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The Economic Impact of COVID-19 Learning Deficits: A Survey of the Literature

By Joana Elisa Maldonado, Anneleen Vandeplas and Lukas Vogel

Abstract

The COVID-19 pandemic has led to a temporary reduction in the quantity and quality of education, with school closures of varying degree implemented across the globe. This paper reviews the literature on learning deficits in compulsory education and their possible economic impact. Studies from different EU Member States show significant learning deficits in primary and secondary education, equivalent to about two months of learning progress during a regular school year on average. The impact of the pandemic on learning outcomes varies widely by country as well as by students' age. As students with a lower socioeconomic status or weaker previous performance experienced larger learning deficits, inequality in educational achievement has increased between students, schools, and countries. While labour market outcomes of the 2020 graduating cohort seem to be resilient at the current juncture of tight labour markets, the long-term economic impact of learning deficits is likely to be non-negligible. Existing studies project small productivity losses for the coming years but a significant impact in the long term, peaking by the second half of the 21st century, when all affected cohorts of students will have entered the labour market. Estimates of the aggregate real GDP effects of 1-year learning deficits, given the number of affected cohorts of students (corresponding to around one third of the future labour force at the maximum) and assuming that no remedial action is taken and losses are not recovered, reach between –0.5% and –4.7% in 2050 in the contributions surveyed in this paper, compared to a baseline without any learning deficits. For an average learning deficit of circa one fifth of a school year this would translate into real GDP effects between -0.1% and -1% by 2050.

JEL Classification: I21; I26; J24

Keywords: learning losses, COVID-19, school closures, growth impact, human capital

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INTRODUCTION

During the COVID-19 pandemic, EU education systems were strongly affected by containment measures aimed at reducing the spread of the virus. Between March 2020 and June 2021, a reduction of the quantity and quality of education of varying degree was observed across the EU. In most EU Member States, schools were physically closed for several weeks or months, and classes at school were partly replaced by distance learning with self-study and online classes.[1] After the first lockdown in 2020, partial physical school closures of shorter periods and reduced hours continued to be implemented in selected grade years or regions. In the school year 2021-2022, regular teaching activities resumed across the EU, with some remote teaching practices remaining in place here and there, particularly at universities.

Studies from different EU Member States show negative effects of the physical school closures and changes in schooling on the level and equality of learning outcomes. A combination of students forgetting previously learned material ('learning loss') and new learning progressing at a slower pace than before ('lost progress') resulted in 'learning deficits'. These learning deficits were systematically larger for students from a disadvantaged socioeconomic background. Given these negative effects, which simultaneously affected a large number of cohorts, the resulting reduction in human capital accumulation could negatively affect economic outcomes in the long run.

Estimates of the macroeconomic implications of learning deficits vary substantially in quantitative terms. The studies reviewed in this paper suggest real GDP (level) effects between –0.5% and -4.7% by 2050 for a persisting one year loss of schooling. Model-based studies tend to indicate smaller losses than empirical estimates with looser theoretical structure.

This paper summarises the existing evidence on learning deficits caused by the COVID-19 pandemic and provides an economic perspective on the possible long-term impact of the slowdown in learning. Section 2 reviews the literature on the effects of the COVID-19 pandemic on educational outcomes. Section 3 assesses whether effects are visible in short-term labour market outcomes and describes modelling results and estimates of the possible long-term impact of the learning deficits on output. Section 4 concludes with a discussion of the policy implications.

REVIEW OF EVIDENCE ON LEARNING DEFICITS IN THE EU

This section provides an overview of the evidence on the impact of the COVID-19 pandemic on educational outcomes of school-aged children. It describes the changes in students' learning outcomes and inequality in education observed in the EU after the pandemic.

Effects on average learning outcomes in primary and secondary education

To date, the evidence on post-COVID-19 outcomes from standardised international tests, which are comparable across countries and years, remains very limited. Assessments are taking place only every few years and have in many cases been postponed due to the pandemic. The first internationally comparative evidence on the post-COVID-19 reading performance of 4th-graders from 57 countries comes from the Progress in International Reading Literacy Study (PIRLS) 2021, published in May 2023. 23 Member States of the EU participated in the assessment, 16 of which have comparable trend data

[1] Complete school closures (without provision of distance teaching or blended learning) only took place for short periods in some EU Member States, mostly in the form of extended holidays. In this paper, the term 'school closure' is used to describe the suspension of face-to-face schooling, while in most cases learning activities (partly) continued remotely. Data on school closures by country or region can be found in the report by European Commission/ EACEA/ Eurydice (2022) and in the Dashboards on the Global Monitoring of School Closures by UNESCO (2017).

available from previous assessment cycles (Mullis et al., 2023).[2] 12 Member States and the Flemish community of Belgium experienced a significant decrease in test scores compared to the 2016 assessment (see Table A.1 in Annex 1).

This is a noticeable negative result, likely at least in part attributable to the COVID-19 pandemic, as 10 of these Member States had a positive or constant trend before 2016. Only three Member States and the French community of Belgium recorded no significant change in test scores from 2016 to 2021, while no Member State achieved a significant positive change in test scores in this period. First correlations with national data on school closures for 29 countries globally show that longer school closures were negatively associated with reading scores, with a one-year school closure resulting in a learning deficit of half a school year (Kennedy & Strietholt, 2023). However, it has to be noted that the data quality of these results is limited due to the variations of school closures within countries.

Reviews of studies covering different countries and age groups expose significant learning deficits after the COVID-19 pandemic. In the absence of comprehensive internationally comparable student assessments for different age groups and subjects, a quickly growing body of literature compares country-specific studies of student outcomes in compulsory education before and after the COVID-19 school closures.

One year after the first school closures, early reviews of these studies consistently found that the COVID-19 pandemic led, on average, to significant learning deficits (e.g., Donnelly & Patrinos, 2021; Hammerstein, 2021; Zierer, 2021).[3] This finding was confirmed in more comprehensive reviews two years after the outbreak of the pandemic (e.g., Patrinos et al., 2022; Moscoviz & Evans, 2022 for high-income countries).

A review of 42 studies from 15 countries, globally, finds a substantial average learning deficit of 35% of a regular school year's learning progress (Betthäuser et al., 2023).[4] For the EU Member States covered in the selected studies (see Table A.2 and Table A.3 in Annex 1), an average loss of 20% of a school year's learning progress was recorded.[5]

Assuming a duration of a regular school year of 8-9 months, this would be equivalent to the loss of the learning progress of almost two months during a regular school year. This learning deficit is equivalent to an 8 score-point decrease on the OECD's PISA test (or 8% of a standard deviation), which is a large setback, given that only nine EU Member States have been able to improve performance in reading in PISA from 2015 to 2018, all of which by less than 8 score points (OECD, 2019). This result is very similar to the decrease in PIRLS reading scores recorded in the 2021 assessment, which would be

[2] In 2021, the following EU Member States participated in PIRLS: BE (Flemish and French communities), BG, CZ, DK, DE, IE, ES, FR, HR, IT, CY, LV, LT, HU, MT, NL, AT, PL, PT, SI, SK, FI, SE. Two of these countries (HR, CY) did not participate in the previous 2016 edition and other countries do not have comparable time trend data due to other reasons, such as structural breaks.

