-based reading tasks and less to leisure-time reading. In the second lockdown phase with emergency teaching students also read significantly more than in the pre-lockdown phase, but not as much as in the first lockdown phase.

In model 2, we introduce interaction terms between the different lockdown phases and our two indicators for student SES to test whether the socioeconomic gradient in students' reading activity increased

Table 1

Results from student fixed effects models on time spent reading in minutes.

	M1	M2	M3	M4
First lockdown (closed schools)	4.129*** (0.315)	3.155*** (0.259)		
Easter period	-0.426* (0.209)	0.286 (0.195)		
Second lockdown (Emergency teaching)	2.055*** (0.252)	2.136*** (0.211)		
First l.* college degree		1.609** (0.543)		
First l.* above median income		1.072* (0.484)		
Easter period* college degree		-0.719+ (0.392)		
Easter period* above median income		-1.123** (0.373)		
Second l.* college degree		-0.080 (0.337)		
Second l.* above median income		-0.130 (0.316)		
Total period			2.302*** (0.202)	2.179*** (0.167)
Total l.* college degree				0.299 (0.314)
Total period* above median income				0.065 (0.285)
Constant	3.359*** (0.155)	3.359*** (0.155)	3.262*** (0.148)	3.262*** (0.147)
Observations (students*days)	586,895	586,895	586,895	586,895

Note: Controlled for weekday. Standard errors in parentheses. +  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

during the initial phase of the Covid-19. Model 2 shows three interesting results. First, there is a positive and statistically significant interaction between both measures of students' SES and the first lockdown phase. Accordingly, children of college-educated parents as well as students of parents above the median income level increased their reading activity more during the first lockdown phase compared to children of parents with no college degree and parents below the median income level. Second, during the Easter holiday, students from high SES backgrounds

decreased their reading activity to a higher degree than their less privileged peers, although only the coefficient estimate for parental income reaches conventional levels of statistical significance. This finding may relate to different patterns of leisure activities during the vacation period for high vs. low SES families as well as stricter rules regarding the use of mobile devices in children's free time in high SES families (see Määttä et al., 2017). Third, for the second lockdown, quite surprisingly both interaction terms are close to zero and not statistically significant. Accordingly, the second lockdown phase in which students attended school again albeit on a limited schedule, did not seem to increase social inequality in digital reading as documented for the first lockdown phase.

In model 2 and 3, we pool the results from the two lockdown phases and the Easter holiday. The results from these models show that although reading activity on the app increased significantly with two minutes per day since the initial lockdown of the country, inequality in reading behavior has not statistically significantly increased across the pooled lockdown. Consequently, these results suggest that inequality in reading with the BB app only increased during the part of the lockdown period when schools were entirely closed and all schooling activities took place online.

#### 4.3. Subgroup heterogeneity

In this section, we extend our empirical analysis by describing group differences in the ways in which Covid-19 affected inequality. Table 2 shows differences across two student characteristics that might be particularly relevant for reading behavior: use of the reading app prior to the lockdown, and gender.

First, we compare students who were already using the app prior to the lockdown and students who had not used the app before. This is important since we could expect a difference in reading activity between these groups stemming from differences in familiarity with reading on the app. In terms of inequality across these two groups, we only see a positive interaction term between children of college-educated parents and the first lockdown phase for students who used the app prior to the

**Table 2**  
Subgroup analyses.

	Prior app reading		Gender	
	Non-pre-Covid-19 readers	Pre-Covid-19 readers	Boys	Girls
First lockdown (closed schools)	2.760*** (0.266)	3.655*** (0.414)	3.249*** (0.296)	3.064*** (0.335)
Easter period	0.702*** (0.091)	-0.237 (0.362)	0.119 (0.180)	0.443 (0.311)
Second lockdown (Emergency teaching)	2.952*** (0.202)	1.279*** (0.322)	1.930*** (0.230)	2.331*** (0.246)
First l.* college degree	0.126 (0.565)	2.707*** (0.807)	1.166 <sup>+</sup> (0.646)	2.068** (0.737)
First l.* above median income	0.772 (0.495)	0.841 (0.705)	0.426 (0.569)	1.694* (0.658)
Easter period* college degree	-0.006 (0.255)	-1.139 <sup>+</sup> (0.653)	-0.540 (0.349)	-0.881 (0.707)
Easter period* above median income	0.159 (0.253)	-1.608** (0.604)	-1.503*** (0.403)	-0.754 (0.598)
Second l.* college degree	0.359 (0.345)	-0.366 (0.533)	0.220 (0.356)	-0.368 (0.593)
Second l.* above median income	0.201 (0.358)	0.027 (0.433)	-0.309 (0.443)	0.045 (0.356)
Constant	0.497*** (0.109)	5.730*** (0.246)	3.293*** (0.163)	3.423*** (0.183)
Observations (students*days)	265,895	321,000	289,007	297,888

Note: Controlled for weekday. Standard errors in parentheses. <sup>+</sup>  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

lockdown. This finding can be interpreted in different ways. First, it might indicate that teachers who first introduced the app in response to the lockdown put more effort into explaining access to and specific use of the app to all students, resulting in less dependency on home resources. Second, it could suggest a positive selection process in which high-SES students also have a higher probability of using the reading app in the first place, possibly due to higher degrees of implementation in high SES-schools.

