Werner, Katharina; Woessmann, Ludger

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The Legacy of Covid-19 in Education

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Katharina Werner, Ludger Woessmann

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The Legacy of Covid-19 in Education

Abstract

If school closures and social-distancing experiences during the Covid-19 pandemic impeded children's skill development, they may leave a lasting legacy in human capital. To understand the pandemic's effects on school children, this paper combines a review of the emerging international literature with new evidence from German longitudinal time-use surveys. Based on the conceptual framework of an education production function, we cover evidence on child, parent, and school inputs and students' cognitive and socio-emotional development. The German panel evidence shows that children's learning time decreased severely during the first school closures, particularly for low-achieving students, and increased only slightly one year later. In a value-added model, learning time increases with daily online class instruction, but not with other school activities. The review shows substantial losses in cognitive skills on achievement tests, particularly for students from disadvantaged backgrounds. Socio-emotional wellbeing also declined in the short run. Structural models and reduced-form projections suggest that unless remediated, the school closures will persistently reduce skill development, lifetime income, and economic growth and increase inequality.

JEL-Codes: I200, H520, J240.

Keywords: Covid-19, school closures, education, schools, students, educational inequality.

Katharina Werner
ifo Institute – Leibniz Institute for Economic Research at the University of Munich
Center for the Economics of Education
Poschingerstrasse 5
Germany – 81679 Munich
werner.k@ifo.de

Ludger Woessmann
ifo Institute – Leibniz Institute for Economic Research at the University of Munich
Center for the Economics of Education
Poschingerstrasse 5
Germany – 81679 Munich
woessmann@ifo.de

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The Legacy of Covid-19 in Education

1. Introduction

The Covid-19 pandemic brought unprecedented challenges to education systems around the world. In many countries, schools were closed for several months in an attempt to curtail the spread of the coronavirus. Children had to learn from home, with schooling provided in a variety of ways ranging from self-study on provided worksheets to online schooling by video calls. The pandemic cost many lives, and the resulting lockdowns curbed people's freedoms and imposed heavy short-term costs on the economy (e.g., IMF 2021). With vaccinations becoming broadly available and incidences and hospitalizations going down from peak levels, however, it is becoming increasingly clear that the pandemic hit children and families particularly hard. In many countries, most adults went to work, whereas children were not allowed to go to school, meet friends, or do group sports or attend youth groups in the afternoons. In particular, the learning losses that many children have accumulated during the school closures may have long-run consequences due to missing skills and lost human capital required for successful participation in the future labor market. Will the pandemic leave a lasting legacy in the education biographies of the affected students?

Countries gave very different priorities to education and to the situation of children when designing their policies to contain the pandemic. Some countries put particularly strong limitations on the interactions of adults in order to allow children to go to schools as soon as possible. Other countries opted to close schools for very long times. Interestingly, the duration of school closures was not related to the intensity of Covid-19 transmission across countries (OECD 2021). If hampered trajectories of skill development persist, these different policy choices will have long-run consequences for the student cohorts.

In this paper, we review what is known so far about how the Covid-19 pandemic and the accompanying school closures affected the education and skill development of school children. We suggest the conceptual framework of an education production function to organize our thinking about the topic. The pandemic and the school closures affected a range of inputs relevant for the process of skill formation of children such as school inputs, family inputs, and student inputs. Based on this framework, we survey empirical work on how the pandemic affected the behavior of children, parents, and schools as well as children's skill development in various domains covering both cognitive and socio-emotional skills. We also cover work that models how the reduced development of skills may ultimately affect students' economic outcomes in the long run.

In our review, we put a particular focus on the consequences of Covid-19 for educational inequality (see also Stantcheva 2021). With the role of schools as the "great equalizer" (Horace Mann 1848) curtailed and the role of teachers as the crucial input for students' learning impaired, one may expect that the pandemic will most severely hit those students who are in particular need. We therefore cover evidence on the impact of the pandemic on children from different socio-economic backgrounds and different levels of prior achievement.

In the review of available evidence from different countries, we include new evidence from a longitudinal component of a survey of the time use of school children and the support provided by parents and schools during the two main phases of school closures in Germany. In many ways, the German experience may be similar to many other countries, in that they were similarly affected by the Covid-19 pandemic, had broadly similar school-closure policies, no previous experience with nation-wide school closures, and no preestablished plans for online school operations. Having implemented a first parental survey during the initial phase of school closures in spring 2020 (Grewenig et al. 2021), for the purposes of this paper we fielded a second survey during the school closures at the beginning of 2021. The longitudinal component of the second survey allows us to track the situation of over 500 school children over time at the individual level, providing evidence on how schools and families adapted to the pandemic situation over time. The new survey also contains basic survey-based measures of the development of various skill domains including digital skills, self-regulated learning skills, psychological burden, socio-emotional wellbeing, and social skills. With these survey items and the panel dimension of the time-use surveys, our new German evidence provides a rich picture of the pandemic situation that complements available evidence from other countries.

As this paper focuses on the pandemic's effects on school education, it does not cover many other important aspects of how the pandemic affected people's life. For example, we do not cover work on the infectiousness of children and the role of schools in the spread of the coronavirus (e.g., Vlachos, Hertegård, and Svaleryd 2021; Isphording, Lipfert, and Pestel 2021; Bismarck-Osten, Borusyak, and Schönberg 2021; Bailey 2021; Goldhaber et al. 2021), which is mostly of epidemiological interest and less focused on children's skill development. We also do not cover work on the effects of Covid-19 on college education (e.g., Aucejo et al. 2020; Jaeger et al. 2021; Logel, Oreopoulos, and Petronijevic 2021) or on the transition from the education system to the labor market. Work on effects of the pandemic on parents (e.g., Croda and Grossbard 2021; Huebener et al. 2021), on skills and mental health of the adult population, and on the economy (e.g., Chetty et al. 2020; Fetzer et al. 2021) is covered only insofar as it informs about the pandemic's impact on the skill development of children.

The remainder of the paper is structured as follows. Section 2 introduces the simple conceptual framework of an education production function in the context of the Covid-19 school closures. Section 3 covers empirical evidence on the educational inputs provided by children, parents, and schools during the pandemic, including the time use of children for learning and other activities as well as the activities of parents and schools. Sections 4 and 5 report evidence on the development of the cognitive and socio-emotional skills of children, respectively. Sections 6 and 7 turn to potential long-run implications, covering structural models of school and family effects and projections of economic effects of the lost human capital due to the Covid-19 school closures, respectively. Section 8 concludes with policy considerations.

2. Conceptual Framework: What Do Covid-19 School Closures Mean for Children?

School closures can affect student outcomes in many dimensions and through a plethora of channels. To organize our thinking about what legacy Covid-19 may leave in children's education, this section develops a conceptual framework on what the pandemic means for school children. It uses the framework of an education production function to model the process of skill formation (section 2.1), which allows us to cover aspects of the behavior and emanating inputs of schools (section 2.2), parents (section 2.3), and the children themselves (section 2.4). We discuss the range of potential outcome dimensions that may be affected by the Covid-19 school closures, a subset of which we will be able to cover with available evidence in the subsequent empirical sections.

2.1 Skill Formation

We use a standard education production function framework (e.g., Hanushek 1986, 2020) to conceptualize the possible effects of Covid-19 on education. The education production function depicts the process and technology of skill formation. Children's skill development is modeled as a function f of student inputs (including ability) A, family inputs F, and school inputs S:

$$\Delta Y_i = f(A_i, F_i, S_i) \tag{1}$$

where ΔY_i is the change in educational output of student i – i.e., learning or the acquisition of skills.

We consider the educational output of children quite broadly in terms of the formation of multidimensional skills. These include cognitive skills such as academic achievement in math,

science, reading, and other subjects that are part of the school curriculum. Additional cognitive skill dimensions that may be affected by the home-schooling experience during the pandemic may include students' digital skills and their ability for self-regulated learning. But there is also a wide array of non-cognitive skills including social skills such as the ability to engage and interact with other people, as well as the psychological and socio-emotional wellbeing of the students. Ultimately, we are also interested in students' long-run outcomes such as their ability to cope with their lives and economic outcomes including their later employment and earnings as adults.[1]

The way in which we conceive the pandemic to affect these outcomes is by changing the inputs into and production elasticities of the production function. In fact, the pandemic is likely to have repercussions on a broad range of inputs. These include standard school inputs S_i such as teachers, resources, and educational material. In our treatment below, interactions with school peers are also subsumed under the category of school inputs. With learning moved from school to home, family inputs F_i take center stage during the pandemic, including parents' time, effort, and encouragement, as well as families' disposable income and home environment more generally. Finally, student inputs A_i encompass students' ability and initial achievement, but also their motivation, effort, and engagement. Importantly, how school closures affect inputs and their production elasticities may differ substantially across different groups of children. In the following, we will discuss the three input factors in turn.

2.2 School Behavior and Inputs

In the education production function framework, school closures can be thought of as a reduction in school inputs S_i. Specifically, a defining feature of school closures is that there is no teacher in the room to help students with their learning (Grewenig et al. 2021). Therefore, students do not have the same support of trained educators as in traditional in-person classroom teaching. Ample evidence shows that teachers are probably the school input factor that is most important for students' educational success (e.g., Rivkin, Hanushek, and Kain 2005; Chetty, Friedman, and Rockoff 2014). They provide the traditional teaching activities such as explaining new material or providing learning-stimulating feedback. In the absence of teachers, students are missing out on key support, and their learning is left more to the discretion of themselves and their families. As learning positively depends on teacher and school inputs:

[1] For evidence on important effects of skills on labor-market outcomes, see, e.g., Hanushek et al. (2015) and the references therein for cognitive skills, Deming (2017) for social skills, and Heckman, Stixrud, and Urzua (2006), Lindqvist and Vestman (2011), and Piopiunik et al. (2020) for both cognitive and socio-emotional skills.

$$\frac{\partial Y_i}{\partial S_i} > 0 \quad (2)$$

we expect that school closures will result in an overall reduction in learning.

Self-regulated learning that is required when teacher support is limited will be more effective for higher-ability students and for students with better support at home. That is, the famous function of schools as the "great equalizer" will be severely limited (Agostinelli et al. 2021). For school closures to affect educational inequality in the specification of equation (1), either the amount or the production elasticities of the other inputs must depend on the extent of school inputs (see below). In standard applications, the education production function is often simplified to be additive in the different inputs. In this case, the effect of a uniform change in school inputs would have the same effect on children from different family backgrounds and different ability levels, thereby leaving educational inequality unaffected.

However, school closures do not necessarily entail the same reduction in school inputs for all students. The decline in effective school inputs may differ for different students. For example, high-SES parents may be more likely to lobby for or support the implementation of better distance-teaching measures. Alternatively, schools may implement specific measures to reach out to low-SES or low-achieving students. Such mechanisms would give rise to differences in the extent to which schools compensate the lack of in-person teaching by other school inputs in one way or the other, thereby affecting education inequality.

Closed schools and the wider social distancing measures during the Covid-19 pandemic also imply the separation of otherwise integrated peer groups. Thus, another aspect of the loss in schools' equalizing feature is that school closures reduce the extent to which children from different backgrounds mix together in a single learning environment (Agostinelli et al. 2021). The peer interactions that are part of the school inputs in equation (1) are transformed or even lost, changing the social interactions and peer environments for many children. In particular, to the extent that schools draw students from diverse neighborhoods, school closures can mean that children lose contact with some of their school peers and possibly replace them with peers from their neighborhood of residence, which could imply greater segregation. All of this will affect the development of children's social and emotional skills, as well as their learning.

The change in school inputs during the pandemic will also depend on what schools do during the closures. There is a wide range of distance-teaching methods, from just providing work sheets for independent study to full online video teaching. These choices are likely to have varying consequences for student learning. The very process of online education may also have repercussions for students' acquisition of practical digital skills. In addition, the pandemic

situation and the distance-teaching requirements can impact the stress situation and mental health of teachers themselves, which may partly depend on whether the teachers have to care for their own children at home during the time of distance teaching.

Beyond the inputs provided by traditional schools, some governments and organizations established programs that provided students with new teaching inputs during the pandemic, such as tutoring or summer camps. Such inputs may be able to compensate some of the reduction in standard school inputs during the school closures.

2.3 Parental Behavior and Inputs

With learning moved to the home, parental inputs F_i become much more important during the pandemic. Students' skill acquisition during the Covid-19 school closures will thus depend on parents' time investments to help them with their learning at home, as well as parents' cognitive and pedagogical skills.

With schools closed, the extent to which families compensate for reduced school inputs may depend on their socio-economic background. There are at least three reasons why the increase in family inputs F_i in response to the school closures may differ across students. First, high-SES parents may have lower budget constraints. Second, their child's education may enter the utility function of high-SES parents more strongly. Third, their own higher education may make high-SES parents better substitute teachers on average. As a consequence, high-SES parents may make sure that their child spends more time on learning. They may increase their family inputs more strongly. And they may be in a better position – either financially or in terms of managing the curricular content – to support their child's learning activities.

Formally, provided family inputs may thus depend on provided school inputs, and high-SES families (*h*) may react more strongly (in absolute terms) to a decline in school inputs than low-SES families (*l*):

$$\left|\frac{\partial F_i}{\partial S_i}\right|^h > \left|\frac{\partial F_i}{\partial S_i}\right|^l \tag{3}$$

To the extent that high-SES parents compensate more of the lost school inputs than low-SES parents, inequality in educational output will thus increase along the SES dimension.

The pandemic will also have direct effects on the work, earnings, health, and psychological wellbeing of some parents. Some parents have lost their job due to the economic turbulences triggered by the pandemic. On the one hand, job loss will increase the budget constraints and psychological costs of affected parents. On the other hand, it may free up time for parents to help their children when learning at home. The extent to which parents can support their

children in their learning will also depend on whether they are able to work from home or not. At the same time, the requirements to take care of the children at home may have affected working hours and earnings of parents. In addition, parents might face direct effects of Covid-19 infections on their health, as well as indirect effects of the pandemic situation on their psychological wellbeing. By potentially affecting family inputs into the children's education production function, all these effects of the pandemic on parents may indirectly also have repercussions for children's skill formation.

Parents may also adapt their parenting styles in response to the pandemic situation. For example, Agostinelli et al. (2021) hypothesize that low-SES parents will adopt more authoritarian (as opposed to authoritative or permissive) parenting styles – e.g., meddling with their children's choice of friends – because of the reduced skill acquisition and the deteriorated peer environment of their children. As a consequence of the exacerbated SES differences in parenting styles, the skill formation of children in poor neighborhoods may be hampered, and highly disadvantaged children may find it hard to get the opportunity to interact with more advantaged children. In some settings, particularly high-SES parents may also choose to switch from public to private schools to maintain in-person instruction.

2.4 Child Behavior and Inputs

A crucial feature of the educational production process is that by necessity, students themselves are an input factor in the production. In contrast to almost all other production processes, the person who is to acquire the production outcome inevitably has to contribute time and effort as inputs into the production process. Without students engaged in learning, there will be no skill development. As a consequence, behavioral responses of the children will be a key mediator of how the Covid-19 school closures affect the development of the children's cognitive and socio-emotional skills.

The sharp decline in teacher inputs that defines school closures implies the necessity of self-regulated learning, where students must acquire new academic material with less support of trained educators. Given dynamic complementarities in the skill formation process (e.g., Cunha et al. 2006; Cunha and Heckman 2007; Cunha, Heckman, and Schennach 2010), the effectiveness of self-regulated learning will depend on individual students' ability and prior achievement. As a consequence, the presence or absence of school inputs, in particular teachers, will affect the production elasticities of students' own prior achievement.

The easiest way to conceptualize this aspect is to depict the extent to which students with different levels of initial achievement A_i can add to their learning as a negative function g of the extent of school inputs:

$$\frac{\partial Y_i}{\partial A_i} = g(S_i) \ , \ g'(S_i) < 0 \tag{4}$$

That is, the rate at which high-achieving students achieve larger learning gains than low-achieving students will be larger in home schooling than in classroom teaching because high-achieving students have a better skill base for self-regulated learning. As a consequence, school closures will widen educational inequality along the dimension of individual students' prior achievement.

The ability of students to engage in self-regulated learning may also itself be affected by the pandemic. In a process of learning by doing, the very process of home schooling may foster the ability to independently acquire knowledge and skills of some children.

Beyond the role of ability and prior achievement, the amount of skill development during home schooling will also be affected by other dimensions of student inputs such as the effort, motivation, and time that children bring to the task. Depending on how children fare on these dimensions, school closures may affect the skill formation process of different groups of children quite differently. For example, children with severe social anxiety may even benefit from online learning where they are less exposed to peers.

Children's skill development during school closures will also be influenced by the type of alternative activities in which they engage during the time freed up by not attending school. On the one hand, children may spend their time on activities such as reading, creative activities, or physical engagement that are often viewed as conducive to child development. On the other hand, children may engage in activities such as watching TV or playing computer games, many aspects of which are often viewed as detrimental for important aspects of child development.