[3] Average learning deficits found in 2021 reviews amounted to 0.10-0.15 standard deviations (SD): 0.10 SD for reading and mathematics in Hammerstein et al (2021), 0.13 SD for mathematics and language in Donnelly & Patrinos (2021), 0.14 SD for mathematics as well as a combination of different subjects in Zierer (2021), and 0.15 SD for combined mathematics and reading outcomes in Storey & Zhang (2021), respectively, only including those studies which provide results measured in standard deviations.

[4] The authors of the study, published in Nature Human Behaviour, conducted a systematic review of the literature and found a learning deficit of 0.14 standard deviations, which can be translated to a loss of 35% of a regular school year (see Box 1).

[5] This estimate, equal to 0.08 standard deviations, is obtained from the authors' own calculations based on the dataset and code provided by Betthäuser et al. (2023), restricting the sample to the 17 studies from seven EU Member States included in their sample (Belgium, Denmark, Germany, Italy, Netherlands, Spain, Sweden). It has to be noted that, due to limited data availability, this estimate is not an accurate estimate for the EU, as a large number of Member States is not represented (e.g., Baltic, Central and Eastern European countries), while there are several studies from other Member States (e.g., Netherlands and Germany). Annex 1 lists all estimates included in the calculation. The reported number is an unweighted average of all estimates. Weighting estimates by the number of reported estimates in each study could yield a higher average.

approximately equivalent to a learning deficit of 25% of a regular school year's learning for 4th graders in participating EU Member States.[6]

BOX 1: MEASURES OF LEARNING PROGRESS

In educational research, changes in learning outcomes are commonly measured in standard deviations (SD). This statistical measure allows comparing the effect sizes of outcomes with different scales and from different samples. It assumes a normal distribution of the test scores, clustered in a bell curve around the mean. Raw test scores are standardised by rescaling to a mean of 0 and a standard deviation of 1.

The standardised score (z-score) indicates how far an observation is lying above or below the mean. A score which is 1 standard deviation above (below) the mean is approximately equivalent to the 84th (16th) percentile, that is 34 percentile points above (below) the mean. Accordingly, a learning deficit of 0.1 (0.2) standard deviations shifts the distribution to the left, moving the student, who was at the median before the pandemic, down to the 46th (42nd) percentile.

Measured learning outcomes can be compared to benchmarks for the learning progress observed during a regular school year, as established in the educational literature (e.g., Bloom et al., 2008; Hill et al., 2008). Learning deficits can then be expressed in terms of lost progress as a share of a regular school year. While school productivity varies in different education systems, grade levels and by other factors, an average learning gain benchmark of 0.2-0.5 standard deviations in one school year is commonly assumed (e.g., Azevedo et al., 2020). In this paper, we use an average learning gain benchmark of 0.4 standard deviations for a regular school year based on Hill et al. (2008).

On the scale of the OECD's PISA, which is normalised to have a mean of 500 score points and standard deviation of 100 score points, a change in learning outcomes by 10% of a standard deviation equals a 10-point difference (OECD, 2019).

A scientific report commissioned by the European Commission (DG EAC) finds an even larger average learning deficit of 30% of a regular school year's learning progress, equivalent to 12 PISA score points, in EU Member States (De Witte & François, 2023).[7] The difference is possibly due to the strict selection based on a risk-of-bias assessment by Betthäuser et al. (2023), which excludes studies with a critical risk of bias, e.g. due to confounding, sample selection, or missing data.

Similar results are found in a comprehensive meta-analysis by the European Commission's Joint Research Centre covering 21 OECD countries (Di Pietro, 2023a), which estimates the pandemic resulted in an average learning deficit of 30-40% of a regular year's learning progress, with a smaller learning deficit in OECD EU countries than in OECD non-EU countries.

The observed decline in learning outcomes following the outbreak of the COVID-19 pandemic represents a combination of various effects. It includes the impact of a loss in instruction time, but also the lower effectiveness of instruction methods used in distance teaching, with varying support of parents and in the absence of (positive and negative) peer effects, as well as other effects, such as the psychological impact, caused by the exceptional situation of the pandemic. Yet, comparisons of schooling modes show that the effect is likely driven largely by the lower effectiveness of remote learning compared to in-

[6] Table A.**1** in Annex 1 shows that the average decrease in test scores from the 2016 to the 2021 PIRLS assessment in participating EU Member States with comparable data available equals 10 PIRLS points. Assuming an international standard deviation of 100 points (as defined in the first PIRLS assessment in 2001), this would equal 10% of a standard deviation.

[7] The report finds, on average, a learning deficit of 0.11 standard deviations for European countries, including the UK. Taking the subset of included studies from EU Member States, excluding the UK, gives an average of 0.12 standard deviations.

person teaching (e.g., Goldhaber et al, 2023; Jack et al., 2023). The observed impact comprises both the reduction in learning progress and the loss of knowledge gained before the start of the pandemic.[8]

The learning deficits vary widely across countries and subjects. Students in middle-income countries experienced larger learning deficits than students in high-income countries, though high-income countries tend to be overrepresented in research, and studies from low-income countries are missing (Betthäuser et al., 2023). Di Pietro (2023a) argues that the smaller effects found for OECD EU countries than OECD non-EU countries are likely due to differences in the length (or intensity) of school closures. In the EU, no impact of the COVID-19 crisis on learning outcomes was observed in Nordic countries (Denmark, Finland, Sweden), while large negative effects were found in Greece and Poland (De Witte & François, 2023). Across subjects, most studies find significantly larger learning deficits in mathematics than in languages (Betthäuser et al., 2023) or no significant differences (Di Pietro, 2023a).

Questions remain as to how long the learning deficits will persist. While it is possible that students catch up after the return to regular schooling, it is also possible that learning deficits accumulate over time, for instance if the curriculum and the instruction are not adequately adjusted to students' learning deficits upon their return to school (Kaffenberger, 2021). In the latter case, the accumulation of losses would amplify the long-term effect in the absence of mitigating policies.