Second, we compare results for male and female students. This is particularly important in the light of research showing gender differences in reading achievement (OECD, 2019) and reading behavior (Schaffner, Schiefele, & Ulferts, 2013). Overall, boys and girls seem to increase their reading time during the lockdown periods at a similar rate. However, girls of parents with a college degree and with above median income increase their reading activity relatively more than similar male students in the first lockdown period. Across all sub-groups, the main results from Table 1 are confirmed in terms of the first lockdown being the most important in terms of inequality.

#### 4.4. Robustness check

To examine the robustness of our results, we re-ran the analysis with another specification of reading activity; a student's number of words read per day calculated as the sum of words across all the pages turned on a specific day. This measure is a function of both students' reading ability and reading time and has the advantage that periods of inactivity (without a page turn) will not lead to a higher word count. Results from this analysis (Table A4) are largely in line with our main results.

## 5. Discussion

The aim of this paper was to investigate children's reading behavior during the lockdown of schools and the extent to which it varies across socioeconomic background. We analyze digital data from a widely used reading app with detailed information on children's reading activity and combine it with administrative information on children's demographic background. Our main finding is that during the first lockdown period, in which schools in Denmark were entirely closed and instruction took place online, inequality in students' reading behavior increased. These results are partly in line with previous research documenting a SES gradient in learning opportunities in homeschooling activities during the initial phase of Covid-19. Nevertheless, contrary to prior research, we find only a short-term increase in inequality on children's actual reading activity during the initial phase of Covid-19 crisis stemming from the period where schools were entirely closed.

The results presented in this paper should be read in context of its limitations. First, while our study accounts for unobserved time-invariant factors that (self-) select children into different (quantitatively as well as qualitatively different) levels of online teaching at the classroom level, future research should aim at analytically distinguishing between family and school contexts in order to investigate the mechanisms by which Covid-19 increased inequality. Second, data from active reading app users cannot necessarily be generalized to the population due to significant heterogeneity in socioeconomic composition among the active users in each municipality. However, as showed in the data section, across the total sample, the social selectivity into app use is moderate in terms of observed parental characteristics. Third, while data from the reading app contains information on reading activity at a more detailed level than most previously available data, there are uncertainties in determining when children are actually reading and when they are just flipping pages. However, we have tested robustness of our results by re-running our analysis using an alternative measure of reading activity and do not find substantial deviations from our main results. Despite these limitations, our analyses provide a unique opportunity to understand inequality in children's reading behavior during the Covid-19 crisis.

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## Declaration of Competing Interest

The authors report no declarations of interest.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.rssm.2020.100568>.

## References

- Andrew, A., Cattan, S., Costa-Dias, M., Farquharson, C., Kraftman, L., Krutikova, S., ... Sevilla, A. (2020). *Learning during the lockdown: Real-time data on children's experiences during home learning*. IFS briefing note BN288. London.
- Bol, T. (2020). *Inequality in homeschooling during the Corona crisis in the Netherlands. First results from the LISS Panel*. <https://doi.org/10.31235/osf.io/hf32q>.
- Jæger, M. M., & Blaabæk, E. H. (2020). Inequality in learning opportunities during Covid-19: Evidence from library takeout. *Research in Social Stratification and Mobility*, 68(June), 100524. <https://doi.org/10.1016/j.rssm.2020.100524>.
- Määttä, S., Kaukonen, R., Vepsäläinen, H., Lehto, E., Ylönen, A., Ray, C., ... Roos, E. (2017). The mediating role of the home environment in relation to parental educational level and preschool children's screen time: A cross-sectional study. *BMC Public Health*, 17(1), 1–11. <https://doi.org/10.1186/s12889-017-4694-9>.
- OECD. (2019). *PISA 2018 results (volume II)*. Paris: OECD Publishing. <https://doi.org/10.1787/b5fd1b8f-en>.
- Ritchie, S. J., & Bates, T. C. (2013). Enduring links from childhood mathematics and reading achievement to adult socioeconomic status. *Psychological Science*, 24(7), 1301–1308. <https://doi.org/10.1177/0956797612466268>.
- Schaffner, E., Schiefele, U., & Ulferts, H. (2013). Reading amount as a mediator of the effects of intrinsic and extrinsic reading motivation on reading comprehension. *Reading Research Quarterly*, 48(4), 369–385. <https://doi.org/10.1002/rrq.52>.