Relatedly, the altered situation during the pandemic is likely to interfere with the development of children's socio-emotional skills. The reduced peer interactions that are a direct consequence of the measures to contain the spread of the virus may affect the development of children's social skills. Similarly, the reduced freedom of movement may impinge children's emotional and psychological wellbeing. For some children, there may also be direct effects of the health consequences of Covid-19 in general, and concerns about their relatives in particular, on their anxiety, stress, and emotional wellbeing.

An important determinant of the extent to which any short-term impediments to the development of children's skills will translate into skill losses in the long term is whether there

are sensitive or even critical periods in a children's life for specific skills to develop. Stages that are more effective in producing a certain skill than others are called "sensitive periods" for the acquisition of that skill (e.g., Cunha et al. 2006; Cunha and Heckman 2007). At the extreme, specific skills may be acquired only in a specific time window of a child's life, which is referred to as "critical periods" for the development of that skill. An obvious example of sensitive periods is the acquisition of a language, which is much easier during early years than later on (e.g., Werker and Hensch 2015). Similarly, certain cognitive and social skills may be much easier to learn at certain stages compared to later stages. In this case, postponement of skill acquisition due to prolonged periods of school closures – e.g., missing out on the development of basic reading, writing, and counting skills in the first couple of years in primary schools or missing out on key social interaction experiences during teenage years – may well have long-run repercussions even if remedial measures are taken after the closure phase.

In sum, consideration of different inputs and outputs in the framework of an education production function suggests that many dimensions of child outcomes ΔY_i are likely to be affected by the Covid-19 pandemic, including cognitive skills, socio-emotional skills, and longer-run outcomes. These effects create the potential that the education crisis caused by the school closures will leave a long-term legacy. Given the differential change in school, family, and individual inputs for different students, a particular focus of the subsequent survey of the available empirical evidence will be on the effect of Covid-19 school closures on educational inequality across the two dimensions of children's family backgrounds and ability levels.

3. Child, Parent, and School Inputs during the School Closures

A first approach to gain a better understanding of how students fared during the pandemic is to look at time-use surveys and surveys of other educational inputs provided at home and by schools. Measures of children's time use provide an encompassing depiction of the consequences of the school closures for their situation compared to normal pre-pandemic times. In addition to providing a first indication of the change in child inputs to the education production function – i.e., the time children spent on school-related activities – time-use data also allow to assess the alternative activities that children engaged in while schools were closed and while many recreational activities were unavailable due to pandemic-mitigation measures. Such evidence is vital as the activities that substituted the time spent on school-related activities are an important piece of the puzzle to predict the consequences of the school closures in the longer term. Moreover, as outlined in the conceptual framework above, the different activities might vary noticeably between families with different socio-economic status, potentially

leading to heterogeneity in the adjustment of learning and living circumstances of children from different backgrounds. In addition to children's time use, available survey data also inform about the learning environment, learning experience, and effectiveness of students at home, as well as the inputs provided by parents and schools.

This section mainly draws on two parental surveys that we fielded to cover the two phases of nation-wide school closures in Germany. After describing the survey methodology (section 3.1), we report results on the time spent by students on school-related activities and the effectiveness of their learning experiences at home (section 3.2), as well as results on time spent other activities that may be either conducive or detrimental to child development (section 3.3). We then turn to evidence on the activities of parents (section 3.4) and schools (section 3.5) from these surveys, thus mirroring all three input categories discussed in the conceptual framework. We close with additional survey evidence on child, parent, and school inputs from other countries (section 3.6).

3.1 Survey Methodology of the Two German Time-use Surveys

To assess the impact of the school closures, we conducted two parental surveys on the time use of German school children during the school closures in spring 2020 and early 2021. The surveys allow us to compare the everyday experience of children during the school closures with pre-pandemic times. In particular, the longitudinal component of the surveys offers some insight on how children and families reacted to the school closures both in the short and medium term. The surveys collected information on the time that children spent on a range of activities, as well as additional information on the involvement of the parents in these activities and on the activities of schools. Surveys provide a unique opportunity to obtain timely data while the pandemic and its impacts were unfolding. At the same time, there are obvious limitations of survey-based data, including limited measurement of skills, self-reported assessments, potential biases from social desirability and limited recall, limited parental knowledge of children's activities, and survey fatigue (see Grewenig et al. 2021 for a detailed discussion).

The first wave of the survey was conducted as part of a large education survey from 3 June to 1 July 2020 (see Grewenig et al. 2021 and Woessmann et al. 2020 for details). The target population of the overall survey, sampled through online-access panels, was the population of Germans between the age of 18 to 69 years. Using quotas, the sample was drawn to be representative for the German population in terms of age, gender, place of residence, and employment status. As part of the larger survey questionnaire, we elicited detailed time-use information for school children from all respondents who reported that they had at least one

child that was currently in school. This resulted in a sample of 1,099 parents of school children who were surveyed about their family's situation during the first phase of school closures, which lasted roughly from March to June. Due to concerns about survey fatigue, we elicited information only for the youngest school child of each respondent.

As the pandemic threatened yet more school closures in the following academic year, for the purposes of this paper we designed a follow-up survey to understand how the preparedness of families and schools had changed over time. The second wave of the survey was in the field from 17 February to 10 March 2021 (see Woessmann et al. 2021 for details). Overall, we surveyed 2,045 parents of children in schools. In contrast to the first survey, the sample in the second survey was immediately restricted to parents, and quotas were again used to ensure representativeness along several dimensions including age, gender, state of residence, and education degree. A total of 513 respondents, equivalent to 47 percent of the original parent sample, were successfully recruited to participate again in the second wave. The sample of re-surveyed respondents serves two purposes. First, it allows us to compare respondents' answers in the first period of school closures and nearly one year later, and hence gain novel insights how individual families and schools adapted to the new realities brought on by the pandemic. Second, by comparing the answers of panelists with the respective cross-sections of parents, we can disentangle whether changes in results between the two cross-sections of our survey are driven by selection or attrition effects, a potential caveat of survey research.

In this paper, we draw on the subsample of panelists who participated in both survey waves to report time trends in answers for those outcomes for which longitudinal data are available. For outcomes measured only in the second wave, we report the cross-sectional results for the entire second-wave sample. Table A1 in the Appendix shows the characteristics of the three samples – the cross-sectional samples of the first and second waves, respectively, as well as the sample of panelists participating in both waves.[2] Despite the necessary deviations in sampling procedure, the cross-sectional samples are quite similar in terms of observable characteristics. The panelists are on average somewhat more likely to have an academic education and higher income, and their children are more likely to attend the higher secondary school track. To account for selection into the sample of panelists, we discuss differences in the results for the panelist sample reported here to the full cross-sectional samples throughout.

On the time-use questionnaire, parents report how many hours their child spent on a variety of activities on a typical workday. The list of activities includes activities directly related to

[2] For further discussion on the representativeness of the sample, see Grewenig et al. (2021).

education, i.e., attending school and learning for school, as well as a range of alternative activities such as reading, watching TV, or exercising. In addition, respondents had the option to add activities they felt were missing from the list. In the first wave, respondents reported the average hours for each activity both retrospectively for a typical workday before the pandemic-induced school closures and for a typical workday during the school closures. In the second wave, respondents reported the average hours for the same activities during the period of the 2021 school closures.

The longitudinal design of the survey items allows us to gain some understanding of how the time use of children changed from before the pandemic and how it evolved over time as the pandemic continued into the second consecutive academic year. The longitudinal component of the data is particularly important to determine to what extent differences observed in the cross-sectional data, for example between different groups of students, already existed before the pandemic or emerged with the school closures.

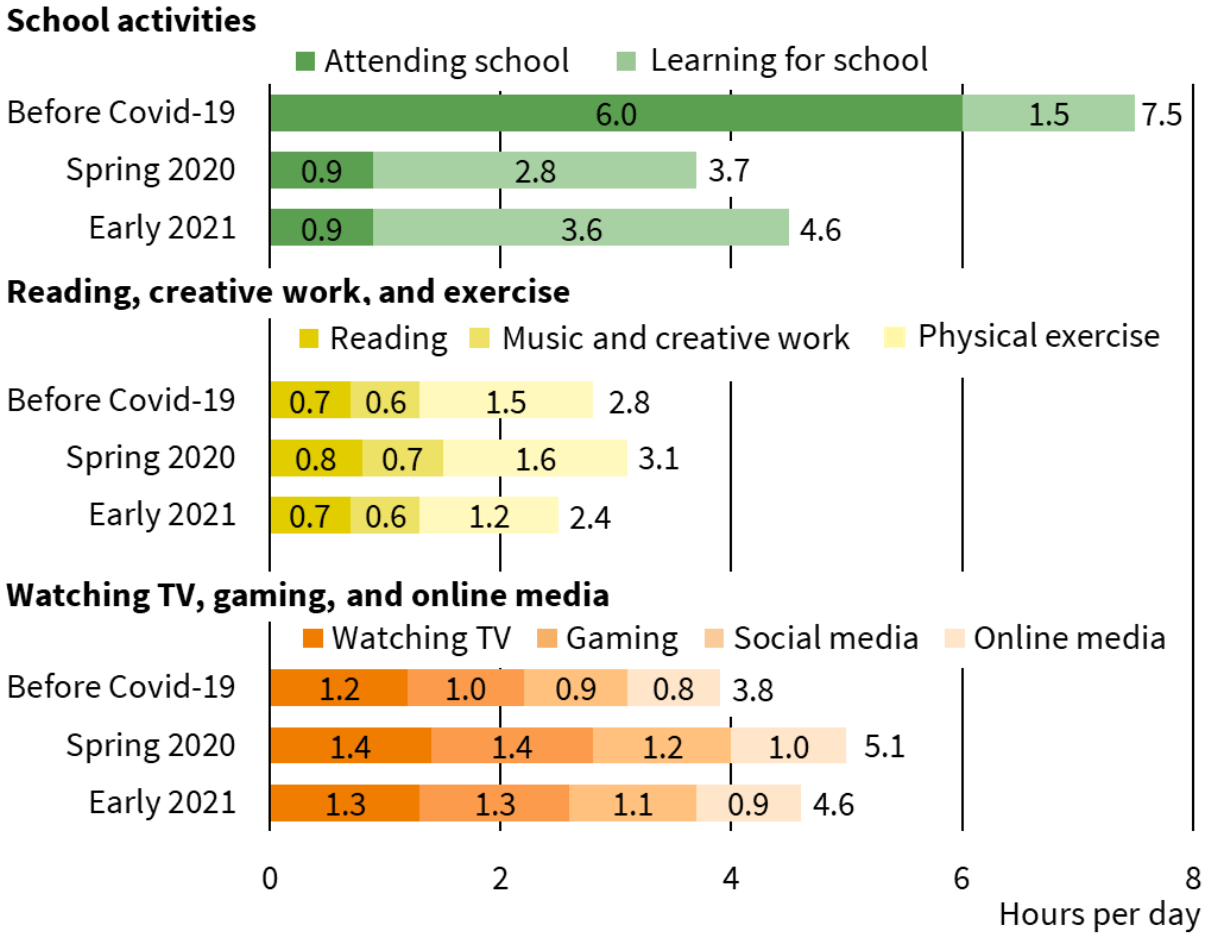
One of the key concerns outlined in section 2 is the potential of the school closures to increase the inequality in skills, in particular, to exacerbate the dependence of education success on the home environment, parental and neighborhood characteristics. To assess to what extent this concern is substantiated in our data, we analyze answers separately for children with different levels of prior achievement and different parental education backgrounds. As part of our background questionnaire, we ask parents which grade their child usually obtained in math and German prior to the school closures. We define low-achieving children as those whose average grade was below the median grade of their respective school type and high-achieving students as those whose prior achievement was at or above the median. In addition, we distinguish between responding parents with an academic education and those without. We focus on parental education background as it has been shown to be a strong predictor of education attitudes in Germany, even more so than alternative measures of socio-economic status such as household income (Lergetporer, Werner, and Woessmann 2021).

3.2 Children's Learning Time and Experiences during the School Closures

We start with results on the average time that children spent on activities directly related to schoolwork. The question asked parents in our German surveys to report the average number of hours their children spent either going to school or learning for school per day. In the first wave of the survey, parents report that during the school closures in spring 2020 their youngest school child spent an average of 3.7 hours on school-related activities (see Figure 1). The majority of this time was spent learning for school at home, whereas only a small part of less

than one hour on average is accounted for by children who attended school (for example due to hardship rules that allow exceptions for school attendance for children from parents in so-called "system-relevant occupations"). The amount of learning time during the first school closures constituted a dramatic decrease from an average of 7.5 hours per day before the school closures. That is, the time that children spent on school-related activities was cut roughly in half on average during the first period of school closures. This reduction was half an hour larger among boys than among girls. The absolute reduction was smaller for primary-school than for secondary-school students, but in relative terms, it was similar for students in primary and upper-track secondary schools and largest for students in other secondary schools.

Figure 1: Time use of students before and during the two phases of school closures in Germany



Notes: Average hours spent in each activity on a typical workday. Sample: Parents participating in both survey waves (see Appendix Table A1 for details). Source: Own calculations based on ifo Education Survey 2020 and second German parental time-use survey 2021.

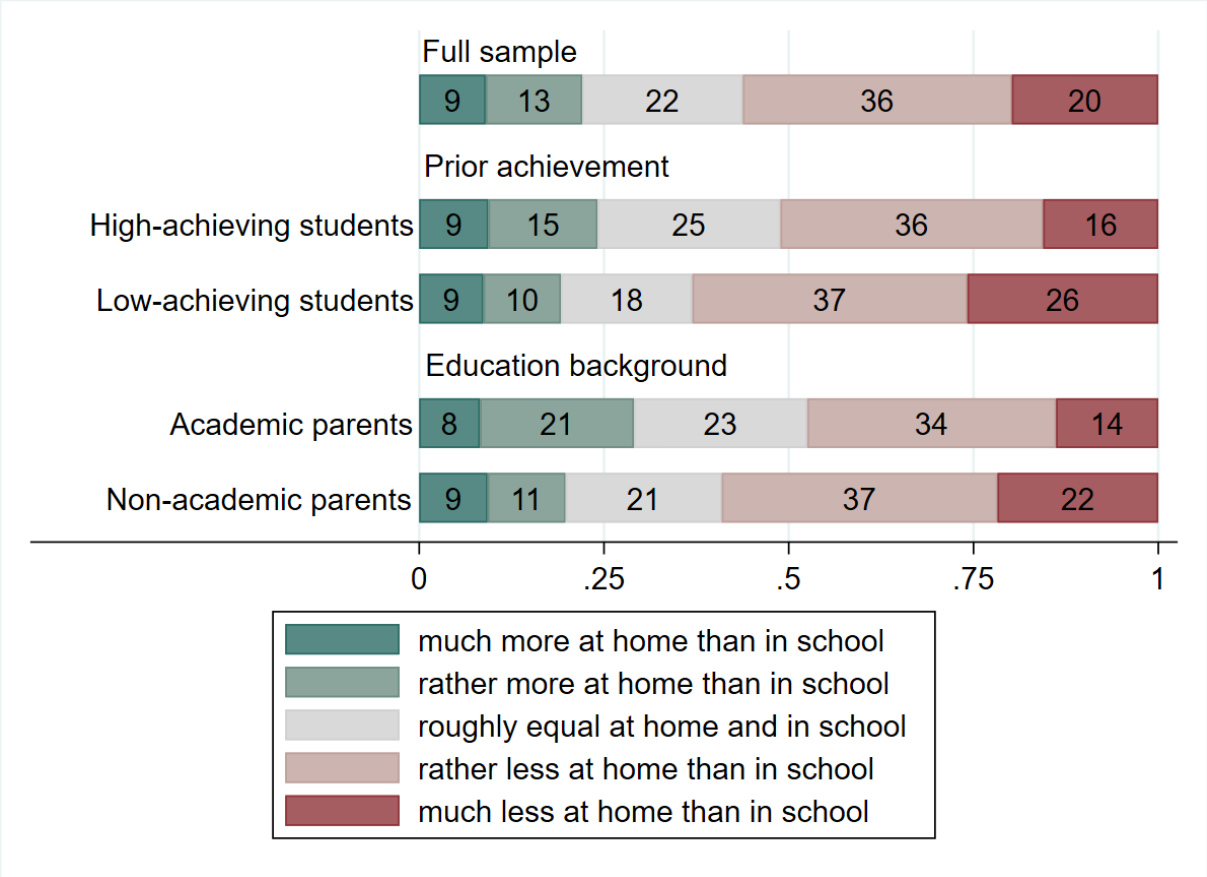
During the second phase of nation-wide prolonged school closures in early 2021, roughly one year later, the time children spent on school-related activities has increased slightly to 4.6 hours. This is close to one hour more than during the initial school closures in spring 2020, but still three hours less than during a typical school day before the Covid-19 pandemic. This pattern is very similar in the full cross-sectional samples of the two survey waves (see Woessmann et al. 2021, Figure 1), suggesting that these time trends hold more broadly in the German population and are not due to differential selection of the panelist sample. The gender gap mostly remained during the second phase. But the absolute rebound was stronger for secondary-school than for primary-school students, so that students from each school type had reduced their average learning time by roughly 40 percent during the second school closures compared to pre-Covid times. Overall, the time-use data suggest that the time children invested in school-related activities dropped sharply when schools closed and increased only slightly over the course of the pandemic.