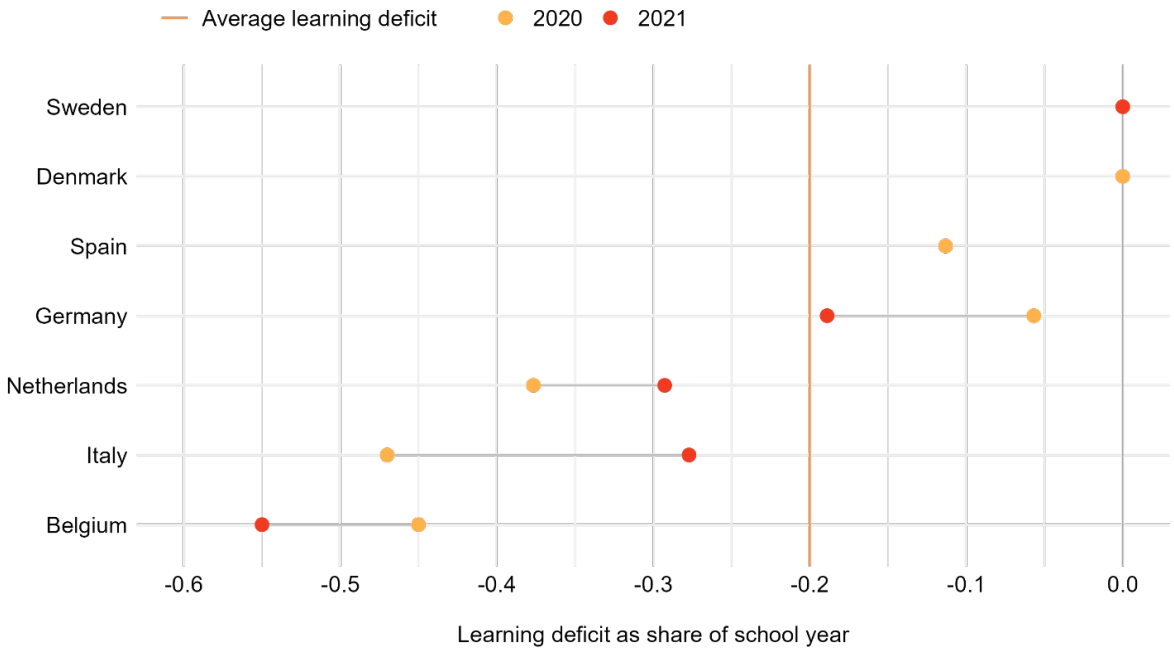
Many EU Member States have already increased spending on education and have taken remedial measures to dampen and reverse the negative effects of the COVID-19 pandemic (De Witte & Smet, 2021; Di Pietro, 2023a). First assessments of the medium-term impact of the COVID-19 pandemic provide a mixed picture of post-pandemic trends in learning outcomes. The systematic review of Betthäuser et al. (2023) finds that learning deficits appeared early in the pandemic and have neither been significantly reduced, nor widened until spring 2022. While this indicates that school closures which took place after the initial lockdown have not increased learning deficits, it also means that efforts to compensate losses had not succeeded in reversing the negative trend by spring 2022. Di Pietro (2023a) even finds learning deficits to increase over time in OECD countries, with larger cumulative learning deficits in assessments made in 2021 or later compared to assessments from 2020.

Graph 1 summarises the findings on average learning deficits in EU Member States for the studies included in Betthäuser et al. (2023). Across countries, no clear pattern of improvement over time becomes visible. In Germany and Belgium, the average learning deficits recorded in 2021 even exceeded those measured in 2020. This widening of the learning deficits could be due to containment measures in schools having continued over this period or result from an accumulation of missed learning progress.

Studies are difficult to compare, as they vary in many influencing factors, such as the geographical context, length of school closure, type of distance teaching, test instruments, student samples, and methodologies. Yet, three factors likely affect the size of the learning deficits: First, a longer duration of school closures is correlated with higher learning deficits (Di Pietro, 2023a; De Witte & François, 2023; Patrinos, 2022). Second, a high level of digitalisation of education before the pandemic was associated with lower learning deficits (De Witte & François, 2023). Finally, while most studies cover primary school students, some reviews observe a correlation with the age of students, with younger students more negatively affected than older students (De Witte & François, 2023). However, this correlation could be driven by differences in the length of school closures, which often differed by grade year, and is found to be statistically not significant in other reviews (Betthäuser et al., 2023; Di Pietro, 2023a).

[8] The use of the term 'learning deficit' emphasises that the estimates of studies measure a broad effect, which comprises different elements, rather than only 'learning loss'.

Graph 1: **Average learning deficits in EU Member States with robust data available**



Note: This graph is based on computations by the authors, using the dataset provided by Betthäuser et al. (2023). It covers the subset of 17 studies from seven EU Member States (BE, DK, DE, ES, IT, NL, SE). Estimates are averaged across grades and subjects. The average learning deficit is computed as average across all available EU estimates (separate by study, year, age, and subject). Learning deficits are expressed in negative numbers (lost share of a school year), with the largest learning deficits on the left side of the horizontal axis. The colour of the dots indicates the year of measurement of student outcomes (2020 in orange, 2021 in red). Values for the respective countries in 2020 and 2021 are generally based on different samples of studies, implying imperfect comparability.

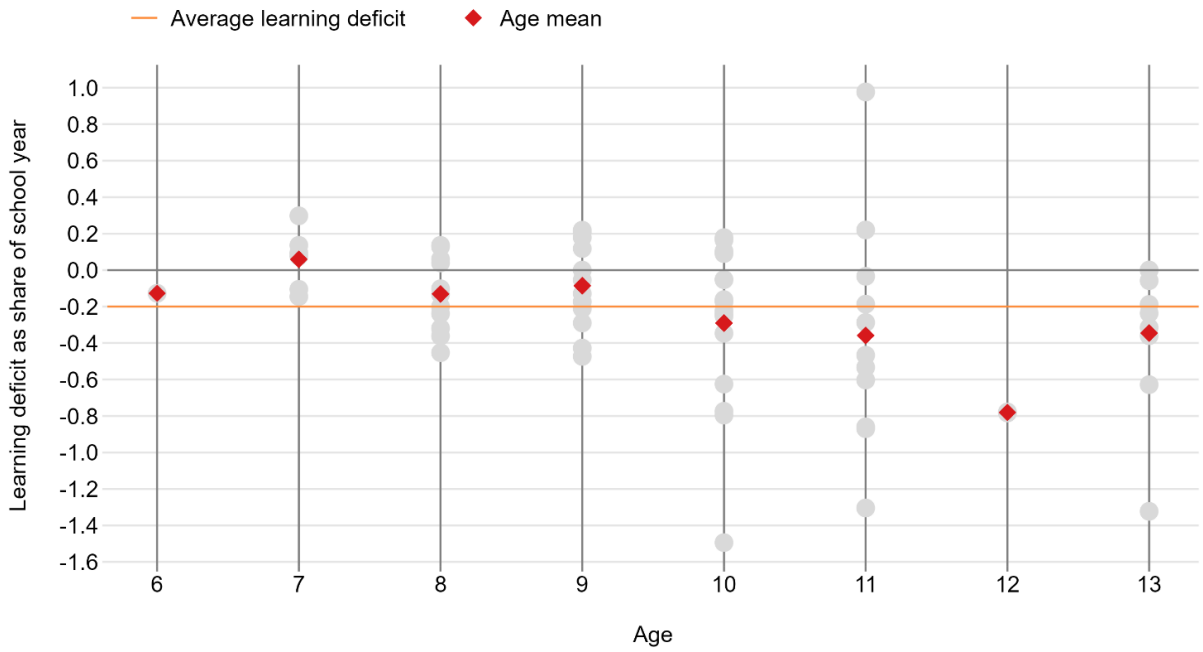
Graph 2 shows that, in studies from EU Member States, the impact of age is not clear. Most average learning deficits by age fall in the range of 10-30% of a regular school year, with exceptions at age 7 (no negative effects found in a study from Sweden) and age 12 (exceptionally large learning deficits of 80% of a school year found in the Netherlands). Educational theory suggests linearly decreasing effects by age, or a U-shaped relationship, with the early and the final years being the most crucial time of the school career. Concerning gender, the evidence remains limited and mixed, with both boys and girls affected negatively, but differences vary by study (De Witte & François, 2023; Patrinos et al., 2022).

It is likely that the learning deficits caused by the COVID-19 pandemic are exacerbating previous downward trends in learning outcomes. The methodological limitations of most studies make it difficult to disentangle the effects of COVID-19 from long-term trends, with most studies not controlling for the general time trend when using pre-pandemic results of previous cohorts as reference (De Witte & François, 2023). The causal effects can be more clearly identified in natural experiments with the same cohort tested before and after the pandemic. For example, Engzell et al. (2021) record significant learning deficits of the same magnitude as the EU average reported above, based on such a natural experiment. The fact that studies using different statistical methodologies yield comparable results (De Witte & François, 2023) could suggest that the learning deficits uncovered do not mainly reflect previous downward trends in learning outcomes.

Next to the effect on school-aged children, the COVID-19 pandemic likely also impacted learning outcomes in early childhood, higher education, and adult learning. Educational activities were reduced, and the learning environment was limited due to containment measures for learners of all ages. Evidence on early childhood, before children enter primary education, is largely limited to qualitative evaluations and studies from outside the EU (Uğraş et al, 2023). In higher education, a large shift to digital instruction and a temporary reduction of international mobility occurred (OECD, 2021). The few

studies that evaluate effects in higher education and are broadly comparable, show similar learning deficits at the tertiary level, as at the primary and secondary level (Di Pietro, 2023b). For example, at an Italian university, students' progress and performance was reduced as a result of online teaching during the first lockdown of the pandemic (De Paola et al., 2023) by a magnitude comparable to the average learning deficits observed at the primary and secondary level in the EU.

Graph 2: **Estimates of learning deficits by age, observations from seven EU Member States with robust data available**



Note: This graph is based on computations by the authors, using the dataset by Betthäuser et al. (2023The grey dots represent the 68 estimates of learning deficits (across the range of country, year, and subject parameters) from a subset of 17 studies with distinct samples from seven EU Member States (BE, DK, DE, ES, IT, NL, SE). The age means represented by red diamonds are the means of the grey dots for each age at the time of assessment (2020 or 2021). The average learning deficit is computed as the average across all available EU estimates, i.e. all countries and all age groups. Learning deficits are expressed as a lost share of a school year, using age- and subject-specific benchmarks from Hill et al. (2008). Negative numbers represent a learning deficit; positive numbers indicate that students have learned more than previous cohorts who were not affected by COVID-19 school closures. The cut-off at 13 years is due to the limited availability of data for students in older age groups.

Increased education inequality between students

Analyses of different dimensions show that not all students were equally affected by the COVID-19 pandemic and that inequality increased in the months and years following the start of the pandemic.

First, increasing inequality is observed through a widening spread in the distribution of test scores, with increasing differences between the best and worst performing students. For example, in Belgium (Flanders) inequality had increased both within and across schools one year after the pandemic (Maldonado & De Witte, 2022).[9] These increases in inequality were found to be slowing down but remaining present three years later (Gambi & De Witte, 2023).

Second, differences in test scores by background characteristics of students or schools have increased. The learning deficits strongly depend on students' socioeconomic status (Betthäuser et al., 2023; Di

[9] The changes in the distribution of test scores were measured by inequality indicators, such as the Gini coefficient and the 90/10 ratio.

Pietro, 2023a; Patrinos et al., 2022) and previous performance level (De Witte & François, 2023; Patrinos et al., 2022). These differences are found in both mathematics and reading, in primary and secondary education and at each stage of the pandemic, no matter which indicator of socioeconomic status is used (Betthäuser et al., 2023). This means that the COVID-19 pandemic has increased the relevance of students' background and home environment in determining educational achievement and reduced the role of the school as 'the great equaliser'.

Third, the pandemic has likely increased inequalities in learning outcomes both within and between countries in the EU. An earlier JRC study identified the risk of learning deficits and rising inequalities between European countries based on pre-pandemic standardised test data from 2019 (Blaskó et al., 2022). It found that those countries with the worst average student outcomes in the EU also tended to be the ones with the largest gap in student achievements within their national boundaries. With COVID-19 learning deficits affecting weakly performing students more strongly, inequalities in learning outcomes could increase in the EU.

Table 1 provides an overview of the review of COVID-19 learning deficits in primary and secondary education in the EU.

Table 1: Review of COVID-19 learning deficits in the EU

	17 studies with 70 estimates from seven EU Member States (BE, DK, DE, ES, IT, NL, SE)
	Tests in two subjects: reading & mathematics
	Evaluated in 2020 & 2021: 3-15 months after the start of the pandemic
	Primary & secondary level: 6–18-year-old students
	Average learning deficit of 20% of a regular school year's progress ≈ 8 PISA score points (8% of a standard deviation)
	Similar learning deficit in 2020 & 2021: learning deficit not reversed, but not worsened
	No clear pattern by age or grade level
	No learning deficits in Nordic countries (DK & SE), largest deficits in BE, IT, NL
	Smaller deficits for shorter duration of school closure or higher level of digitalisation
	Larger deficits for students with low previous performance or low socioeconomic status

Note: This table provides a summary of COVID-19 learning deficits in primary and secondary education in the EU and presents calculations by the authors based on Betthäuser et al. (2023)'s dataset.

POTENTIAL ECONOMIC IMPACT

This section sketches the possible impact of the observed learning deficits on economic outcomes. It describes the first evidence on labour market outcomes of cohorts that graduated during the pandemic and provides a tentative quantitative assessment of the effect of the observed learning deficits on potential output in the long-term.

Short-term effects observed in the labour market

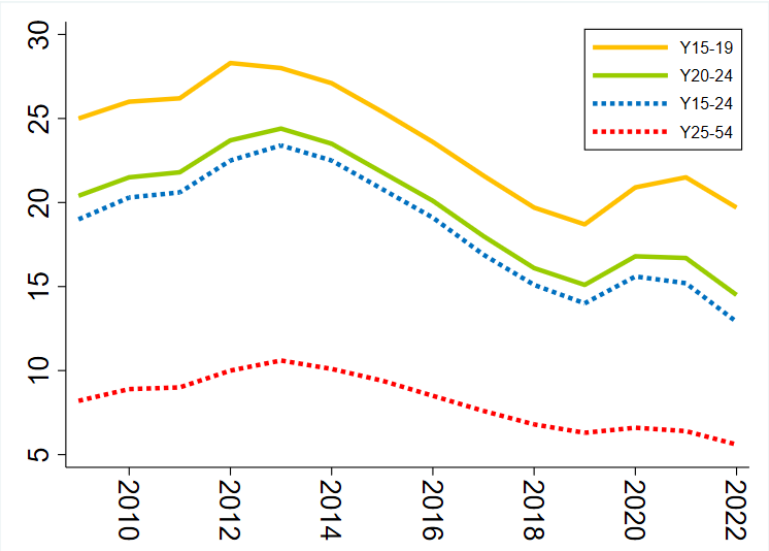
Data on the labour market outcomes of youth immediately following the COVID-19 pandemic likely reflect the impact of the recession, rather than the disruption to learning.