In the first wave of school closures, the reduction in learning time was significantly larger for low- than and for high-achieving students (Grewenig et al. 2021). Before the school closures, there was no noticeable difference in the time that low- and high-achieving students spent attending or learning for school. But during the first wave of school closures, low-achieving children spent a significant 0.5 hours per day less on school-related activities than high-achieving children. Regression analyses indicate that this gap cannot be accounted for by observable background characteristics of students, suggesting that it is genuinely linked to the achievement dimension. By contrast, the decline in learning time did not differ between children from academic and non-academic parents. Unfortunately, statistical power in the panelist sample does not allow for clear conclusions on these subgroup differences in the second wave. In the full cross-sectional sample of the second wave, the difference in learning time between low- and high-achieving students is substantially lower and no longer statistically significant. This may be related to the fact that the increase in average learning time entails a clear reduction in the share of students who spent very little time learning (e.g., at most two hours), which might indicate that schools were more successful in the second wave to reach most of the students. However, in the panelist sample, the difference in the reduction in learning time between low- and high-achieving students is nearly as large in the second as in the first wave, but does not reach statistical significance, so that a precise quantification of the subgroup difference in the second wave is not possible.

However, even in the best-case scenario where gaps in learning time have narrowed, evidence from the second wave suggests that the quality of learning time differed significantly

between low- and high-achieving students. We asked parents to assess how much their child learns during one hour of learning at home compared to one hour of regular instruction at school. A majority of 56 percent of parents thinks that their child learns less per hour of studying at home than in school (see Figure 2). Such a difference in the effectiveness of learning per hour would imply that the reduction in learning time indicated above in fact underestimates the reduction in acquired skills for most students. Interestingly, there is also a minority of 22 percent of parents who think that their child learns more per hour at home than in school, suggesting that there is ample heterogeneity across students in their effectiveness of learning at home.

Figure 2: Parental assessment of effectiveness of children's learning time at home vs. in school



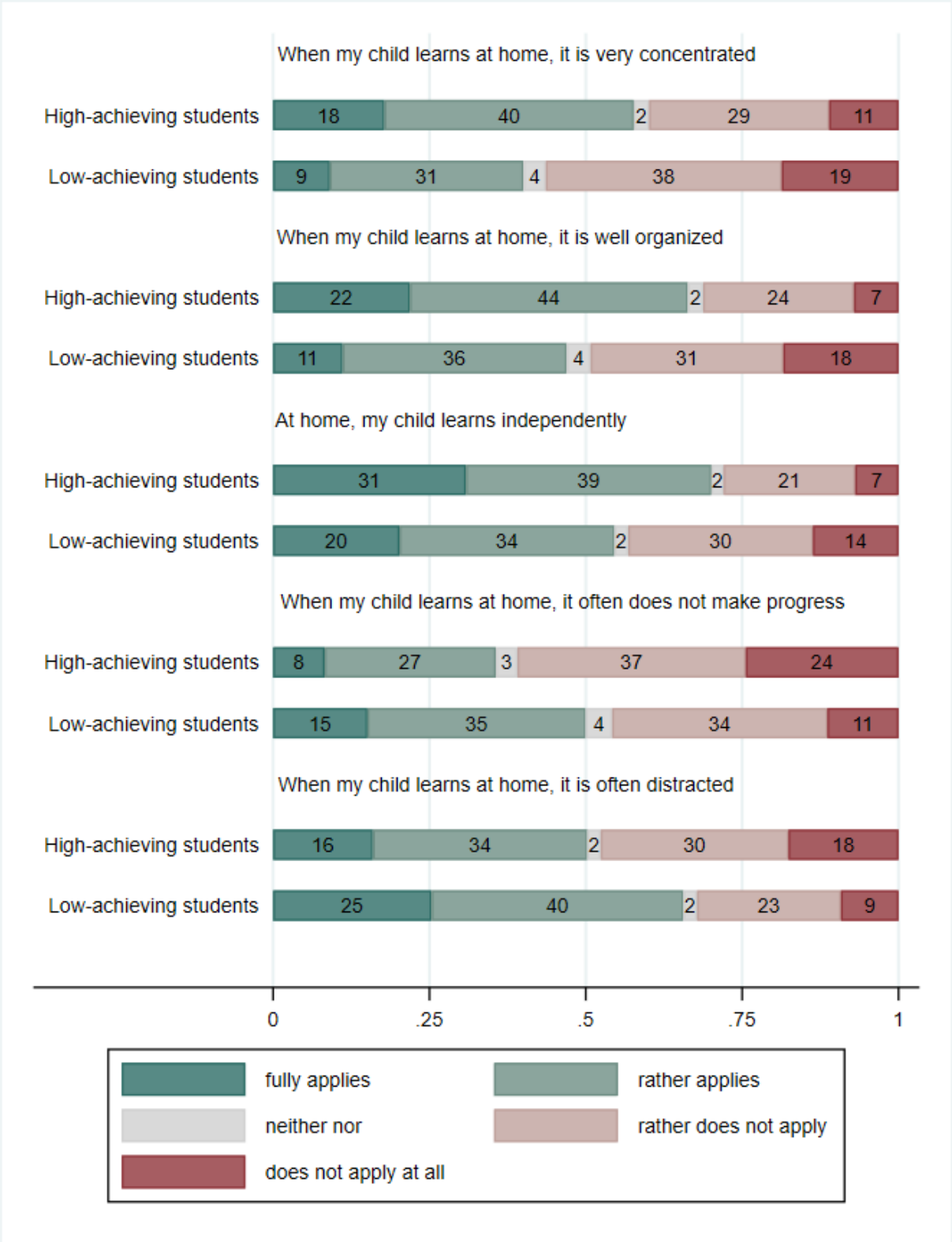
Notes: Parental response to the question, "How much do you think your child learns during one hour of learning at home compared to one hour of regular instruction at school? Per hour, child learns…" Sample: Parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

Importantly, there is also heterogeneity by students' prior achievement and parental education: The share of parents reporting that their child learns less per hour at home than in school is 12 percentage points higher for low- than for high-achieving students, as well as for children of non-academic compared to academic parents.[3] These results indicate that the same time investment may translate into different skill growth depending on the prior achievement level of a student, consistent with dynamic complementarities in skill acquisition (e.g., Cunha et al. 2006), and suggest that important inequalities remained in children's skill development during the second phase of school closures.

Important differences in the home-learning experiences of low- and high-achieving students also emerge in parents' assessments of how their child learns at home. Overall, parents are remarkably split: 47 percent say that their child is very concentrated when learning at home, but 49 percent say that this is not the case (with only 3 percent being indeterminate). These assessments differ substantially between parents of low- and high-achieving students: 58 percent of parents of high-achievers, but only 40 percent of parents of low-achievers report that their child is very concentrated when learning at home (see Figure 3). Similarly, large differences emerge for parents' assessment of how organized their child is when learning at home, whether it learns independently, whether it is often stuck, and whether it is often distracted. Such differences also emerge, although to a somewhat smaller extent, between children of academic and non-academic parents. These patterns are consistent with the perspective in our conceptual framework in section 2.4 that the effect of school closures on skill development may be mediated by the effectiveness of self-regulated learning, which depends on students' prior achievement and SES background.

[3] On another survey item, 68 percent of parents of low-achieving students and 61 percent of non-academic parents agree with the statement that their child has learned "much less" than usual during the school closures in early 2021, compared to 54 percent each among parents of high-achieving students and academic parents.

Figure 3: Parental assessment of children's learning experiences at home



Notes: Parental assessment of respective statements. Sample: Parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

3.3 Children's Other Activities that Substituted for the Reduced Learning Time

While the reduction in time spent on school-related activities is large, the implications of this dramatic shift also depend on the activities that children substituted to instead of attending or learning for school. We therefore also asked parents to report the average daily hours their child spent on a variety of other activities: reading or being read to, being creative (e.g., playing an instrument), exercising, watching TV, playing games on computers or smartphones, and spending time on social media and consuming online media. Additionally, we asked parents whether they think that a particular activity is conducive to their child's further development or not (see Grewenig et al. 2021 for details).

Results show that the average hours that children engaged in activities which most parents consider conducive – reading, being creative, and exercising – increased only slightly during the first phase of school closures in spring 2020. The average time children read or were read to increased from 0.7 before the period of school closures to 0.8 during the first school closures, the time spent on creative activities from 0.6 to 0.7 hours, and the time for exercise from 1.5 to 1.6 hours (see Figure 1).

By contrast, the average time children spent on activities which most parents consider rather detrimental – watching TV, playing computer games, and spending time on social media and online media – increased markedly during the school closures. While it was 3.8 hours per day before the school closures, it increased to 5.1 hours each day during the first period of school closures. Overall, these results suggest that during the first school closures, the time children spent on activities that are particularly conducive to their skill acquisition dropped sharply. It was particularly substituted for by time spent on activities that are less well suited for learning and overall skill development.

Results from the second survey wave show that a large part of the increase in time spent on activities deemed rather detrimental by parents persisted throughout the course of the pandemic. Our new data show that even after nearly a year of pandemic-induced education interruptions, children still spent 4.6 hours a day on average on activities such as watching TV, playing computer games, and consuming social media or online media. Therefore, the increase of time children spent on learning for school observed during the second period of school closures only partly translated into decreases in the time spent on activities that are deemed rather detrimental. By contrast, it also translated into a substantial decrease in the time spent on activities deemed rather conducive (mostly a reduction in exercise, which may partly reflect a seasonal pattern).

Additional analyses show that the shift towards more detrimental activities was particularly pronounced for initially low-achieving students. In the first phase of school closures in spring 2020, the increase in detrimental activities such as watching TV or playing computer games was 1.7 hours among low-achievers and 1.0 hour among high-achievers (Grewenig et al. 2021). Thus, it was particularly the low-achievers who disproportionately replaced learning time with detrimental activities rather than with activities more conducive to child development. This heterogeneous pattern in the time spent on detrimental activities by students' prior achievement persists, although at a slightly reduced level, in the second phase of school closures in early 2021.

3.4 Parental Support during the School Closures

When school closures reduced the contribution of teachers in the everyday delivery of children's education, the role of parents became ever more important. As highlighted in the conceptual framework of an education function in section 2.3, parental inputs constitute a key factor that can potentially exacerbate or mitigate the loss of formal education arrangements. To understand to what extent parents changed their time investments into their children during the time of school closures, we elicited the time that either the responding parents or their partner spent on different activities together with their youngest school child on a typical day.

Table 1 shows the average time parents spent with their children on the different activities. On average, parents report that they spent 1.2 hours per day on school-related activities with their children in both waves of the survey. Compared to the average of 0.5 hours that parents report spending on school-related activities with their child prior to the school closures, this suggests parents more than doubled their time investment to support their children in distance-learning activities.

Table 1: Parental time investments during the two phases of school closures in Germany

	Before Covid-19	Spring 2020	Early 2021	Difference 2020 to before Covid-19	Difference 2021 to 2020
	(1)	(2)	(3)	(4)	(5)
School activities					
Learning for school	0.54	1.17	1.17	*0.63*	*-0.01*
Reading, creative work, and exercise					
Aggregate	0.96	1.34	0.91	*0.38*	*-0.43*
Reading	0.26	0.31	0.23	*0.04*	*-0.07*
Music or creative work	0.19	0.24	0.16	*0.04*	*-0.08*
Physical exercise	0.51	0.8	0.52	*0.29*	*-0.28*
Watching TV, gaming, and online media					
Aggregate	1.02	1.29	1.04	*0.27*	*-0.25*
Watching TV	0.59	0.74	0.62	*0.15*	*-0.12*
Gaming	0.14	0.19	0.16	*0.04*	*-0.03*
Social media	0.14	0.15	0.11	*0.01*	*-0.04*
Online media	0.14	0.21	0.15	*0.07*	*-0.06*

Notes: Average hours parents spent with their child on different activities on a typical workday. Sample: Parents participating in both survey waves (see Appendix Table A1 for details). Source: Own calculations based on ifo Education Survey 2020 and second German parental time-use survey 2021.

Furthermore, results show that parents of low-achieving students spent less time with their child learning for school than parents of high-achieving students. During the first period of school closures, parents of high-achieving children spent on average 0.3 hours more time learning for school with their child than parents of low-achieving students (Grewenig et al. 2021). Much of this gap (0.2 hours) had already existed before the pandemic. In the second period of school closures, this gap shrank to just 0.1 hours, suggesting that the inequality in parental time investments for children with different prior achievement was attenuated. Still, high-achieving children receive slightly higher time investments from their parents, increasing the likelihood that low-achieving children fall further behind on the learning accomplishments of their high-achieving peers. That is, far from compensating any differences between low- and high-achieving students, parental time investments actually tend to exacerbate them.

Beyond parental time inputs, there are also differences in children's learning environment at home. In our second survey, 30 percent of parents report that their child does not have an own room to study in at home. 25 percent report that their child does not have a reliable internet

connection at home, and 21 percent indicate that their child cannot print out assignment sheets for school at home. Asked about the availability of digital devices, 53 percent of parents report that their child has an own computer or tablet to use for school (only 6 percent of children had them provided by the school). An additional 32 percent can always use someone else's device for school, 11 percent have at least limited access (e.g., sharing with other family members), and 5 percent never have the opportunity to use a computer or tablet for school at home. Inequalities in the learning environment at home may therefore contribute to inequalities in learning opportunities.

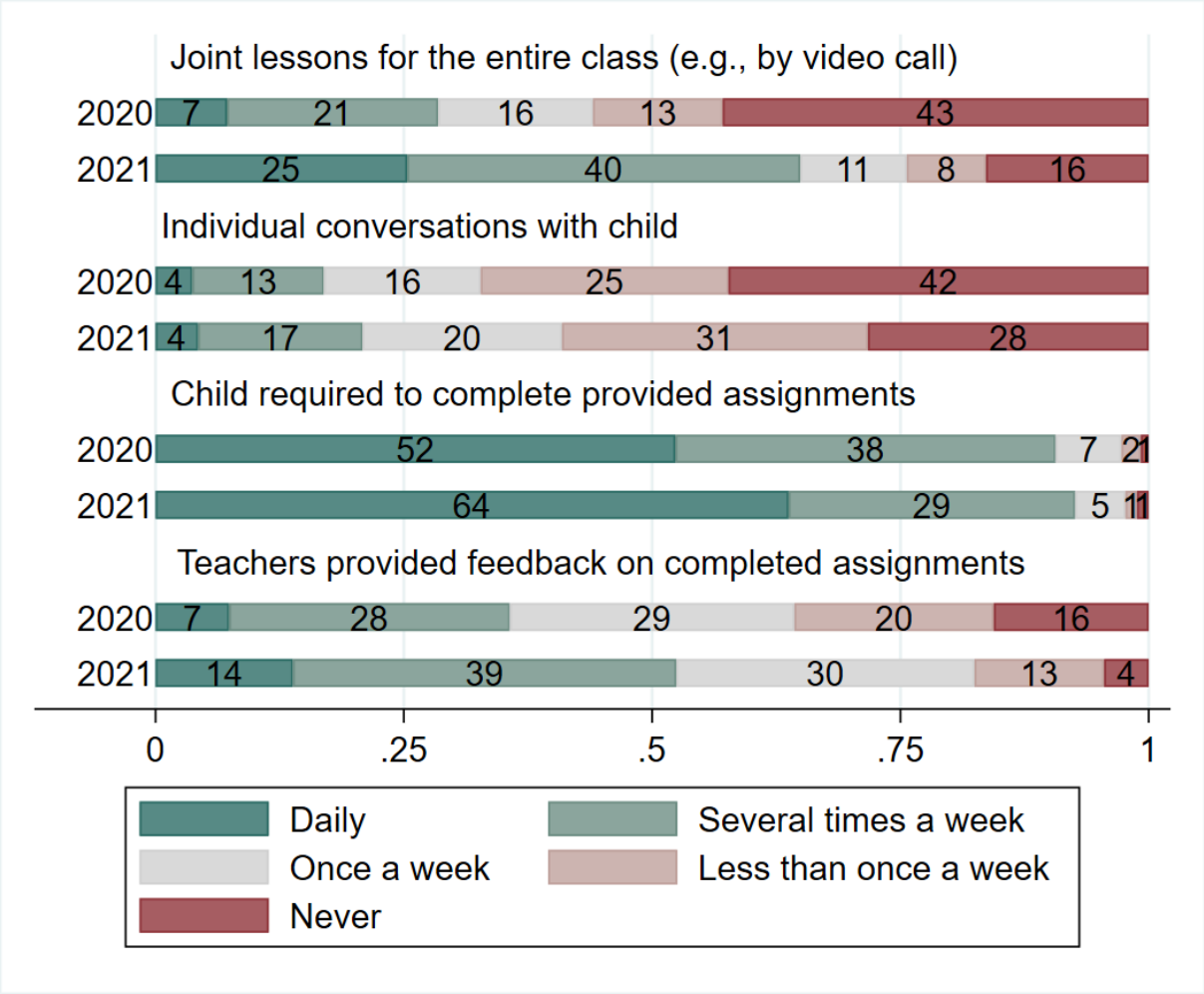
3.5 Schools' Activities during the Physical Closures

The closing of schools, a measure designed to limit in-person contact among the population, did not absolve schools from the responsibility to support the skill formation of students. However, in the wake of the first school closures in Germany, there was little guidance on how schools were expected to keep up their vital role as education facilitators in a distance-learning format. Instead, decisions on how to deliver lessons to children were left to individual schools and often to individual teachers. As a result, anecdotal evidence points to a fragmentation of the education landscape, with a wide array of individual solutions that differed substantially both in the intensity and type of distance teaching provided to students.

To gain a more comprehensive picture of how schools organized their teaching during the period of the school closures, we asked respondents to detail which activities their child's school engaged in. We were again able to elicit the same measures in the second wave of our survey, allowing us to gain some insight into how the education system adapted to the new requirements of distance teaching as the pandemic progressed. To facilitate the interpretation of time trends, we again restrict the analysis to the sample of panelists.

The results show that initially, many schools all but ceased to provide real-time instruction to students. During the first period of school closures, only 7 percent of parents report that their child's school offered daily lessons for the entire class, e.g., by video calls (see Figure 4). This was not compensated for by individual conversations between children and teachers, which parents report at an equally low level. Instead, the main activity of schools was to provide students with assignments for self-processing: more than 90 percent of parents report that their child received exercise sheets for at-home study several times a week. Yet, only a subset of 64 percent of parents report that their child received feedback on their completed assignments at least once a week.

Figure 4: Activities of schools during the two phases of school closures in Germany



Notes: Parental response to the question, "Which activities did your child's teachers or school engage in during the multi-week period of school closures?" asked in spring 2020 and early 2021, respectively. Sample: Parents participating in both survey waves (see Appendix Table A1 for details). Source: Own calculations based on ifo Education Survey 2020 and second German parental time-use survey 2021.

Results from the second wave of our survey show that the intensity of online teaching offered to students increased markedly over time. During the school closures in early 2021, 25 percent of parents report that their child's school holds daily online lessons for the entire class, a substantial increase over the 2020 level. At the same time, however, even in the second year of the pandemic, 35 percent of parents report that their child had online lessons at most once a week. Exercise sheets remained a dominant way of teaching, with 64 percent of children working on assignments provided by the school on a daily basis, an increase from 52 percent in the spring of 2020. Overall, schools increased their teaching activities in all dimensions

measured in the survey from 2020 to 2021, although a substantial fraction of parents still report very limited interaction between their child and their school.

Interestingly, parents without academic education and parents of low-achieving children report less school engagements. In both survey waves, children with less educated parents are less likely to receive any online lessons, to have individual conversations with their teachers, and to receive feedback on submitted homework. Therefore, we do not find evidence that teachers were able to differentially support children who were faced with potentially more challenging distance-learning circumstances.

As argued in our conceptual framework in section 2.2, the choice of distance-teaching activities may have repercussions for student outcomes. To provide a quantification of which school activities are particularly related with student learning, in Table 2 we report regressions of students' daily learning time on the different school activities (included linearly in the underlying categories) as well as controls for child characteristics, parent characteristics, and the home environment (see Table A2 in the Appendix for a list of control variables). The first column refers to the first phase of school closures in spring 2020 and conditions on students' learning time before the closures. We include the full battery of school activities from the survey, which – in addition to the four activities documented in Figure 4 – include the use of educational videos or texts, the use of educational software, and whether children had to submit completed assignments. The regression indicates a positive association of students' learning time during the first school closures with the extent to which their school provided online lessons and with whether students had to submit their completed assignments, as well as marginally with the use of education software. The second column reports a similar cross-sectional regression for the second phase of school closures in early 2021. We include the time that parents spent helping their child with learning at home as a control variable, which enters significantly positively. As parental time investments may be partly endogenously determined in response to the extent and type of provided school activities, it is debatable whether it should be included as a control; however, results are insensitive to the inclusion, so we show specifications with the parental time control throughout.

Table 2: Schools' distance-teaching activities and students' learning time

	Phase of school closures		Value-added (early 2021 conditional on spring 2020)		
	Spring 2020	Early 2021			
	(1)	(2)	(3)	(4)	(5)
Joint lessons (e.g., by video call)	0.207***	0.202***	0.213**		
	(0.065)	*(0.047)*	*(0.098)*		
Joint lessons = daily				0.939**	1.110***
				(0.415)	*(0.248)*
Joint lessons = several times a week				0.014	
				(0.365)	
Joint lessons = once a week				0.067	
				(0.444)	
Joint lessons = less than once a week				-0.313	
				(0.458)	
Individual conversations with child	0.124	-0.102**	-0.066	-0.055	
	(0.076)	*(0.052)*	*(0.107)*	*(0.107)*	
Educational videos or texts	-0.028	0.144**	0.123	0.121	
	(0.064)	*(0.056)*	*(0.117)*	*(0.116)*	
Educational software	0.095*	0.057	-0.039	-0.022	
	(0.055)	*(0.043)*	*(0.089)*	*(0.088)*	
Child required to complete provided assignments	0.032	-0.066	0.053	0.024	
	(0.087)	*(0.076)*	*(0.168)*	*(0.168)*	
Child had to submit assignments	0.267***	0.132*	0.091	0.093	
	(0.084)	*(0.068)*	*(0.156)*	*(0.156)*	
Teacher provided feedback on completed assignments	-0.019	0.031	0.137	0.096	
	(0.080)	*(0.061)*	*(0.135)*	*(0.135)*	
Learning time before Covid-19	0.263***		0.018	0.022	0.023
	(0.035)		*(0.060)*	*(0.059)*	*(0.058)*
Learning time in spring 2020			0.237***	0.243***	0.252***
			(0.048)	*(0.048)*	*(0.046)*
Parental support time in spring 2020	0.340***		0.013	0.009	0.012
	(0.056)		*(0.094)*	*(0.093)*	*(0.092)*
Parental support time in early 2021		0.287***	0.257***	0.266***	0.277***
		(0.037)	*(0.080)*	*(0.080)*	*(0.078)*
Child controls	yes	yes	yes	yes	yes
Parent controls	yes	yes	yes	yes	yes
Home environment controls	no	yes	yes	yes	yes
Observations	1,093	2,014	508	508	508
R^2	0.186	0.085	0.177	0.192	0.183

Notes: OLS regressions. Dependent variable: students' hours of school-related activities on a typical workday during the respective period of school closures due to Covid-19. School activities coded from 1=never to 5=daily. See Appendix Table A2 for list of child, parental, and home environment control variables. Samples: parents participating (1) in the first survey wave, (2) in the second survey wave, and (3)-(5) in both survey waves, respectively (see Appendix Table A1 for details). Standard errors in parentheses. Significance levels: *** $p<0.01$, ** $p<0.5$, * $p<0.1$. Data source: ifo Education Survey 2020 and second German parental time-use survey 2021.

More generally, these cross-sectional regressions are likely to suffer from endogeneity bias, as schools' activities are choice variables that may be correlated with unobserved background variables and may even be chosen in direct response to students' behavior. Such potential biases caution against a causal interpretation of the cross-sectional associations. To partly address these concerns, we can exploit the panel dimension of our data collection process to estimate value-added models: For the parents who participated in both survey waves, we can condition on students' learning time in the first phase of school closures when estimating the effect of school activities during the second closures on students' learning time during the second closures. Any bias from unobserved factors that already affected students' learning time during the first closures will thus be accounted for, and identification is based on the *change* in learning time from the first to the second wave.

In the value-added specification, only the extent of online instruction enters significantly positively into predicting the change in students' learning time (column 3). There is also some positive association of learning time with schools' use of educational videos, the requirement to submit completed assignments, and teachers' feedback on these assignments, but none of these reaches statistical significance in this specification.[4] Both students' learning time in the first phase of school closures and parental support time enter significantly positively, and conditional on these, their prior observations (learning time before the closures and parental time during the first closures) do not enter significantly.

There is an important non-linearity in this result: When entering the categories of the frequency of online instruction as separate dummy variables, only the daily incidence of online instruction enters significantly and strongly, whereas there are no significant differences in students' learning time among the less frequent incidences of online instruction (column 4). Interestingly, when subdividing any of the other school activities into dummy variables, not a single of the separate dummies enters significantly. The preferred specification that includes only a dummy for daily online instruction (column 5) thus indicates that learning time during the second school closures increased by over one hour more for students whose school had implemented daily online teaching by that time compared to students whose school had not. A dummy for whether the school had already had online instruction in the first wave (a low incidence, see above) does not enter this model significantly and does not qualitatively affect

[4] Note that this is partly due to the smaller sample size of the panelist sample. Restricting the model of column (2) to this sample also leads to a loss of statistical significance of all school-activity variables except for joint lessons. It is thus unclear whether the effect loses significance due to the value-added specification or a lack of statistical power. Regardless, joint lessons are always the strongest predictor in these models.

the coefficient estimate on online instruction in the second wave (not shown), indicating that it is indeed the change from no daily to daily online instruction that gives rise to the increase in students' learning time.[5]

Surprisingly few of the observed measures of the family and home environment enter significantly in predicting learning time during the second closures (not shown). In particular, neither an own room nor a reliable internet connection nor the opportunity to print assignment sheets at home are significantly related to learning time. In the value-added model, the only home environment measure that enters significantly is having an own computer or tablet at home to use for school (compared to using someone else's device). Among the rich set of child and parent controls, only being a single child enters the value-added model significantly positively. Overall, there is thus little evidence in our data that home inputs are of primary importance for students' learning time.

Overall, the descriptive results suggest that in the first phase of school closures, schools mostly provided students with exercise sheets for self-processing, whereas very few schools implemented online instruction on a daily basis. The panel dimension of our time-use surveys indicates a mild rebound in the provision of daily real-time instruction during the second phase of school closures. In both phases, these school activities were less likely to reach disadvantaged children, so that schools were not able to compensate for their situation in particular. The results of the value-added model suggest that – rather than any other school activity – daily online instruction was indeed highly effective in raising students' learning time.

3.6 Further Survey Evidence on Children, Parents, and Schools from Different Countries

The pattern of differential pandemic effects on the learning opportunities of children from more and less advantaged backgrounds replicates in several studies in a variety of contexts. Using extensive time-use evidence for the United Kingdom, Andrew et al. (2020) highlight considerable heterogeneity in the amount of time children spent learning, as well as in the resources available to them. Similarly, Bansak and Starr (2021) show that in a sample of U.S. households, less-educated parents spent less time learning with their children. However, when school activities such as live online classes with the teacher are accounted for, this difference vanishes, indicating that differences in school activities contributed to widening inequality in the resources that were available to different groups of students. This assessment is mirrored in

[5] Accordingly, results are very similar in a first-difference model that regresses the *change* in students' learning time from the first to the second wave on the *change* in schools' daily online instruction status.

U.S. survey evidence sampling teachers and principals who also indicate large disparities in students' access to learning support (Hamilton, Kaufman, and Diliberti 2021). Leveraging early tracking data from an online math application used in a number of U.S. school districts prior to Covid-19, Chetty et al. (2020) show the learning progress of students attending schools in lower-income areas suffered a particularly strong decline during the early school closures. Studies from specific German samples also show significant differences in learning time between high- and low-performing students (e.g., Anger et al. 2020) and between students who report they are more or less able to learn productively at home (Huber and Helm 2020). Overall, the available survey evidence consistently points towards unequal impacts of the Covid-19 school closures.

In many families, prior patterns of family life were disrupted during the lockdowns, with altered work patterns, chore allocations, and household tensions among parents (Biroli et al. 2020). In general, the additional child-related responsibilities during the period of school closures increased the burden on parents. For example, Tani et al. (2020) show that mental health decreased particularly strongly for working parents when homeschooling. Increasing evidence suggests that the burden of additional childcare responsibilities fell disproportionately on mothers, with potential detrimental effects on their labor-market attachment and wellbeing (e.g., Del Boca et al. 2021; Danzer et al. 2021; Zamarro and Prados 2021). In principle, the impact of disruptions in parents' labor-market participation on children's development could be ambiguous, though: Using U.K. data from before and during the pandemic, Hupkau et al. (2020) show that children whose fathers experienced negative labor-market shocks are significantly less likely to have received additional paid learning resources, but received more parental help time with their schoolwork. For Italy, Mangiavacchi, Piccoli, and Pieroni (2021) show that increased involvement of fathers in childcare and homeschooling activities is correlated with higher emotional wellbeing of children and reduced TV and passive screen time.

The situation of parents during the school closures is also mediated by the intensity of activities provided by schools. Exploiting variation in school closures at the school-district level in the U.S. in a differences-in-differences approach, Amuedo-Dorantes et al. (2020) find that a higher intensity of school closures reduced parental labor supply, particularly among mothers. Similarly, Schüller and Steinberg (2021) show that access to emergency childcare policies decreased harsh parenting behavior in Germany, although it did not causally affect overall parental wellbeing. In an Italian survey, Bovini and De Philippis (2021) show that the time parents spent assisting their children was greater during periods of distance learning than during periods of face-to-face learning, especially for those with younger children. While parental time

investment for first-graders did not differ by SES, support for older students was greater among more educated parents. Overall, almost half of distance learning hours were covered in asynchronous mode without joint teacher-student presence for primary-school children, whereas most distance lessons were synchronous in upper secondary schools. Mangiavacchi, Piccoli, and Pieroni (2021) document that the type of distance learning activities offered by the schools is associated with the quality of children's at-home learning in Italy. The period of distance teaching and limited social interactions may also have been highly demanding on the mental health of teachers, in particular those who had to take care of children at home themselves. For example, Jakubowski and Sitko-Dominik (2021) report that roughly half of a sample of teachers they surveyed in Poland experienced at least mild levels of stress, anxiety, and depressive symptomatology during the two phases of the pandemic.

Where school resources are lacking, evidence shows that many parents look for alternative ways to improve their child's access to education. For example, Bacher-Hicks, Goodman, and Mulhern (2021a) find that higher-income areas in the United States saw larger increases in demand for online instruction, measured by the frequency of search engine use for applicable terms. Overall, the findings highlight important gaps both in the resources available to different groups of students and in parents' demand for education. Corroborating this point, Dee et al. (2021) document that offering remote-only instead of in-person instruction reduced enrollment in public elementary schools in Massachusetts.

Ample survey evidence from many countries thus indicate that learning inputs provided by schools, parents, and the children themselves all tended change due to the Covid-19 school closures in a way that particularly challenged students from disadvantaged backgrounds, aggravating patterns of educational inequality.

4. Children's Cognitive Development

The presented evidence on the time use of school children during the school closures paints a pessimistic picture of the potential learning progress of those affected by the disruptions. In the next two sections, we review the emerging empirical literature that investigates how the shift from face-to-face to online teaching affected the development of children's cognitive and socio-emotional skills, respectively. Covering aspects of the cognitive development, this section mainly focuses on students' performance on achievement tests to quantify any learning losses in academic subjects taught in school (section 4.1). We also briefly mention two areas where the remote-learning experience might be hypothesized to have positive effects, namely digital skills and self-regulated learning skills (section 4.2).

4.1 Students' Academic Achievement

A common issue for studying the impact of the Covid-19-induced school closures is that in many countries, testing children in the usual way was not possible during the height of the pandemic. For example, achievement tests such as the Programme for International Student Assessment (PISA) halted their preparations to collect data due to the difficult situation in the participating countries. Similarly, a number of countries and states canceled the usual conduct of standardized tests of students. Therefore, in most settings data to inform education policy about students' state of achievement are not available. However, a few studies have access to data on students' performance on standardized tests and aim to identify the effect of Covid-19 school closures on academic achievement, with a particular focus on inequality by socio-economic background.

Two main problems complicate deriving the impact of the school closures from the testing data that are available. First, in most data it is difficult to disentangle any Covid-19 effect from usual cohort effects. As the school closures affected virtually all students, there is no convincing contemporaneous control group in cross-sectional data that could directly inform about the achievement in the absence of the closures. Most available studies therefore compare achievement of the affected cohort on a test after the closures to the achievement of previous cohorts who had taken the test in previous years. The problem is that the cohorts may have performed differently even in the absence of the school closure "treatment". For example, the movements of country averages between subsequent waves of international achievement tests such as PISA or TIMSS indicate that cohort differences are quite common and often substantial. Such cohort effects may be due to changes in education policies, changes in the underlying average ability of student cohorts, or even pure chance. Whatever their source, such cohort effects would introduce bias into an interpretation of differences in average achievement across cohorts as effects of the Covid-19 school closures.