Literature suggests that even in the absence of learning disruptions, young people who graduate during a recession may face negative consequences in terms of their socioeconomic outcomes (including earnings) for up to 10-15 years after graduation (Oreopoulos et al., 2012; Schwandt & Von Wachter, 2019; Regan, 2020). This may be less of a concern in the current context, where the pandemic-related increase in youth unemployment was nowhere near the large increase observed in the aftermath of the

financial crisis, helped by substantial policy efforts to stabilise labour markets during the pandemic (such as short-time work schemes), reducing risks of scarring effects.

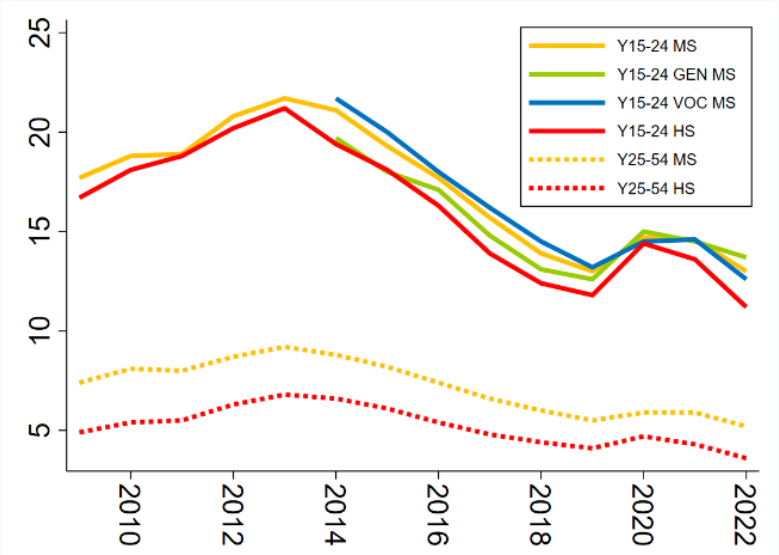
Job finding rates tend to be driven mainly by the business cycle but could partly reflect changes in students' performance. An empirical study by the Institute for Fiscal Studies shows a negative effect of the pandemic in the short run, but resilient employment rates one year after graduation for youth who graduated during the pandemic-related school closures in the UK (Ray-Chaudhuri & Xu, 2023). In particular, students who graduated in 2020 were less likely to find a job 3-6 months after graduation and more likely to start in lower-paid occupations than previous cohorts, but they recovered to similar outcomes compared to previous cohorts 9-12 months after graduation.

Graph 3: **Unemployment rates by age group, EU27**



Source: EU-LFS [lfsa_urgaed].

Graph 4: **Unemployment rates by age group and qualification level, EU27**



Source: EU-LFS [lfsa_urgaed].
Note: MS (medium level of schooling), HS (high level of schooling), GEN (general education), VOC (vocational education).

Data on EU youth unemployment suggest that youth unemployment rates reached an all-time low just before the pandemic and picked up moderately (more so than prime-age unemployment rates) in 2020 and 2021 (Graph 3). These short-run impacts are more likely to reflect the direct impact of the recession on labour demand than the disruptions to learning. Youth may have been more affected by the pandemic as they are more likely to work on temporary contracts, and in contact-intensive sectors such as hospitality. In general youth unemployment tends to be more sensitive to the business cycle than prime-age unemployment.

The EU labour market recovered fast, and by 2022, unemployment rates for youth, like for other age groups, declined beyond their pre-pandemic level, bringing them to historically low levels. They remained slightly above their pre-pandemic level only for the 15-19 age group; while participation rates exceeded their 2019 levels for all age groups considered, but even more so for young age than for prime age cohorts.

Demographic trends are likely to play an important role, as the EU27 working-age population is shrinking and young cohorts entering the labour market are significantly smaller than older cohorts retiring from the labour market. In all, the tight labour market is likely to mask or counteract the possibly negative impact of the pandemic associated with less human capital accumulation. Further research that relies on micro-level data would be required to assess more precisely the impact of the pandemic on labour market outcomes through learning disruptions.

Despite improving labour market outcomes of youth over the post-COVID recovery, it is possible that learning gaps will have an impact in the medium- to long-term. Despite good employment rates of graduates, lower levels of hard and soft skills and reduced learning on the job can also affect long-term labour market outcomes of young people. For example, some companies in the UK report weaker performance of new employees who graduated during the pandemic (O'Dwyer, 2023). To date, quantitative studies on the long-term economic impact of the learning deficits have drawn on simulation models, which are presented in the next section.

Recently graduating cohorts, having completed most of their school years before the pandemic, are likely to be relatively less affected by school closures than the youngest cohorts. As mentioned before, economic models often assume either linearly decreasing or U-shaped marginal returns to education, with the latter suggesting the highest returns in primary and tertiary education (OECD, 2022). Students experiencing interruptions of schooling and learning deficits during their first years at school, in which the largest learning progress is commonly recorded (Bloom et al., 2008; Hill et al., 2008), could potentially carry the resulting learning gaps throughout their school career and suffer the largest negative impact in the long term. Nevertheless, some catching up of losses and compensation effects from entire cohorts being affected by the learning loss remain a possibility.[10]

Modelling long-term effects

The negative impact of the COVID-19 pandemic on students' learning is likely to affect macroeconomic outcomes through a reduction in individual lifetime earnings and skilled labour supply. It is well-established that high-quality education leads to higher earnings, better health, longer working lives, and an improved quality of life. In addition, a skilled labour force contributes to economic growth through increased productivity and innovation, although the benefits of investment in education usually only take effect with a long time lag (OECD, 2022).[11]

Historical evidence demonstrates that school closures can have negative economic effects. Studies using natural experiments, such as teacher strikes and natural disasters, find lasting economic effects for

[10] Some channels of the transmission of individual learning deficits to individual income have been muted during the pandemic in many countries. These include the (partial) catching-up on lost parts of the curriculum as well as the (endogenous) adjustment of exam scores in graduating cohorts that reduce the risk that school leavers would enter the labour market or tertiary education with worse formal qualifications than previous cohorts.

[11] Chapter 1 of OECD (2022) gives a comprehensive overview of the role of human capital in growth models and the macroeconomic effects of investment in education.

affected individuals.[12] Similarly, learning breaks during long summer holidays also have negative long-term effects on individual economic outcomes (Kuhfeld et al., 2020). However, the COVID-19 pandemic situation of far-reaching worldwide interruptions of face-to-face learning with possibilities of digital schooling is very different from previous situations of school closures.

Research draws on structural models and projection models to predict the economic impact of the COVID-19 learning deficits. Structural models introduce a school closure shock in terms of a reduction of public investment in education in calibrated macroeconomic frameworks. Projection models use established correlations between educational and economic outcomes to simulate the effect of learning deficits on economic growth. All estimates presented in this section adhere to the assumption of no policy change, i.e. they abstract from remedial measures, and they assume that learning deficits persist over time. Hence, one can understand these results as conditional (worst-case) projections in the absence of policy support, which may deviate from the best guess about actual policy responses.

Structural models

Structural models predict real GDP effects of a 1-year learning deficit between –0.5% and –3.4% by 2050, compared to a baseline without learning deficits. Structural models are a simplification of reality and attempt to specify (and quantify) the main transmission channels from shocks or policies to economic outcomes. The model parameters are estimated or calibrated to match empirical regularities of interest. Model results need to be interpreted against the background of underlying theory and assumptions and the parameter choices. Structural models allow to simulate counterfactuals ("what if") that illustrate the dependence of transmission channels and net outcomes on structural features of the economy and policy responses.

A school closure shock of one year yields average losses in the present discounted value of lifetime earnings of affected children of 2.1% in the partial-equilibrium life-cycle model with overlapping generations by Fuchs-Schündeln et al. (2022), calibrated to US data, equivalent to welfare losses of about 1.2% of permanent consumption, and, when aggregated, to 3% of 2019 US GDP. In addition, this model finds large differences by children's age and background, with younger children affected more than older children, and children from the most disadvantaged households experiencing four times larger welfare losses than children from the most privileged households. This approach is likely to overestimate the impact of school closures by ignoring schooling through distance teaching, i.e., ignoring that schooling of a different kind continued (to various degrees depending on the countries and age cohorts considered) during the physical closure of schools during the pandemic.

A similar framework (Jang & Yum, 2022), calibrated to the US economy, finds negative effects for aggregate output for up to 15 decades, reaching a trough after 55 years, with an output decline at the trough of around 0.3%, 0.8% and 1.5% for full school closures of 0.5, 1 and 1.5 years respectively.[13] In contrast to other research, this model suggests larger negative effects for older children, whereas younger children are (assumed to be) able to make up for pandemic-related losses over the longer remaining duration of their educational career.[14] The model also produces a significant decrease in the intergenerational mobility of educational attainment, as children become more dependent on parental input (and investment in private tutoring services) during school closures. Virtual schooling almost halves the aggregate impact of the learning deficits, but further increases inequality in their model. This result

[12] For example, students affected by school closures in Virginia in the 19th century had a lower income later in life compared to students who were not affected by school closures (Winfree, 2023) and teacher strikes in Belgium had lasting negative effects on educational outcomes of affected students (Belot & Webbink, 2010).

[13] The extreme persistence of the effect in Jang and Yum (2022), with output, labour and capital returning to the no-COVID baseline only after 150 years, derives from the importance of private (parental) investment in child education. This investment depends on parental human capital and income, which provides the basis for some intergenerational transfer of learning deficits in their model.

[14] The model-implied increase of individual losses with students' age does not account for the theory of human capital accumulation, which supposes self-productivity in human capital and predicts the COVID-19 shock to affect both the current level of human capital and its future accumulation (Schady et al., 2023).

is in line with a structural model of skill formation, which suggests that the negative effects of school closures on human capital formation are highly unequal and persistent (Agostinelli et al., 2022).

Simulations by Viana Costa et al. (2021) with a rich structural model (Penn Wharton Budget Model) on US data also suggest an impact of COVID-related learning deficits on labour productivity and output. In particular, the model simulation finds a negative impact on both variables, which is increasing over a 45-year horizon. For a learning deficit of one year, the results would translate to a 2.9% reduction in productivity and a 3.4% drop in output in 2050 compared to a no-COVID baseline. This simulated output effect is significantly larger than the Jang and Yum (2022) result (0.5% output loss after 30 years for a 1-year learning deficit). The difference may be attributable to the assumption in Viana Costa et al. (2021) of separate labour productivity effects by students' socioeconomic background. Comparability with Fuchs-Schündeln et al. (2022) is limited by the fact that the latter do not report the dynamics of macro variables, but only present discounted aggregate losses.

The substantial differences in estimates between structural models are due to the strong influence of assumptions and modelling choices on the results. In general, the simulations consider only (different) subsets of potential transmission mechanisms and possible behavioural responses of students, parents, and teachers.

Correlation-based projections

Projection models suggest real GDP effects of a 1-year learning deficit of up to 4.7% by 2050, compared to a baseline without learning deficits. This approach exploits regularities in the data, notably correlations between the variable of interest and possible determinants, without imposing a tight theoretical structure.

Hanushek and Woessmann (2012) suggest that a reform bringing about an improvement in PISA scores by 25 points (equivalent to 25% of a standard deviation or 2/3 of the usual learning gain over a school year following Hill et al. (2008)) would bring about a 0.5 percentage point higher long-run growth rate in EU Member States, or a cumulative economic gain of EUR 35 trillion in present value until 2090 (corresponding to a 6.2% increase in discounted future GDP). The authors correlate economic growth with measures of the quantity as well as the quality of education in cross-country comparisons. In particular, they regress countries' average GDP growth on student test scores from the PISA survey, years of schooling as well as initial GDP per capita. The estimated 'growth coefficient' of PISA test scores is then used for projections of future growth, in the spirit of endogenous growth models.[15] While the estimates could be biased by endogeneity or reverse causality, the authors show that the results are robust when controlling for potentially omitted variables (e.g., economic institutions, geographical location, political stability, capital stock, and population growth). Balart et al. (2018) find that the relationship between student test scores and economic growth is smaller but remains robust when accounting for non-cognitive skills.

By implication, and inverting signs, if the learning deficit in the EU equivalent to an 8-point decrease in PISA scores were to persist and would apply to the entire population, this would translate into a 0.2 percentage point lower long-run growth rate. Given that the pandemic only implies a temporary negative shock on learning outcomes, which in the long run would affect at most one third of the working-age population[16], the impact of the pandemic would be more contained, but still substantial.

Hanushek and Woessmann (2020) simulate a temporary school closure of various lengths and find that a one-year school closure results in a permanent individual income loss of 7.7%. The estimates for lifetime income losses are the sum of lost individual returns to education. Hence, it is assumed that the income loss due to the learning deficits does not decrease if all students are affected simultaneously, which likely makes it an upper bound estimate.

[15] The authors also present an alternative projection model based on the neoclassical growth framework. The gains are somewhat smaller, but still substantial. In the neoclassical growth model, changes in test scores lead to higher steady-state levels of income, but they do not permanently affect the growth rate.

[16] Assuming that the 12-16 age cohorts have been affected by schooling under COVID-19 conditions, and assuming a working life of around 50 years.