Most studies do not explicitly report the size of achievement differences between different cohorts prior to the one exposed to the pandemic. However, in one study in the German state of Baden-Württemberg differences in the average achievement in the three cohorts prior to the school closures (2017-2019) – which are used for comparison to the 2020 cohort affected by Covid-19 – reach 7 percent of a standard deviation (SD) in math and more than a quarter of a SD in reading (Schult et al. 2021). Using the general rule of thumb that the average learning of students during one school year tends to equal roughly one-quarter to one-third of a SD on most standardized tests, these cohort effects are equivalent to somewhere between one fifth of a year

and more than an entire year of average student learning. In other words, if cohort effects are that large, it is hard to place any meaningful bounds on what cohort comparisons in repeated cross-sectional testing data imply for the causal effect of Covid-19 school closures on student achievement.

To address bias from cohort effects, one needs individual-level longitudinal (panel) data that allows to observe how the students tested after the school closures had performed on tests before the school closures (compared to earlier cohorts). To our knowledge, the only study that has access to this type of data is Engzell, Frey, and Verhagen (2021). In the Netherlands, national tests in primary school take place twice a year: once in January/February and once in June. The first nationwide school closures in the Netherlands started on March 16 and lasted for eight weeks. As a consequence, the national tests took place just before and after the closures. Engzell, Frey, and Verhagen (2021) exploit this setup in a differences-in-differences framework: They estimate the effect of the Covid-19 school closures as the difference in learning gains from January/February to June between the 2020 cohort affected by the closures and the three previous cohorts (2017-2019) for whom this period of learning was not disrupted by school closures. As any differences in the levels of achievement between the 2020 cohort and the prior cohorts that existed at the beginning of the respective calendar year are taken out, this approach should mitigate concerns of bias from cohort effects.

Drawing on data on math, spelling, and reading test scores for 350,000 students aged 8 to 11 (covering 15 percent of Dutch primary schools that appear reasonably representative for the universe of schools), Engzell, Frey, and Verhagen (2021) find an average learning loss of 0.08 SD. That is, the students in the 2020 cohort who were affected by the Covid-19 school closures learned substantially less between January/February and June than students in the respective cohorts in the three prior years. When the authors perform a placebo analysis that compares achievement gains among the three previous cohorts, they do not detect any significant "effects", suggesting that the differences-in-differences approach is successful in addressing bias from cohort effects.

In their data, 0.08 SD is equivalent to the average student learning of one-fifth of a school year. Intriguingly, the eight weeks that schools had been initially closed in the Netherlands also correspond to one fifth of the weeks of a school year. That is, the results imply that "students made little or no progress while learning from home" (Engzell, Frey, and Verhagen 2021, p.

1).[6] This is despite the fact that the authors argue that the Dutch case probably reflects a "best-case" scenario as the Netherlands had comparatively short school closures, an equitable system of school funding, and a broadband penetration unmatched in the world. Their estimates therefore likely provide a lower bound for learning losses in most other countries.

Their estimated learning losses due to the Covid-19 school closures mostly do not differ systematically across subjects, grade levels, gender, or students' achievement in the previous year. However, there is heterogeneity by parental education: Treatment effects are 40 percent larger for children whose parents both do not have a degree above lower secondary education (8 percent of the population). This implies that for some student groups, the change in achievement during the school closures is even negative, which is well possible if children forget and lose some of their previous skills in times without schooling (consistent with a large literature on learning losses during summer holidays; e.g., Cooper et al. 1996; Alexander, Pitcock, and Boulay 2016).

There is a second main problem when estimating effects of the Covid-19 school closures from testing data, which presumably is quantitatively the major problem with most available tests: during or after the closures, often substantial fractions of students did not participate in the testing. In repeated cross-sectional data, such non-participation can introduce substantial attrition bias, as attrition of individual students is unlikely to be random but rather concentrated at the bottom of the achievement distribution. Participation is not compulsory in most available tests, particularly so in pandemic times. It seems likely that those students who are hardest hit by the pandemic, who discontinued learning the most during the closures, or who may not even have returned to school yet are most likely not to participate, either because they choose so or because their teachers or schools discourage them from participation (for example, because they do not expect them to grasp even the most basic concepts).[7] In all likelihood, the attrition bias therefore is an upward bias in the average achievement – i.e., any loss in skills would be underestimated due to the non-participation.

To indicate the size of the problem in normally distributed data, consider what happens to the mean achievement of a student population if it is truncated from the bottom. If one drops the lowest-achieving 10 percent of students from a population, the mean achievement will increase by 0.2 SD; dropping the lowest 25 percent increases mean achievement by more than

[6] Calculations in van de Werfhorst (2021) suggest that the 0.08 SD learning loss may rather be equivalent to 0.14 (rather than 0.2) of a school year.

[7] In some countries, participation in post-Covid testing may also be skewed because students with the worst pandemic experiences may have repeated the grade.

0.4 SD. Put differently, if one observes no change in the average achievement of participating students, but there is 10 percent non-participation at the bottom, this would mean that the true decline in the overall population is, in fact, 0.2 SD – the equivalent of somewhere between 60 and 80 percent of an average school year of learning. Put differently, even if *every individual* student lost 0.2 SD, by comparing all students in *t*–1 to only the 90 percent best students in *t*, it looks as if there were no change.

In the Dutch data studied by Engzell, Frey, and Verhagen (2021), there is also substantial non-participation in the test conducted after the Covid-19 school closures. For example, the share of students not participating in the June math test was 1-2 percent in 2017-2020, but 38 percent in 2020 (and even higher in the other subjects). However, the differences-in-differences approach already reduces concerns of substantial attrition bias because it is not identified from the level of achievement of the students participating in each wave, but by the change in their achievement over time. In fact, the differences-in-differences estimates of the achievement loss are substantially larger than an assessment even based on the raw before-after difference – 40 percent larger in math and 400 percent larger in spelling – indicating that estimated effects of the Covid-19 school closures can be strongly biased by changes in the sample composition and other confounders.

Engzell, Frey, and Verhagen (2021) report a series of additional analyses that suggest that it is unlikely that strong attrition bias remains in their differences-in-differences estimates. In particular, results hardly change (1) in a regression analysis that controls for individual-level covariates, which in particular include individual students' achievement in prior years; (2) in analyses that use weighting to balance treatment and comparison years either on the estimated propensity score of treatment or on maximum entropy weights based on rich observables; (3) in a sample restricted to schools where at least 75 percent of students participated in the June test; (4) in specifications with school fixed effects; and (5) in specifications with family fixed effects. By using only variation that is observed between siblings within the same family, this last specification removes many of the most obvious sources of attrition bias.

Other available studies cannot address the problems of cohort effects and attrition bias to the same extent. For example, another important study by Maldonado and de Witte (2021) uses school-level achievement data in a large sample of Catholic schools in Flemish Belgium, where full closures continued for two months followed by partial openings, so that more than a third of the school year was affected by either full or partial closures. While the data cover a large sample of schools, the sample of participating schools is shown not to be representative of the network of Catholic schools or of Flemish schools overall. The authors can compare

achievement of sixth-grade students on a standardized test conducted annually in June in 2020 to the five previous years. Controlling for a vector of school characteristics, their estimates suggest that school average achievement in the 2020 cohort was 0.17 SD lower in math and 0.19 lower in Dutch compared to the previous cohorts. Schools with larger shares of disadvantaged students (low mother's education, high financial support from government) show larger losses, and the inequality in achievement scores increased both within and across schools.

With the data at hand, Maldonado and de Witte (2021) can partly address concerns of bias from cohort effects and school-level attrition, but do not address possible bias from student-level attrition. The test data come in the form of an unbalanced school panel but are not available at the individual level and cannot be linked individually over time. However, in their regression analysis the authors condition on the average achievement of fourth-grade students in the school two years earlier. This substantially reduces the point estimates, indicating that cohort effects would be a serious source of bias if they did not have these data at hand. There is also serious non-participation at the school level, and the authors show that school-level non-participation is clearly non-random in 2020. To partly address this concern, the authors present specifications that (1) restrict the sample to schools that participated throughout and (2) include school fixed effects. In these specifications, estimates remain relatively similar in math, but increase to around 0.3 SD in Dutch. However, there is also extensive individual non-participation within schools, which is not addressed in the analysis. While within-school participation was close to 100 percent in years prior to 2020, 10 percent of students did not participate in the 2020 Dutch test and 60 percent in the 2020 math test (Maldonado and de Witte 2021, p. 20, footnote 2). Considering the above discussion of the potential size of the attrition bias introduced by such extensive non-participation, the Flemish estimates are likely an underestimate of the true extent of learning losses due to the Covid-19 school closures.

The issues of cohort effects and non-participation bias caution against far-reaching interpretations of the results on student achievement tests during or after the Covid-19 school closures presented in a series of additional studies for a number of countries (see Hammerstein et al. 2021 and Zierer 2021 for reviews). For example, Blainey, Hiorns, and Hannay (2020), Schult et al. (2021), Kogan and Lavertu (2021), and Kuhfeld et al. (2021) find lower achievement of tested students in 2020 compared to previous years in England, Baden-Württemberg (Germany), Ohio (United States), and U.S. school districts participating in the NWEA tests, respectively. By contrast, Tomasik, Helbling, and Moser (2021) and Depping et al. (2021) find more mixed evidence for different grades, subjects, or tests in Switzerland and

Hamburg (Germany), respectively, and Gore et al. (2021) find no significant average differences between two samples of schools in New South Wales (Australia) drawn separately in 2019 and 2020. However, the datasets used in these studies generally do not allow for a serious analysis of bias from either cohort effects or non-participation or both, which – based on the previous discussion – is likely to be substantial. Not all studies observe or report non-participation rates, but attrition tends to be substantial in those that do. For example, Kogan and Lavertu (2021) report that participation in Ohio's third-grade ELA assessment declined by 14 percentage points (from 95 to 81 percent) between fall 2019 and fall 2020, and Kuhfeld et al. (2021) report attrition rates of 16-28 percent of students (depending on grade and subject) in the year impacted by Covid-19.

For some of the evidence, there are additional hurdles to drawing conclusions from the available test score performance on the effects of the school closures. For example, the implementation of some tests was postponed, so that they were conducted several months later than in usual years (e.g., Depping et al. 2021). Finding similar performance over the years would therefore imply that students in the cohort affected by the Covid-19 pandemic lost out on learning equivalent to the length of the delay. Furthermore, some tests were graded by students' teachers rather than outside agencies during the pandemic, which may result in additional lenience in the grading. Some other studies are based on diagnostic tests taken at home, and concerns have been raised about the validity of at-home testing. Given the respective datasets and mentioned main concerns, we caution that reported cohort differences in the achievement of tested students are unlikely to provide an unbiased representation of the size of any impact of the Covid-19 school closures on students' academic skills.

Overall, beyond the evidence for the initial closures of Dutch primary schools presented in Engzell, Frey, and Verhagen (2021), our knowledge about the size of the loss in academic achievement due to the Covid-19 school closures is thus very limited. Still, available reviews conclude that overall, the available studies suggest that there are large negative effects of Covid-19-related school closures on student achievement (Hammerstein et al. 2021; Zierer 2021). Furthermore, bias from selective attrition is likely to underestimate the true learning losses in many studies. The literature on student achievement thus corroborates the findings on potential learning losses indicated by the studies of children's time use during this period. In addition, children of lower-educated parents and with lower socio-economic backgrounds seem to be less successful in acquiring the appropriate skills during the period of school closures.

Only time will tell how the initial losses in academic achievement will translate into long-run losses in human capital. First, there is no evidence yet on effects of the continuing school

closures. The large learning losses identified by Engzell, Frey, and Verhagen (2021) refer only to the initial closures of eight weeks. In many countries, extended school closures continued even more than fifteen months after the initial closures. On the one hand, this leads to an expectation of additional learning losses due to the subsequent closures. On the other hand, improved adaptation of schools to the new situation may have reduced any weekly losses, e.g., by replacing passive delivery of problem sets by active online teaching. Clearly, the initial losses of the first eight weeks observed in the Netherlands cannot be extrapolated linearly to the substantially longer closure experiences seen in most countries over the course of the pandemic.

Second, it is unclear to what extent there will be persistence or fade-out of the short-run losses in the longer run as children move through other grades and graduate. The extent to which the initial losses will persist or fade out will also depend on the measures taken by families, schools, and policymakers to help children recoup some or all of their lost learning. It should be noted that some fade-out on subsequent test observations is likely just by the fact that tests in different grades measure different content. Even if learning builds on prior learning, performance on new content will be unlikely to fully picture the skills lost on content covered in previous grades. In fact, a consistent pattern of apparent fade-out of treatment effects on cognitive tests in subsequent years followed by re-emergence of substantial effects on real-life outcomes in later life such as college completion and earnings has been consistently found for several treatments including early childhood education programs (e.g., Heckman, Pinto, and Savelyev 2013), classroom quality in kindergarten (Chetty et al. 2011), and teacher quality (Chetty, Friedman, and Rockoff 2014). This evidence would suggest substantial and consequential persistence of lost skills in adulthood outcomes.[8]

4.2 Digital Skills and Self-Regulated Learning

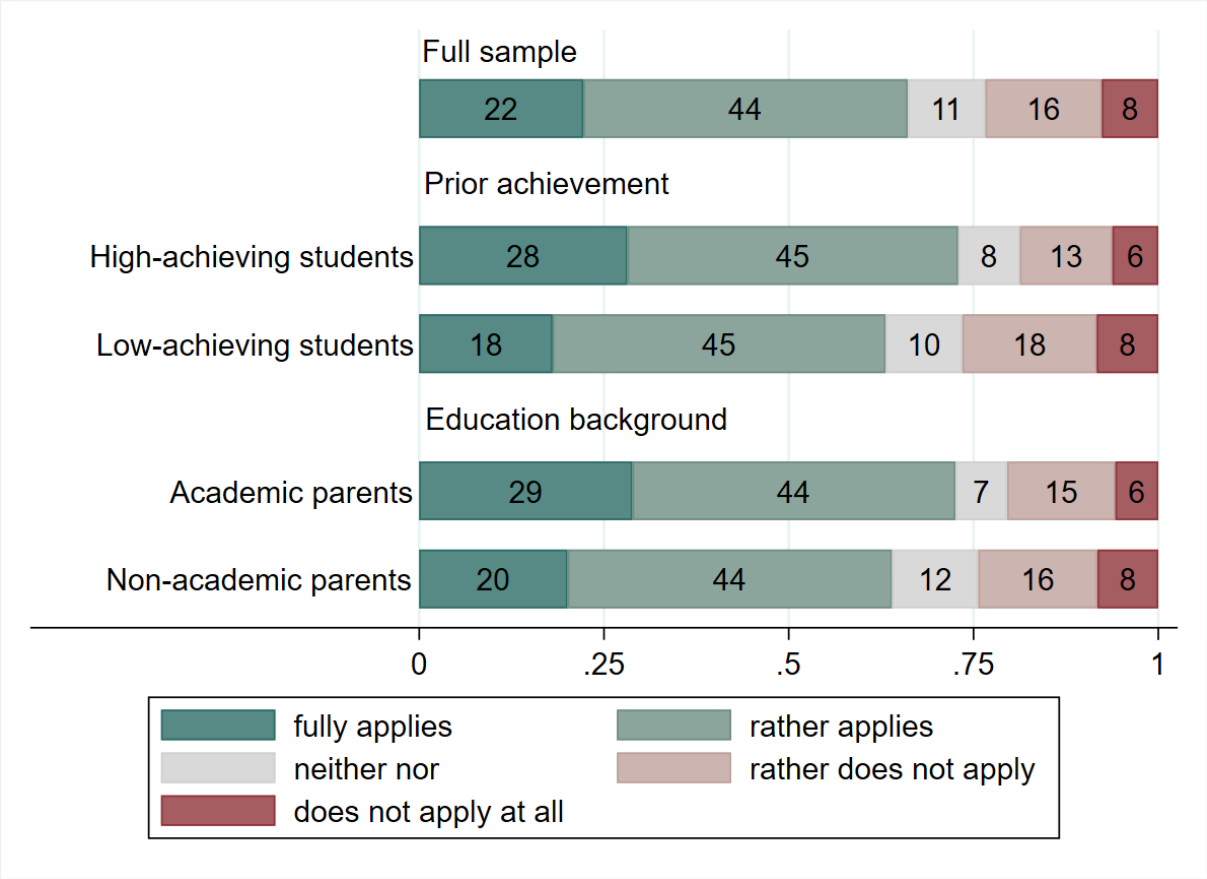
The school closures are likely to affect children's cognitive development beyond their impact on achievement in academic subjects that are part of the school curriculum. Given the

[8] Evidence from case studies of various previous closed-school situations also indicates that long school interruptions have lasting effects that cannot easily be made up for. Persistent effects on later schooling, educational attainment, and earnings have been shown for other types of school closures (see Woessmann 2020 and Annex A of Hanushek and Woessmann 2020 for a short overview) such as strike-induced school closures (Belot and Webbink 2010; Baker 2013; Jaume and Willén 2019), the German "short school years" of the 1960s (Cygan-Rehm 2018; Hampf 2019), and long summer holidays (e.g., Cooper et al. 1996; Alexander, Pitcock, and Boulay 2016). Kuhfeld et al. (2020) provide projections of the potential impact of Covid-19 school closures on student achievement based on estimates from the literature on absenteeism and summer learning patterns. Blaskó, da Costa, and Schnepf (2021) combine estimates of the importance of home and school resources in the TIMSS 2019 pre-pandemic achievement data with countries' school closure duration policies to map the potential consequences of the Covid-19 crisis on learning losses and educational inequalities across European countries.

experiences that students have made during home learning and online schooling, two specific aspects on which there may in fact be positive rather than negative effects are their digital skills and their skills to engage in self-regulated learning. To provide some indication of the potential relevance of these effects, we collected additional data on parental assessments of these dimensions in the second wave of our German survey in early 2021 (see section 3.1 above). In terms of digital skills, the German experience may be somewhat specific compared to many other countries, as Germany substantially lagged other countries in the classroom usage of digital technologies prior to the pandemic (e.g., Beblavý et al., 2019; Fraillon et al., 2020).