The same paper suggests aggregate losses of 4.3% of GDP on average for the remainder of the century, equivalent to a cumulative GDP loss of the magnitude of 200% of current GDP by 2100, drawing on data from a sample of 50 lower-middle to high-income economies. By 2100, the reduction in annual GDP would amount to 7.5% compared to a baseline without learning deficits, assuming 80 years with a lower achieving labour force (corresponding to the average life expectancy of somebody born in 2020); by 2050, real GDP would be lower by around 4.7% compared to the no-loss benchmark.[17]

To arrive at those estimates, the authors assume that annual economic growth increases by about 2 percentage points per standard deviation in educational achievement of the labour force, an effect of similar magnitude as the assumption used by Hanushek and Woessmann (2012). The estimates assume the complete loss of a school year, neglecting mitigating effects of distance learning. Scaling the numbers to a learning loss of 20% of a school year would imply a GDP level 0.9% below baseline by 2050.[18]

A study that uses a similar approach for the US, as it correlates US-specific standardised test outcomes to long-term growth, but considers in addition the effects of school drop-outs, produces smaller estimates, i.e. –1.1% to –1.8% GDP level reduction by 2040 for a one-year learning deficit (Dorn et al., 2020).[19]

Recent work by the OECD finds that expected productivity losses are initially small, but build up over time and peak after 45 years when affected cohorts are in the older part of the labour force, with an overall productivity (TFP) loss of 1.1% at the peak for a 1-year school closure (de la Maisonneuve et al., 2022).[20] These negative effects diminish when affected cohorts gradually retire as of 2068 and disappear when all affected cohorts have retired by 2083. The timing of the peak impact derives from the assumption that all cohorts are affected equally, with no possibility for younger students to catch up learning deficits. If older students were affected more than younger students, who have more time to recover from the shock, the trough would be at an earlier point in time, when most affected cohorts are at prime working age.

The estimated learning deficits for the EU of approximately 10% of a standard deviation, or 1/5 of a school year (see above) come closest to the lower bound impact of a 12-week school closure in de la Maisonneuve et al. (2022), which they translate to a 0.2% reduction in overall human capital by 2067, when all affected cohorts have entered the labour force. This reduction in human capital is predicted to cause productivity losses until the retirement of the last affected cohort in 2083, and to peak at a productivity loss (compared to a no-COVID-19 baseline) of 0.4% in 2067.

Table 2 summarises the estimated effects of the COVID-19 learning deficits on economic output from both structural models and projection models.

[17] The value for 2050 is taken from the comparison in de la Maisonneuve et al. (2022).

[18] A simple back-of-the-envelope calculation provides somewhat smaller magnitudes. Taken the value from Jones (2002) of an additional year of schooling raising labour productivity by 7%, missing 1/5 of a year of learning progress implies a productivity loss by 1% for the (future) workers concerned. As the age cohorts concerned will account at maximum for around one third of the labour force in the future, this would suggest aggregate income losses peaking at around 0.3%. The survey by Sianesi and van Reenen (2003) reports effects of a one-year increase of average education on per capita output of 3-6% in a neo-classical growth specification, or a 1 pp increase in the growth rate according to endogenous growth theories.

[19] See the comparison in de la Maisonneuve et al. (2022).

[20] The model uses a new measure of the human capital stock and multivariate productivity regressions (Égert et al., 2022). The new measure is composed of the cohort-weighted average of past student test scores and mean years of schooling, to reflect both the quality and quantity of education of the working-age population. The authors compute the effect of the pandemic on human capital as the sum of population-weighted averages for each of the 16 cohorts of school-aged children. The effect on productivity is derived from regressions, which (controlling also for other factors) suggest that a 1 percent decrease in human capital is associated with more than 2 percent fall in the long-term total factor productivity (TFP) level.

Table 2: **Estimated effects of a 1-year learning deficit on economic output**

	Approach and sample	Dependent variables	Main results
Structural models			
Fuchs-Schündeln et al. (2022)	– Partial-equilibrium life-cycle model with overlapping generations – Calibrated to US data	Lifetime earnings of affected children	Present discounted earnings loss of 2.1% for affected children, on aggregate equivalent to 3% of 2019 US GDP
Jang & Yum (2022)	– General equilibrium model with overlapping generations (OLG) – Calibrated to US data – Younger students are assumed to catch up over time	Range of macroeconomic aggregates	Reduction of annual output during several decades with trough in 2080 at -0.7% (-0.5% in 2050)
Viana Costa et al. (2021)	– OLG macro model with rich heterogeneity across households in which an individual's labour productivity changes throughout lifetime and is affected by learning deficits – Calibrated to US data	Range of macroeconomic aggregates	Reduction of annual output, worsening during several decades until forecast horizon in 2056 (GDP effect -3.4% and labour productivity –2.9% in 2050)
Projection models			
Hanushek & Woessmann (2020)	– Regression of countries' average GDP growth on student test scores (PISA), years of schooling and initial GDP per capita; estimated 'growth coefficient' used in endogenous growth model (2% higher growth per standard deviation in educational achievement) – Data from OECD countries and emerging economies	Lifetime income Output growth	GDP –7.5% in 2100 (-4.7% by 2050) compared to no-COVID-19 baseline
Dorn et al. (2020)	– Hanushek & Woessmann (2008) correlation of academic achievement to GDP growth, combined with impact of school drop-outs due to the pandemic – Simulation for the US	Output in 2040	Output reduction of 1.1-1.8% of GDP in 2040 (no results reported for other years)
de la Maisonneuve et al. (2022)	– New measure of the human capital stock (cohort-weighted average of past student test scores and mean years of schooling of current cohorts) and multivariate productivity regressions (1-percent decrease in human capital associated with >2-percent fall in long-term TFP) – Assumes 16 cohorts to be affected equally, without catching up of younger students – Sample of OECD countries	Productivity (TFP)	Productivity losses until expected retirement of affected cohorts in 2083, peaking in 2067 at -1.1% TFP compared to no-COVID-19 baseline

Note: The presented estimates are specific for the COVID-19 pandemic, as they assume all cohorts that are in school during the learning shock to be affected. For comparison purposes, reported effects for different lengths of school closure are proportionally translated into a learning deficit of one school year. Based on the estimates of learning deficits in the EU of, on average, 20% of a school year, the economic impact for the EU could be scaled to 20% of the numbers presented in this table.

Studies based on data from non-EU OECD countries could overestimate the potential economic impact of learning losses for EU Member States. Even after considering that learning deficits were, on average, smaller in EU countries than non-EU OECD countries due to differences in the length of school closures, the level of digitalisation, and the quantity and quality of distance teaching, countries may differ in the channels of transmission from lower human capital to economic outcomes.