For most students, the Covid-19 school closures implied an increase in digital learning experiences. For some students, teaching experiences went online with video lessons. Others would at least receive and submit exercise sheets online. Mostly as a matter of learning by doing, these experiences may have improved the digital skills of students. And indeed, 66 percent of parents in our German survey agree with the statement that through the school closures, their child has learned to better handle digital technologies, e.g., computers, tablets, and the internet (see Figure 5). Only 23 percent of parents think that this does not apply. However, there is significant heterogeneity in the answer pattern: Parents of low-achieving students are 10 percentage points less likely to report improved digital skills than parents of high-achieving students. Similarly, there is a difference of 9 percentage points between children of academic and non-academic parents.

Figure 5: Parental assessment of effect of school closures on children's digital skills

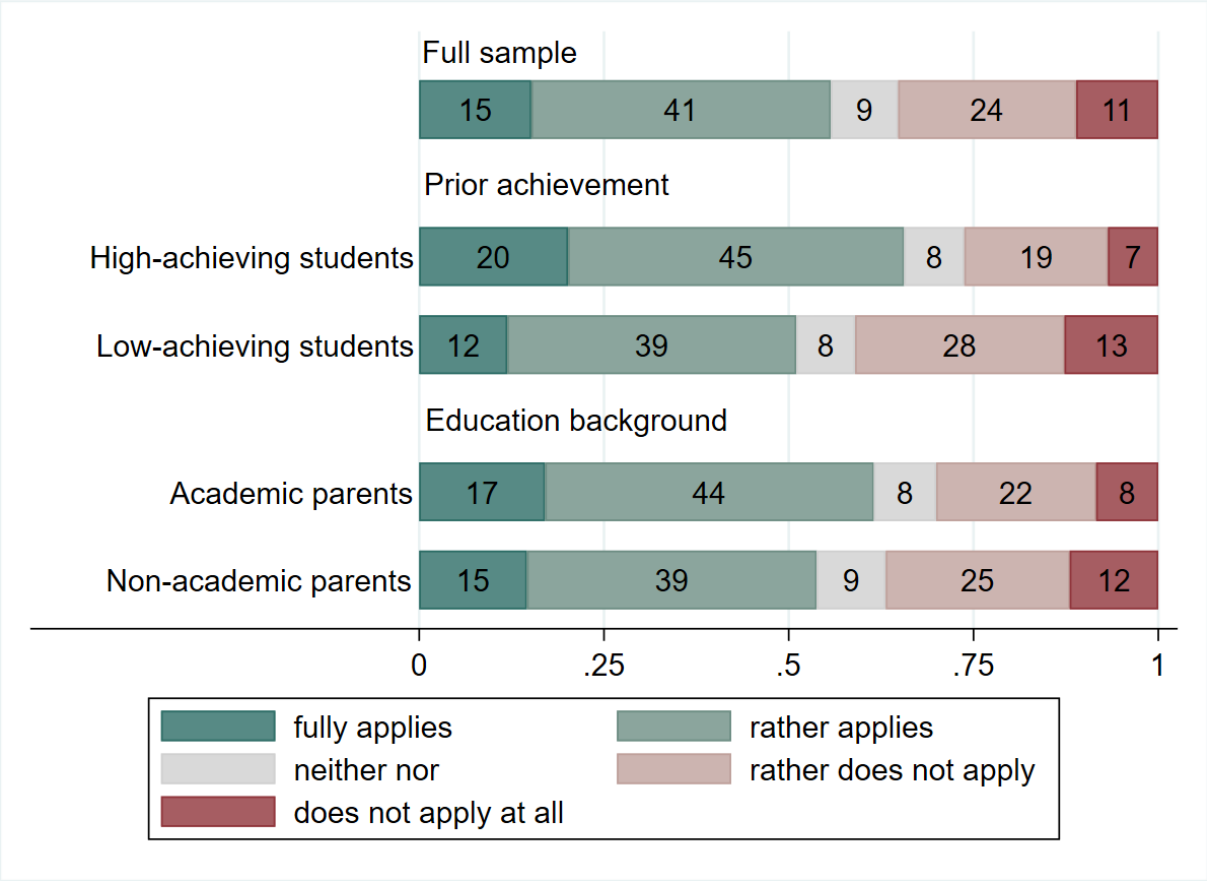


Notes: Parental assessment of the statement, "Through the school closures, my child has learned to better handle digital technologies (e.g., computer, tablet, internet)." Sample: Parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

As discussed in sections 2.4 and 3.2 above, the ability of students to engage in self-regulated learning is a key feature that moderates the effect of school closures on students' learning. In turn, however, the ability for self-regulated learning may itself have been expanded by the experiences during the Covid-19 school closures. At least for some students, the process of having to structure, organize, and conduct their own learning at home may have taught them how to better regulate their learning in the future. And indeed, more than half of parents (56 percent) in our German survey agree with the statement that through the school closures, their child has learned to independently acquire course material (see Figure 6). At the same time, more than a third (35 percent) disagree with the statement, indicating that there is substantial heterogeneity in the extent to which students have gained self-regulated learning skills during the school closures. There is a particularly strong gap along the prior-achievement dimension:

low-achieving students are 15 percentage points less likely to be reported to have acquired self-regulated learning skills than high-achieving students. These differences in skill acquisition are likely to exacerbate differences in learning trajectories in the future.

Figure 6: Parental assessment of effect of school closures on children's self-regulated learning skills



Notes: Parental assessment of the statement, "Through the school closures, my child has learned to work out subject matter independently." Sample: Parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

It remains to be seen to what extent the parental assessments of the extent to which the experience of the school closures furthered their children's digital and self-regulated learning skills will materialize in observable skill development and objective measures of these skills. Furthermore, compared to basic academic skills, much less is known about the importance of these skills for students' later labor-market outcomes. Thus, it is hard to predict how these skills

will affect long-run outcomes such as employability and earnings and to what extent they may counteract some of the negative effects expected from the loss in basic academic skills.

5. Children's Socio-Emotional Development

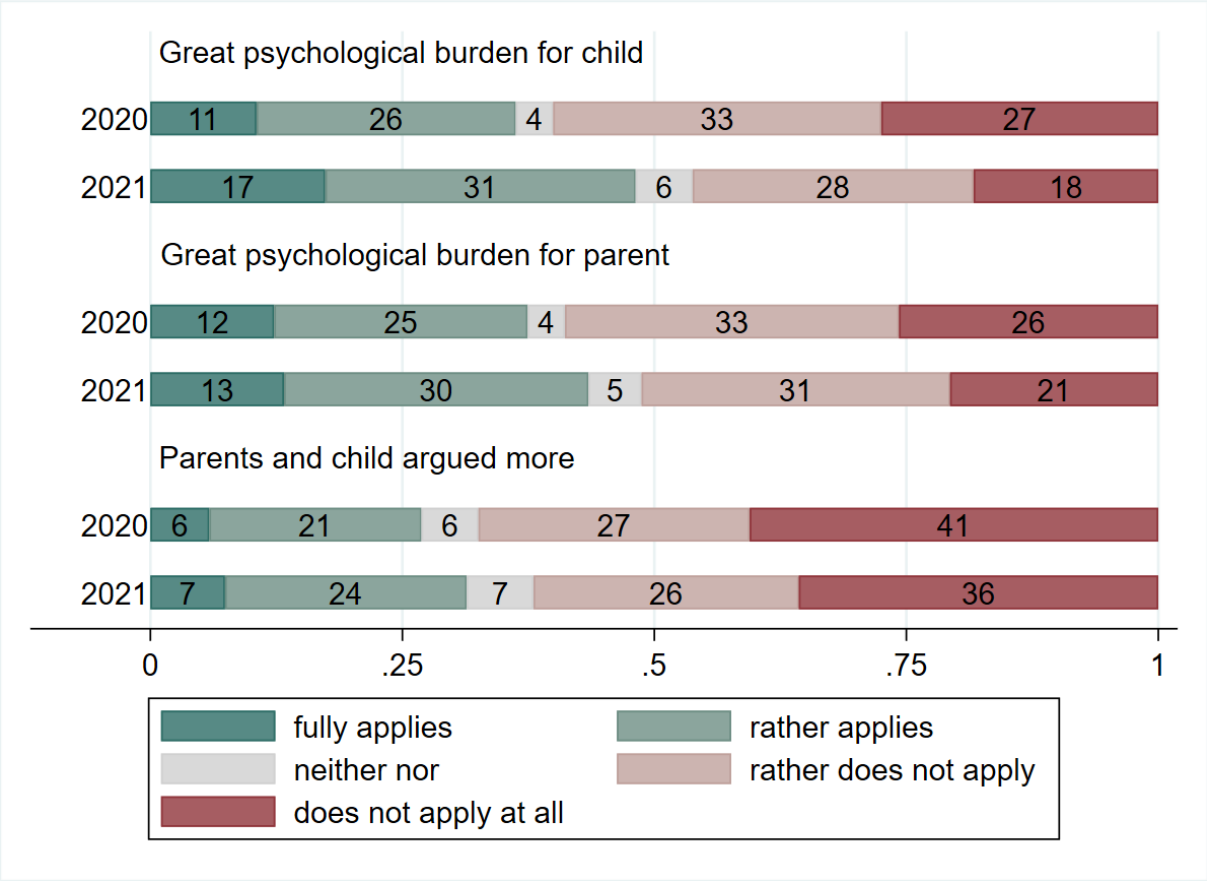
In most countries, the key strategy to control the spread of the virus – and the main aim of closing schools – was to isolate students, teachers, and parents at home and limit social interactions as much as possible. Beyond the effects on the cognitive skills and learning of the affected children, much concern has therefore been on the possible detrimental effects that such forced isolation of households might have on the socio-emotional development of children. In this section, we report evidence on this question from our German parental surveys (section 5.1) as well as from other studies (section 5.2).

5.1 Evidence on Socio-Emotional Development from the German Surveys

The two waves of our parental surveys contained a few questionnaire items on the psychological and social situation of the school children in Germany. Thus, we can again take advantage of the panel structure of the surveys to shed some light on the development of socio-emotional wellbeing during the two periods of school closures. In most parts of Germany, social distancing rules introduced massive restrictions on children, requiring the closure of public playgrounds, severely restricting meeting with friends, and prohibiting the operation of sports clubs, youth groups, and the like during the extensive lockdown periods.

A short questionnaire item elicited how parents assess the psychological situation of their child during the school closures. In the first period of school closures in spring 2020, 36 percent of respondents agreed with the statement that the situation during the school closures was a "great psychological burden" for their child (see Figure 7). This share increased to 48 percent during the second period of school closures in early 2021, indicating that the repeated closures had an important fatigue effect.

Figure 7: Parental assessment of psychological burden during the two phases of school closures in Germany



Notes: Parental assessment of the following statements: "The situation during the school closures was a great psychological burden for my child." "The phase of school closures was a great psychological burden for me." "I argued more than usual with my child during the school closures." Sample: Parents participating in both survey waves (see Appendix Table A1 for details). Source: Own calculations based on ifo Education Survey 2020 and second German parental time-use survey 2021.

A similar pattern emerges when parents are asked to assess the psychological burden of the school closures for themselves. In early 2021, 43 percent of parents considered the school closures to be a great psychological burden for themselves, up from 37 percent in spring 2020. In addition, 31 percent of parents reported during the second period of school closures that they argued more with their child compared to usual times, a slight increase from the 27 percent during the first period of school closures.

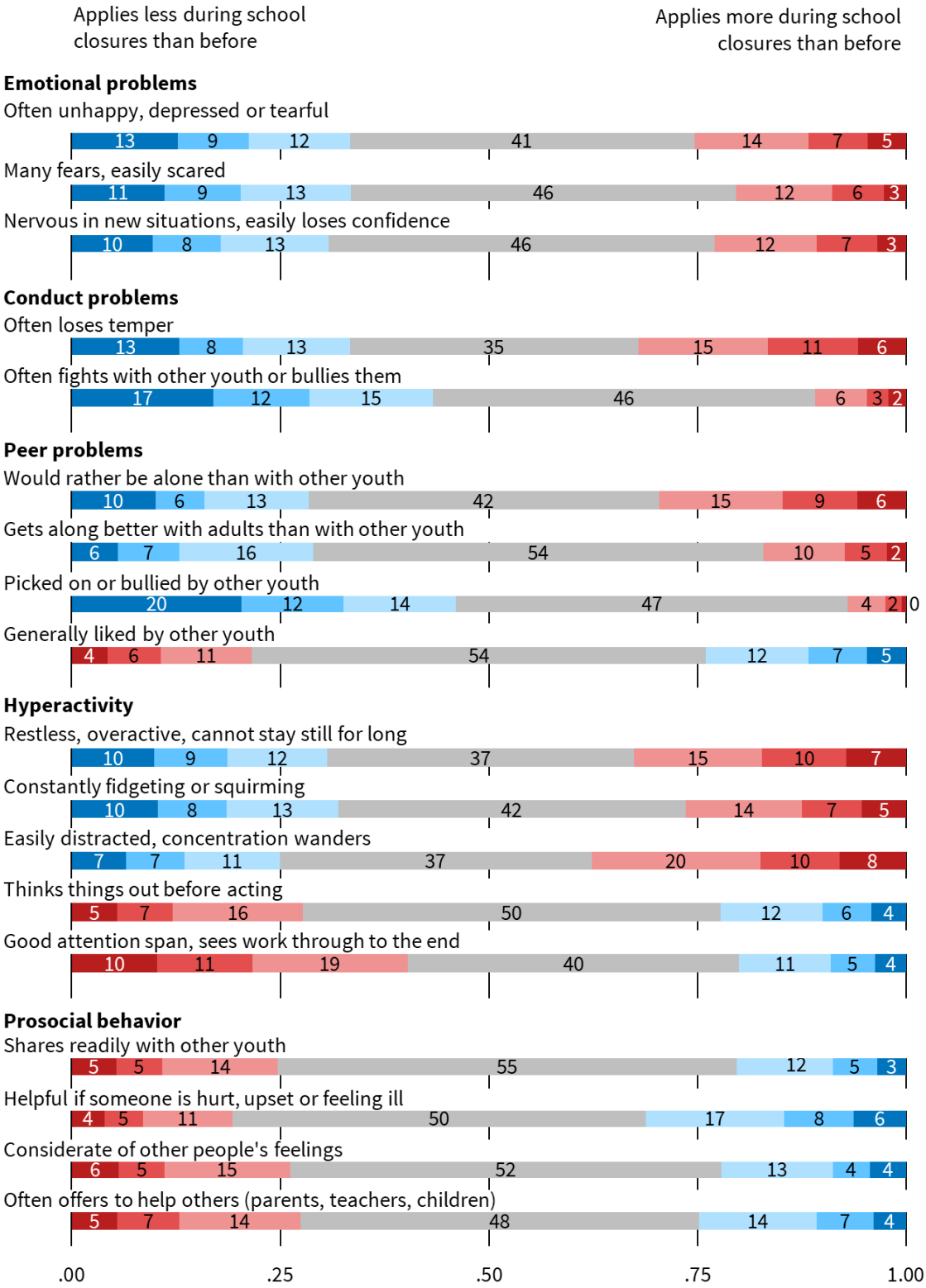
To obtain a richer picture of the children's socio-emotional wellbeing during the school closures, in the second survey wave in early 2021 we included items from the Strength and Difficulties Questionnaire (SDQ, see Goodman 1997; Schupp, Spieß, and Wagner 2008). The SDQ items are developed to pick up potential issues in children and cover emotional problems,

conduct problems, peer interactions, hyperactivity, and prosocial behavior. In a slight adaptation, we ask parents to rate whether each statement applied to their child more or less during the period of school closures compared to the time before the pandemic.[9]

Results provide a mixed pattern on the impact of the school closures on children's socio-emotional wellbeing. Among the answer categories on the seven-point Likert scale, the middle category that suggests no change is always the largest one, making up between 35 and 55 percent on the different items (see Figure 8). Of those parents who report changes in their child's behavior during the period of the school closures, for many measures the number of children whose socio-emotional wellbeing improved is similar to those where it deteriorated, indicating substantial heterogeneity in the impact of the school closures on individual children's socio-emotional wellbeing. For instance, 25 percent of parents report that their child was more often in a down mood or likely to cry frequently during the school closures, while 33 percent of parents state that this was less likely to be the case. The remaining 41 percent of parents did not observe a difference in their child's behavior on this dimension. Similarly, some children showed better prosocial behavior during the period of school closures, while other parents observed an increase in problematic behavior in this area.

[9] A random split of the sample received this version of the SDQ battery. The other split received a standard version of the SDQ that asks about the children's socio-emotional wellbeing at the time of the questionnaire in levels, with qualitatively very similar result patterns (see Woessmann et al. 2021, Figure 14).

Figure 8: Parental assessment of change in children's socio-emotional wellbeing during the school closures



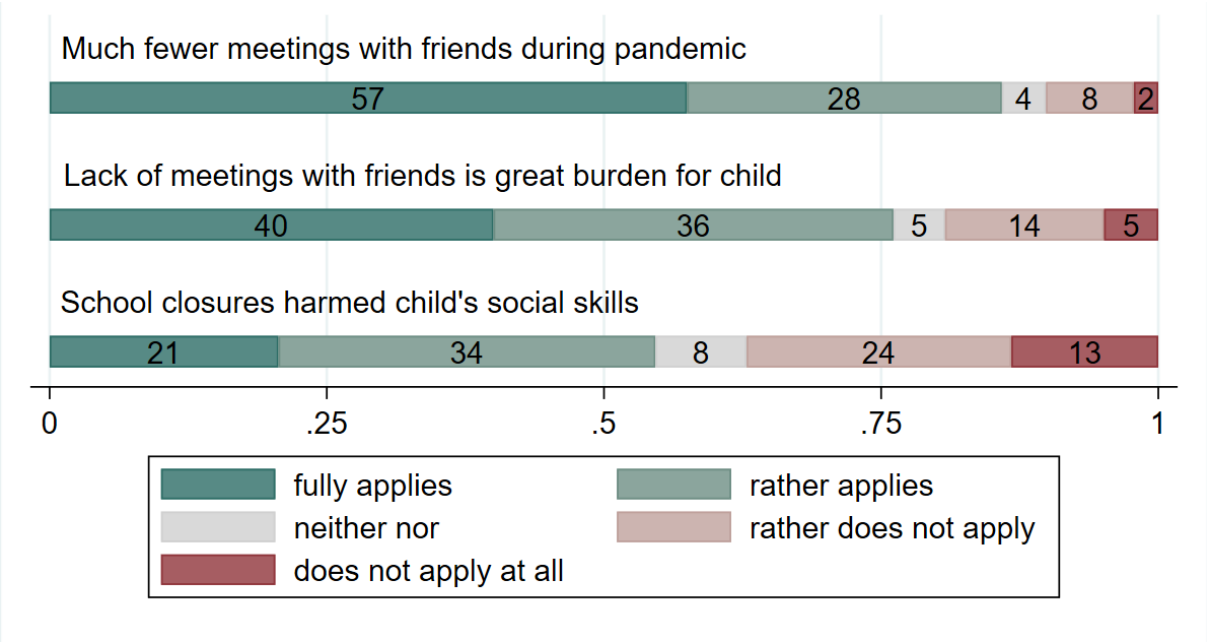
Notes: Parental response to the question, "To what extent do these statements apply or not apply to your youngest school-age child? In answering, please compare your child's behavior before the Covid-19 pandemic with your child's behavior during the several weeks of Covid-19-related school closures in early 2021." Seven-point Likert scales. In the figure, response categories are arranged in each case so that blue reflects positive responses and red reflects negative responses. Sample: Random subset of parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

Two features stand out among the otherwise generally similar pattern of results across the individual SDQ items. First, there are two items referring to the ability to concentrate, closely related to our discussion of self-regulated learning above. In both cases, around 40 percent of parents note a deterioration compared to before the pandemic. The fact that these items on a lack in concentration show the largest shares of deterioration among the different items further corroborates the finding reported in sections 3.2 and 4.2 above that a substantial share of children struggles to successfully self-regulate their learning at home.

Second, the two items with the most positive overall development are items referring to a reduction in bullying, both in the active and passive form. For example, only 7 percent of parents report an increase in the likelihood that their child is picked on or bullied by other children, whereas 46 percent say that this is less likely to be the case during school closures. These results indicate that the move of the learning environment from schools to homes may in fact have had a positive effect on the socio-emotional wellbeing for the subgroup of students who have strong problems with peers and are often bullied. This pattern that the discontinuation of in-person interaction during the Covid-19 pandemic disrupted school bullying and cyberbullying has also been highlighted by Bacher-Hicks, Goodman, and Mulhern (2021b) using U.S. data on Google internet searches.

Finally, we included a few questionnaire items on the effect of the pandemic on social interactions and the development of the social skills of the children in the second survey wave. According to the parents, 86 percent of children met significantly less often with their friends during the pandemic (see Figure 9). Three quarters of parents (76 percent) agree with the statement that it is a great burden for their child not to be able to meet friends as usual during the pandemic. Asked directly about the effect of the school closures on the development of the social skills of their children, 55 percent of parents report that the school closures have harmed their child’s social skills.

Figure 9: Parental assessment of effect of school closures on children's social skills



Notes: Parental assessment of the following statements: "My child meets with friends much less often during the Covid-19 pandemic than before." "It is a great burden for my child not to be able to meet friends as usual during the Covid-19 pandemic." "The school closures have harmed my child's social skills." Sample: Parents participating in the second survey wave (see Appendix Table A1 for details). Source: Own calculations based on second German parental time-use survey 2021.

Overall, the evidence from our German parental surveys provides a mixed picture of the effect of the school closures on children's socio-emotional wellbeing during the pandemic. The situation was clearly a huge psychological burden for many children and families, and most children suffered from the reduction in social interactions with peers.[10] Still, the majority of children may in the end prove quite resilient to the situation, with most parents reporting no change in most dimensions of their child's socio-emotional wellbeing during the school closures and some even reporting improvements. However, there is substantial heterogeneity across families, and some children seem quite prone to negative developments in their socio-emotional wellbeing. Even more than with the previous findings on cognitive development, this highlights the challenge to design targeted support for children most adversely affected by the pandemic.

[10] The school closures might also have affected the children's physical health, for example through a reduction in sport club attendance or a lack of similar activities. In our German parental survey, 31 percent of parents report that their child gained body weight during the Covid-19 pandemic, e.g., due to lack of exercise.

5.2 Further Evidence on Socio-Emotional Skills

The concern that the school closures and the forced isolation during the lockdowns more generally might have detrimental effects on children's socio-emotional development has been widely shared. A number of studies attempt to quantify the effects of the Covid-19 pandemic on the mental health, psychological wellbeing, and behavioral issues of children and adolescents. Another aim shared by many of these studies, especially during the early period of school closures, is to identify the most severely affected groups of children to allow for prompt targeted interventions for those most vulnerable (Golberstein, Wen, and Miller 2020).

There are two main hurdles facing studies that attempt to assess the impact of the school closures on the socio-emotional development of those affected. First, as is the case for our German surveys, many of the studies available so far rely on self- or parent-reported survey data. In this review, we therefore focus on facets of mental health such as depression, anxiety, and psychosomatic complaints, rather than clinical pathologies (Ravens-Sieberer et al. 2021b).[11] Second, many of the studies that exist to date have to rely on sampling strategies that focus on a narrow subset of the population, for example students in a specific region (e.g., Kaman et al. 2021; Shanahan et al. 2020) or snowball samples (e.g., Orgilés et al. 2020; Waite et al. 2021; Champeaux et al. 2020).

An exception to the second concern is the study by Ravens-Sieberer et al. (2021a, 2021b) conducted on a representative sample of families in Germany. Importantly, the study includes a longitudinal element that allows some indication of how the socio-emotional wellbeing of students changed as the pandemic progressed. The authors show that in spring 2020, children and adolescents scored substantially lower on survey instruments measuring mental health and wellbeing compared to cohorts surveyed before the pandemic. In addition, they document in a second wave that emotional problems, peer problems, and indicators of poor mental health further deteriorated by the end of 2020 and beginning of 2021. Children from socially disadvantaged backgrounds – for example, families with a migration background, lower parental education, or single-parent households – were more at risk of experiencing negative effects.

The available evidence from cross-sectional studies is in line with these conclusions. While the multitude of sampling heterogeneity and variety in the measurement of outcomes hampers comparability across different studies (Meherali et al. 2021; Ravens-Sieberer et al. 2021b),

[11] A complementary approach is to focus on the likely effects of the pandemic on the incidence of highly destructive experiences including child maltreatment (Baron, Goldstein, and Wallace 2020) and domestic violence (Ravindran and Shah 2021).

consistent evidence from a range of countries points toward higher rates of anxiety, depression, and stress among adolescents due to the pandemic (Jones, Mitra, and Bhuiyan 2021). Furthermore, the literature documents a number of characteristics and circumstances that correlate with the deterioration in the socio-emotional wellbeing of students. Consistently, students from disadvantaged backgrounds are found to be more at risk of experiencing socio-emotional issues. In addition, evidence from a U.K. household survey suggests that girls seem to be more affected by the negative short-term effects of the lockdowns than boys (Mendolia, Suziedelyte, and Zhu 2021). Furthermore, worse mental health outcomes tend to be correlated with the time that students spend on passive screen activities (Champeaux et al. 2020) and on social media (Biroli et al. 2020).

One of the defining features of the Covid-19 pandemic is that in many countries, the measures necessary to contain the health crisis quickly triggered an economic and social crisis. Indeed, in a longitudinal analysis of young adults in the city of Zurich, Switzerland, Shanahan et al. (2020) argue that the presence of pre-pandemic stressors and pandemic-related life shocks such as economic and labor-market consequences account for more of the deterioration in socio-emotional wellbeing than health-related concerns. This is consistent with emerging evidence that re-establishing social connections, even in digital formats, effectively mitigated some of the detrimental effects of the school closures. For example, leveraging longitudinal survey evidence from the U.K., Blanden et al. (2021) show that students in grade levels that were not prioritized to return to school reported more difficulties on the SDQ measure of mental wellbeing compared to students who were likely to return to school sooner. Similarly, in a study of middle-school students in Italy, Carlana and La Ferrara (2021) find that an intervention that randomly assigned online tutoring to selected students improved students' happiness and lowered the incidence of depressed moods.

The key open question remains to what extent children and adolescents will be able to recover from the socio-emotional implications of the lockdowns and the associated school closures in the medium to long term. While some studies that are able to track student outcomes over time report slight improvements in socio-emotional wellbeing when restrictions are lifted, they are cautious not to draw overoptimistic conclusions (Blanden et al. 2021; Meherali et al. 2021). A related concern is that there could be sensitive or critical periods of socio-emotional development, and children exposed to a negative shock in such a sensitive period might experience a persistent shift in their mental health (see our conceptual framework in section 2.4). However, evidence from past disasters shows that in many cases, the majority of youth exposed to negative shocks is able to recover well within a number of years (Bonanno et al.

2010). It thus remains to be seen to what degree transient experiences of worse mental wellbeing will persist into long-term behavioral issues.[12]

6. Structural Models of School and Family Effects

In the following two sections, we turn to longer-term implications of the school closures. To study potential effects that lie in the future, the literature has reverted to structural models (section 6) and projection models (section 7).

Three complementary papers use theoretical models of the production of human capital, calibrated to match relevant parameters in real-world data, to study the persistent effects of the Covid-19 school closures on the affected students' skill formation, their lifetime income, and macroeconomic output in the long run, respectively. The papers model different inputs, mechanisms, and outcomes, and they are particularly interesting and relevant to further our understanding of the various mechanisms and behavioral responses that may give rise to the overall reduced-form effects of school closures. All three papers have a particular focus on the distributional effects of school closures.

Obviously, such quantitative structural models cannot cover all the elements discussed narratively in our conceptual framework using a general education production function (section 2), as they have to simplify and rely on specific assumptions of relationships, functional forms, and parameterization to be tractable. Somewhat surprisingly given the nature of what Covid-19 school closures are about, though, none of the studies directly models the behavior of the children themselves, including their effort investment in the learning process when schools are closed. The quantitative bearing of the various approaches should always be interpreted with an awareness of the specific assumptions and parameter choices, imposed functional forms, and other choices made in the modeling. For example, a lot will depend on whether the shock of the Covid-19 school closures is modeled as a shock to acquired skills – the approach taken in this paper – or whether it is modeled as a shock to public educational spending.[13] Here, we therefore

[12] For example, it has been hypothesized that worse mental health might increase the risk of substance abuse disorders in adolescents, which would lead to a long-term negative effect on socio-emotional wellbeing. While some suggestive evidence exists, further research is needed to better understand whether there is a meaningful relationship (Bonanno et al. 2010; Jones, Mitra, and Bhuiyan 2021).

[13] Different results based on these approaches would be consistent with broad evidence in the literature that educational expenditures do not systematically raise student skills on a broad basis (e.g., Woessmann 2016a; Hanushek 2020) and that skills are strongly related to income and growth, whereas educational expenditure and attainment measures are less clearly associated with aggregate economic outcomes (e.g., Hanushek and Woessmann 2015, 2016). The available evidence discussed above suggests that the Covid-19 shock may be better thought of as a shock to skill development rather than to reduced public investment.

focus on describing the main ingredients of the models as they relate to our conceptual framework above.

To study how school closures affect the skill acquisition of adolescents, Agostinelli et al. (2021) provide a structural model of skill formation that models three channels: the move from in-person schools to online education, changed peers, and parental responses during the pandemic. First, there is a direct impact of lower productivity of the learning technology of virtual instead of in-person schooling. Second, children from low-income families in particular lose some positive peer interactions when the peer environment is moved from the school to the neighborhood of residence. Third, partly due to differences in the ability to work from home, low-income parents are more constrained in helping their children during remote learning. In their quantitative analysis, the authors calibrate the learning shock described in their model to the learning loss estimated by Maldonado and de Witte (2021) on Belgian data (see section 4.1 above), assuming that model parameters revert to prior levels after a Covid-19 shock that lasts for one school year. Most other parameters are chosen to match statistics observed in U.S. data. In their calibration, there are very large skill losses for children in poor neighborhoods, whereas children in the richest neighborhoods experience almost no losses. As a consequence, school closures substantially increase educational inequality. All three channels contribute to the result, but the peer mechanism turns out to be the strongest in their calibration. While the shock is temporary, the loss in skills persists because of the dynamics of children's skill formation, but also because of peer and parental responses.

Fuchs-Schündeln et al. (2021) use a two-generation life-cycle model to study the long-term effects of the Covid-19 school closures on educational attainment, lifetime earnings, and welfare. In their model, public investment, parental monetary investment, and parental time are the relevant inputs in the education production function. The educational output modeled is whether affected children later acquire a high-school or college degree. The paper models Covid-19 school closures as a reduction in public investment equivalent to a half-year reduction in schooling. In the model, this effect is mitigated by increased parental investments as parents endogenously react to the shock by increasing their time investment and inter-vivo transfers to their children. (In a model extension, parents also experience a negative income shock due to the Covid-19 recession, but that effect is negligible.) When parameterized to U.S. household data, the model implies that despite the mitigating parental adjustments, there are significant reductions in affected children's future likelihood to obtain high-school and college degrees, discounted lifetime earnings, and welfare. Due to self-productivity and dynamic complementarities in the education production process, losses are most pronounced among

younger children. They are also larger for children with poorer parents, implying adverse distributional effects.

Jang and Yum (2020) turn to the long-term macroeconomic implications of school closures for aggregate output and intergenerational mobility. They use a dynastic overlapping-generations general-equilibrium model with several features similar to the model by Fuchs-Schündeln et al. (2021): public investments and parental monetary and time investments are the inputs; school closures are represented by a reduction in public investment according to the closure length (one academic year in their baseline case); heterogeneous parental responses mitigate the reduced public investment to different extents; and the model is calibrated to the U.S. economy. Their calibrated model implies moderate negative effects on aggregate output that last for many decades, whereas effects on college attainment and cross-sectional inequality are negligible. General equilibrium effects such as price adjustments play an important role for the results. Furthermore, the model predicts a reduction in intergenerational mobility. In contrast to Fuchs-Schündeln et al. (2021), effects in their model are strongest for older children, as younger children tend to recover more during their remaining time in school. Interestingly, the authors show that the elasticity of substitution between public and parental inputs is a key parameter in the model: While the baseline calibration assumes that public and parental investments are highly substitutable (which they argue may be relevant for the U.S. and East Asian countries), they show that a lower substitutability (which they argue may be more relevant, e.g., in Scandinavian countries) generates a substantially larger reduction in aggregate output, but a lower reduction in intergenerational mobility.

7. Projections of Economic Outcomes

All analyses so far suggest that Covid-19 will leave the affected students with a profound legacy of losses in skill development. Such skill losses are likely to have substantial economic impact in the long run. The skills that people acquire through education make them more productive at carrying out their work tasks, particularly in modern knowledge-based economies (e.g., Woessmann 2016b). The acquired skills also enable people to generate and apply new ideas and innovations that foster technological progress and overall economic growth. A couple of studies use reduced-form estimates of the economic value of skills acquired in school to project out the economic effects of the lost human capital due to the Covid-19 school closures on future wages (section 7.1) and economic growth (section 7.2). These projections provide a sense of the potential long-run economic legacy of the Covid-19 effects in education.

7.1 The Impact of Covid-19 Learning Losses on Individual Income

Hanushek and Woessmann (2020) use estimates of the association between cognitive skills and earned income to quantify the economic impact of Covid-19 learning losses. While not necessarily capturing income effects of potential losses in other skill domains such as social and emotional skills, quantitative estimates of the income effects of cognitive skills are more readily available. There are two approaches used in the literature to estimate the cognitive skills-income relationship. The first approach is to measure the skills of students towards the end of high school and then follow these students into the labor market, allowing to estimate the association between the skills measured at school age and later income during early years of employment. The second approach is to survey the cognitive skills of adults in order to directly investigate the association of these skills with current income in the labor market for all age groups. Overall, studies of the two approaches tend to come to very similar conclusions. Hanushek and Woessmann (2020) employ estimates of the second approach applied to data from the OECD's Survey of Adult Skills (PIAAC) which surveyed the literacy and numeracy skills of representative samples of the population aged 16 to 65 in 32 countries (Hanushek et al. 2015; Hampf, Wiederhold, and Woessmann 2017).

Using the estimates of average returns to skills across the participating countries, Hanushek and Woessmann (2020) suggest that students who lose the equivalent of one-third of a school year's learning would on average suffer 2.6 percent loss in income over their working life. Losing the equivalent of two-thirds or even an entire school year would correspondingly imply 5.2 percent or 7.7 percent lost lifetime income, respectively. As the returns to skills differ across the labor markets of different countries – ranging from the lowest returns in Greece to the highest in Singapore in the PIAAC sample – so do the respective estimates of the lost individual income due to the Covid-19-induced learning losses in the different countries.

The big question is the magnitude of the learning losses that might have accumulated after the school closures. The Dutch estimates in Engzell, Frey, and Verhagen (2021) which suggest that eight weeks of school closures led to skill losses equivalent to one-fifth of a school year (see section 4.1 above) would imply that average learning losses are equivalent to the time period that schools remained closed. However, these numbers cannot be easily extrapolated to the substantially longer closure experiences seen in most countries by now. Furthermore, it is unclear to what extent these estimates generalize to other countries, although Engzell, Frey, and Verhagen (2021) suggest that losses may be even larger in other countries because the Netherlands has an unmatched broadband infrastructure for online schooling. Furthermore,

their results indicate that losses are substantially larger for children from low-SES families, suggesting that the expected income losses will be equivalently larger for this subpopulation. In any case, the projections suggest that the income losses due to the Covid-19 school closures can clearly be large unless the learning losses are effectively remediated.

Interestingly, Psacharopoulos et al. (2021) come to surprisingly similar results using an approach that resorts to years of schooling rather than measured skills. Based on prior research on the returns to years of schooling, their projections assume that a year of schooling leads to 8 percent higher future earnings – very similar to what would be implied by the returns to skills used in the projections by Hanushek and Woessmann (2020). Psacharopoulos et al. (2021) provide estimates of the global income losses due to the school closures, covering over 200 countries and different levels of education. Again, the estimated losses in future lifetime income accrued by current students are significant.[14]

7.2 The Impact of Covid-19 Learning Losses on GDP Growth

Beyond the loss in individual income, Hanushek and Woessmann (2020) also provide projections of the loss for the economy as a whole. Given the importance of education for technological change and economic growth, the full impact on the gross domestic product (GDP) may well exceed the sum of the individual income losses. In fact, prior research shows that the basic cognitive skills of the population, as measured by international student achievement tests in math and science, are a crucial determinant of long-term economic growth and thus of the long-term prosperity of a society (Hanushek and Woessmann 2015, 2016).

Hanushek and Woessmann (2020) use these results on the relationship between measured skills and economic growth to calculate projections of the macroeconomic costs of learning losses. Assuming that only the cohorts currently in school are affected by the closures and that subsequent cohorts resume to normal schooling, their estimates are based on a comparison of the GDP expected over the remainder of the century with the given learning losses versus that without such losses.

In these projections, a learning loss equivalent to one-third of a school year for the current student cohort is estimated according to the historical growth relationships to be 1.5 percent lower GDP on average for the remainder of the century. The present value of the total cost would amount to 69 percent of current annual GDP for the typical country. The macroeconomic

[14] Hanushek and Woessmann (2020) also discuss this kind of estimates based on the association of years of schooling and earned income. Similar simulations for a large set of countries are also provided in Azevedo et al. (2020).

cost of larger learning losses would be commensurately larger. Hanushek and Woessmann (2020) provide dollar estimates of the aggregate losses in GDP for the G20 countries. While the reduced growth from the loss of skills among current students will only emerge in the long term, the macroeconomic losses can eventually assume an enormous magnitude.[15]

8. Policy Conclusions

The evidence available so far suggests that children suffered severely from the Covid-19 school closures and other lockdown measures. The cognitive and socio-emotional development of many children has been seriously impeded, but these impediments are strongly heterogeneous across children. Because child development is a dynamic and synergistic process, many of these losses will have long-term repercussions. The evidence surveyed in this paper clearly requires the conclusion that overall, there will be a strong persistent legacy of Covid-19 in education. The economic losses of the reduced skill development will be substantial if remediation fails.

The evidence suggests that one should expect substantial losses in the development of cognitive skills. Average learning losses were enormous during the first phase of school closures. Even if the panel dimension of our time-use surveys suggests that there was at least a modest rebound in learning time during the second school lockdown, skill losses are likely to grow with extended closure periods. These losses in academic skills will be highly unequal: Children from low-SES families and children with low initial achievement are likely to be hit much more severely on average than their more advantaged counterparts. The repercussions of the Covid-19 school closures are therefore likely to exacerbate future educational and economic inequality.

[15] Quantitatively, these reduced-form estimates are substantially larger than the long-term macroeconomic effects modelled in the structural model by Jang and Yum (2020). While many modeling choices play into this difference, two main reasons are likely to be important. First, the structural model is not calibrated to match the effect of skills on growth, but rather stationary-equilibrium features of educational investment in U.S. data. While this is considerably more sophisticated and aims to depict several assumed relationships and parameters in the economy, it leads to a model calibration that predicts neither the school closure-skill nexus nor the skill-growth nexus well. On the authors' own account, in their model a 0.5-year school closure predicts a loss in human capital that is slightly smaller than the loss in skills estimated by Engzell, Frey, and Verhagen (2021) for a 0.2-year school closure (see section 4.1) – an underprediction by a factor of more than 2.5. Second, the overlapping generations framework does not model the core feature of endogenous growth models that human capital affects the long-run rate of economic growth by increasing the innovative capacity of the economy through developing new ideas and new technologies and thus raising the rate of technological change (e.g., Romer 1990; Aghion and Howitt 1998). While the reduced-form projections are much more simplistic than the structural model, they do in fact capture important features of the structural model such as endogenous parental responses (captured in the observed achievement data) and macroeconomic general equilibrium effects (captured in the observed long-run skill-growth relations) to the extent that they are in fact at play in the real-world data underlying the empirical skill and growth analyses. A limitation of projections from past experiences is that the pandemic is global, which may give rise to different general equilibrium effects whose quantitative size is hard to predict.

With its major restrictions, the Covid-19 pandemic clearly also interfered with the socio-emotional development of many children. What this means for the long-run development of the socio-emotional skills of the affected cohorts is less clear. The situation of the school closures and restrictions to social interactions was a real burden for many children. But if children in general prove as resilient to the Covid-19 situation as to previous crises, serious medium- to long-term damage to the psychological development may be restricted to a limited subgroup of children. With respect to the loss of social interactions during extended periods of time, it remains to be seen whether certain phases of development, for example, during teenage years turn out to be sensitive or even critical for the long-run development of social skills in broader parts of the affected cohorts.

Importantly, the long-term legacy will also depend on the policy responses that countries take in the coming years. Depending on the measures taken, students will or will not be able to recoup some of the lost learning. Given the unequal pandemic experience of different groups of children, the chosen measures should have a particular focus on the identified at-risk students. Part of the measures should be directed at equipping children with self-regulated learning skills that would allow them to better get through any phases of school closures that may occur in the future. Even if possibly limited in size, the group of students whose psychological development is severely impacted requires particular help. To document some of the options at hand, we close with a discussion of possible implications of our current state of knowledge for policies to alleviate the negative effects of the pandemic on the level and inequality of children's skill development. Most likely, there is no silver bullet that is able to solve all problems at once, particularly when addressing the needs of disadvantaged students. Therefore, governments should use strategies that combine various interventions and approaches to help make up for the lost development of children in the various dimensions. While some of the policy options clearly require additional funding, it seems likely that the costs of most policy measures that effectively mitigate the educational legacy of Covid-19 are easily outweighed by their long-term economic gains.

In designing policy responses, policymakers should be aware that successful strategies will hinge on the concurrent support by children and families. A crucial feature of the educational production process is that it inevitably requires complementary inputs on part of the person who is to accumulate the knowledge. Unless students contribute time and effort into the learning process, human capital cannot be produced. The children's choices on which activities to spend their time will affect their overall development. Likewise, the extent and quality of children's time investments will depend on the support and encouragement they receive at home.

Successful policy measures therefore require the support of the children and will be helped substantially if they are accompanied by support from the parents.

In the short term, a key lesson from the pandemic is that school closures should be avoided whenever possible. They carry huge costs for the affected children. Closing schools should therefore be the last measure of resort after other measures – which may put greater burden on adults than on children – have been exhausted. If school closures are unavoidable, the responsible policymakers and administrators should make it mandatory that schools implement universal daily online lessons with video interaction among teachers and students. As indicated by the results of our value-added model, daily online instruction can be a key driver of students' learning engagement. To enable online teaching, policymakers need to ensure that all children have access to decent digital devices and internet connections at home. The same is true for teachers, who should be additionally supported by professional development and training in the use of digital technologies and distance-teaching pedagogy. While online teaching is unlikely to be able to fully substitute for in-person teaching, the daily interaction is likely to better protect children's cognitive and socio-emotional development than pure self-studying without explanations by educators and interactions with peers. The compulsory online education concepts should have a particular focus on helping disadvantaged student groups – those from low-SES families and those with lower initial achievement levels.

Even during pandemic times and closed schools, there are additional ways to help children. There is first evidence that interventions that have been initiated at short notice can successfully support students. An online tutoring program where voluntary university students operated as individual tutors for disadvantaged middle-school students in Italy effectively raised participants cognitive achievement, socio-emotional skills, and psychological wellbeing, with effects being particularly strong for low-SES children (Carlana and La Ferrara 2021). Similarly, a low-tech intervention that sent parents of primary-school children in Botswana SMS text messages with basic problem sets supplemented by live phone calls from instructors who walked parents through the material significantly increased children's cognitive outcomes (Angrist, Bergman, and Matsheng 2021). These examples demonstrate that help provided through remote tools can effectively mitigate some of the burden of school closures on children's development.

Beyond the time of school closures, various measures can be taken within and outside school to help affected students recoup some of the lost learning. In school, small-group remedial education lessons instituted after normal school hours could be targeted at students who have shown the largest learning losses. Similarly, summer schools implemented during

vacation times could help to make up for some of the lost development of disadvantaged children. At the same time, it may be hard to reach those students who are most in need with voluntary programs. Evidence from our second German survey indicates that by early 2021, 11 percent of children from academically educated parents, but only 2 percent of children from parents without an academic education had participated in a vacation course during the summer or fall breaks (Woessmann et al. 2021) – exactly the opposite of what such remedial efforts should aim for. To reach at-risk children, the overall intervention strategy will have to include components with low entry barriers that, e.g., depend as little as possible on the initiative of parents to apply for the respective program.

Close attention to the modified re-opening of schools may also offer strategies that could ameliorate the learning losses. Teachers should be supported by making sure they have the necessary preparation and tools to close learning gaps once schools re-open, and teachers that have accrued mental health problems require particular support. With the increase in video-based instruction, matching the skills of the teaching force to the new range of tasks and activities could move schools to heightened performance. Additionally, because the heterogeneous effects of the school closures will have increased the variation in learning levels within classrooms, pivoting to more individualized instruction may improve achievement across the entire distribution of students. With luck, the pandemic experience could work as a catalyst for the digitalization of schools and the use of adaptive learning software more generally. Any such measure will be helped by better information for schools where individual students stand when school systems resume suspended student assessments and school accountability (Hanushek and Woessmann 2020).

There are also various options outside school to mitigate losses in children's development. Two measures that have been shown to be effective are tutoring and mentoring. Tutoring refers to instructional programs to convey curricular skills on a one-on-one or small-group basis. Tutoring programs have been found to increase participating students' learning outcomes substantially, in particular when conducted by educators or other professionals and when implemented at early ages (e.g., Nickow, Oreopoulos, and Quan 2020). As such, they could be used to recoup some of the lost learning for disadvantaged students. For example, to put children from poor families in a position to profit as much from private tutoring options as children from rich families, governments could provide poor families whose children's learning is lagging behind with vouchers to obtain tutoring from private providers. The second approach, mentoring, is not primarily aimed at the instruction of academic content, but instead refers to programs that offer children the support of one-on-one mentors who build a specific

relationship and help the children with their development more broadly. Recent evidence documents that mentoring programs can have substantial effects on both the cognitive and the socio-emotional development of both young children and adolescents, in particular for those from the most disadvantaged family backgrounds (e.g., Kosse et al. 2020; Resnjanskij et al. 2021). Establishing mentoring relationships on a broad basis may help children who are particularly affected by the pandemic situation not only to recoup their learning losses, but also to persistently reach a more positive trajectory of development through sustained support.

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Appendix Tables

Table A1: Characteristics of the two cross-sectional samples and the panelist sample of the German time-use surveys

	Spring 2020	Early 2021	Panelists
	(1)	(2)	(3)
Child characteristics			
Age	12.5	12.2	12.4
Female	0.48	0.50	0.49
Single child	0.38	0.33	0.38
School type			
Elementary school	0.36	0.42	0.36
Gymnasium	0.30	0.26	0.35
Other secondary school	0.34	0.33	0.29
Parent characteristics			
Female	0.49	0.52	0.45
Academic education	0.27	0.24	0.33
Income	3,370	3,297	3,646
Observations	1,099	2,045	513

Notes: Sample shares. Panelists: Parents participating in both survey waves. Source: Own calculations based on ifo Education Survey 2020 and second German parental time-use survey 2021.

Table A2: Variables included in regression analysis

Variable	Definition
Dependent variable	
Learning time	Hours spent by student on "attending school" or "learning for school" on a typical workday during the respective period of school closures due to Covid-19
School activities	Which activities did the teachers/school of your child carry out during the several weeks of Corona-related school closures? Answer categories: never, less than once a week, once a week, several times a week, daily (coded 1-5 in linear specification)
Joint lessons (e.g., by video call)	Joint lessons for the entire class (e.g., by video call or telephone)
Individual conversations with child	Individual conversations with child (e.g., by video call or telephone)
Educational videos or texts	Child should watch provided educational videos or read texts
Educational software	Child should use educational software or programs
Child required to complete provided assignments	Child should work on provided assignments
Child had to submit assignments	Child had to submit completed assignments
Teacher provided feedback on completed assignments	Teachers provided feedback on the completed assignments
Prior learning time	
Learning time before Covid-19	Dependent variable on a typical workday before the Covid-19 school closures (reported retrospectively)
Learning time in spring 2020	Dependent variable on a typical workday during the first phase of school closures, spring 2020 survey
Parental support time	
Parental support time in spring 2020	Hours spent by parent with their child on learning for school on a typical workday, spring 2020 survey
Parental support time in early 2021	Hours spent by parent with their child on learning for school on a typical workday, early 2021 survey
Child controls	
Age	Child age (in years)
Gender	Child gender
Single child	Child does not have siblings
School type	Two dummies: upper-track secondary school (*Gymnasium*), other secondary school; omitted category: primary school

(continued on next page)

Table A2 (continued)

Variable	Definition
Parent controls	
Parent university degree	Highest education degree of responding parent is university degree or degree of university of applied sciences
Single parent	Responding parent lives with at least one child, but does not live in household with a partner
One parent not in household	Responding parent does not live in same household as child
Both parents working (at least 20h each)	Responding parent and partner work at least 20 hours per week during the period of school closures
Parents work majority in home office	Responding parent and partner work less than 10 hours of their weekly work hours outside of home office
Household income	Monthly household income, net of taxes (combining salaries, earnings, business returns, retirement payments, income from social benefits, income from real estate, child transfers)
Migrant background	Dummy indicating if responding parent was born in Germany
West Germany	Living in West Germany
Home environment controls	
Own room	Child has own room to study at home
Computer at home	Three dummies on child access to computer or tablet at home to use for school: own, at restricted times (e.g., sharing with other family members), never; omitted category: can always use someone else's device (e.g., family member) for school
Reliable internet at home	Child has reliable internet connection at home
Print at home	Child can print out assignment sheets for school at home

Notes: Data source: ifo Education Survey 2020 and second German parental time-use survey 2021.