Countries also vary considerably with respect to the individual returns to skills, with significantly higher returns to skills found in the United States compared to European countries (Hanushek et al., 2015). Contributing factors could be higher union density, stricter employment protection legislation, and larger public sectors, which are related to lower wage inequality and thus lower individual returns to skills (Hanushek et al., 2015), inversely implying a lower economic impact of decreasing skills. Therefore, studies based on US data could overestimate the economic impact of learning deficits for the EU, which may furthermore differ widely between EU Member States. Finally, differences in remedial policies to compensate learning deficits, which are not accounted for by any of the estimates presented, could diversify the actual economic impact across countries in coming years.

CONCLUSIONS

The evidence on the impact of the COVID-19 pandemic on educational outcomes suggests significant learning deficits for school-aged children in several EU Member States, which equal approximately 20% of a school year's learning progress on average. Importantly, large inequalities in the learning deficits, driven particularly by students' socioeconomic status, could increase disparities in socio-economic outcomes.

Labour market outcomes of the 2020 graduating age cohort seem to be resilient at the current juncture of tight labour markets and simulations suggest small productivity losses for the coming years. A larger effect can be expected in the long term, peaking when all affected students will have entered the labour market, by the second half of the 21st century. The estimated long-term real GDP effects for an average learning deficit of approximately 1/5 of a school year in the EU range from -0.1% to -1% by 2050, compared to a baseline without any learning deficits and assuming no effective remedial action is taken. Realisations are likely to fall closer to the lower bound of this range in absolute value terms (-0.1%), since upper bound estimates rest on assumptions of a very strong and persistent deterioration of the quality of the labour force, assuming no policy change and no or little scope for compensating losses over time. Jack & Oster (2023) note that this is a very strong assumption, as the unprecedented school closures will likely trigger unprecedented compensation efforts, making it difficult to extrapolate short-term results on long-term consequences.

The estimates of learning deficits provided in this paper are based on available studies for a small selection of EU Member States and have limitations. Currently available study results are possibly biased by the selection of non-representative samples, missing data and potential measurement errors (Betthäuser et al., 2023). To reduce bias, the review of the empirical literature discussed in this paper excluded studies with small sample sizes, convenience samples, and absence of statistical adjustment for confounding factors.

At the same time, first internationally comparable data from the PIRLS 2021 reading assessment for 4th graders showed a decline of learning outcomes of a magnitude similar to the estimates put forward in this paper, reinforcing previously recorded negative time trends. Computing representative estimates for different subjects and age groups that are comparable across countries will only be possible after the publication of forthcoming comparative international studies, such as evaluations of the OECD's PISA 2022 for mathematics, reading and science, IEA TIMMS 2023 for mathematics and science, and IEA ICILS 2023 for digital skills.[21]

Monitoring the evolution of student achievement will be crucial to determine the persistence of learning losses over time. It will provide evidence on whether the affected age cohorts are able to catch up over the duration

[21] With the great advantage of providing comparable indicators, these international assessments of student achievement come with the disadvantage of being published with a delay. Another drawback of these tests is the small selection of subjects and grade years covered. For example, OECD's PISA, which tests 15-year-old students, includes varying optional components, resulting in a limited sample of countries. Also, some countries may choose not to participate.

of their remaining educational career, or whether, to the contrary, learning deficits are accumulating and increasing over time. For that matter, monitoring efforts at the national and regional levels remain important complements to comparative international studies, as local standardised tests often provide more timely and more detailed insights than large-scale international assessments. In addition to changes in student achievement, a wider range of student outcomes, which are not yet measured in a systematic way (e.g., mental health), could be considered when modelling the macroeconomic impact of the school closures in the future.

Compensatory policies, such as summer schools or tutoring programmes, have been shown to mitigate the learning deficits caused by the COVID-19 pandemic (De Witte & François, 2023). Tutoring, that is instruction in small groups, is a well-researched education method, which has proven to deliver large learning effects (e.g., Nickow et al, 2020; Dietrichson et al., 2017). Following the comparison of effect sizes made by Goldhaber et al. (2023), on average, 20% of students would need to be offered high-dosage tutoring (i.e., in groups of fewer than four students three to five times per week for at least 30 minutes) to compensate the estimated EU learning deficit. De Witte & François (2023) further recommend a stronger focus of the curriculum and investments on the digitalisation of education, including by strengthening internet connectivity, access to ICT tools, and the professional development of teachers in this area.

Given the rise in inequality, many remedial programmes focus on disadvantaged students. While this is important to ensure equity, inclusion and fairness in education, teachers also note that the strongest students are often neglected when inequality in the classroom is high. Gambi & De Witte (2023) find that, in Flemish schools, the weak performance of the best-performing students is contributing to an increase in learning deficits over time. As both basic skills and top skills are important drivers of economic growth, it is important to design compensatory policies in a way that gives learning opportunities to all students.

As all remedial actions require staff, addressing the teacher shortages currently observed in many EU Member States will be crucial to reverse the negative trend in learning outcomes. Teachers are playing an important role in reducing the COVID-19 learning deficits, since quality teaching is a key factor in improving educational outcomes. For the Flemish region of Belgium, Gambi & De Witte (2023) find that average learning deficits in 2022 were larger in schools with high shares of teacher shortages. Recruitment and retention of quality teachers can be ensured through financial incentives, work-stress reduction, teacher training and opening of alternative routes to teacher qualifications (Fack et al., 2023; de Witte et al., 2023).

On a positive note, the COVID-19 pandemic has been speeding up the digital transition in schools and given a stimulus to experiment with new ways of teaching. While access to technology alone is insufficient to contribute to skill formation, computer-assisted learning (software designed to improve academic skills) and technology-enabled behavioural interventions (e.g. text messages to guide students towards desirable behaviours) are effective in improving educational outcomes, when implemented by qualified teachers (Escueta et al., 2020).

Going forward, the experiences gained during the pandemic and the progress in digitalisation can be used to improve the quality of education in the EU. In the context of the Recovery and Resilience Facility, Member States have planned measures worth EUR 51 billion to improve 'general education' and 'early childhood education and care', including investment in digital education, and, for some Member States, targeted measures to mitigate learning deficits caused by the COVID-19 pandemic. The European Commission is also working with Member States through a recently created 'Learning Lab on Investing in Quality Education and Training'[22] to help them design policies and programmes which can make the EU educational systems more effective and equitable.

[22] https://education.ec.europa.eu/focus-topics/improving-quality/learning-lab.

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ANNEX 1 – STUDIES ON COVID-19 LEARNING DEFICITS FROM EU MEMBER STATES

Table A.1 **PIRLS 2021 results from EU Member States (Reading in Grade 4)**

Member State	***Change from 2016 to 2021***	*Change from 2011 to 2016*
Austria	-11 ↓	↑
Belgium (Flemish)	-14 ↓	*no data*
Belgium (French)	*no significant change*	↓
Bulgaria	-12 ↓	↑
Czech Republic	*no significant change*	*no significant change*
Denmark	-8 ↓	↓
Finland	-17 ↓	*no significant change*
France	*no significant change*	↓
Germany	-13 ↓	*no significant change*
Italy	-11 ↓	↑
Netherlands	-18 ↓	*no significant change*
Poland	-16 ↓	*no data*
Portugal	-8 ↓	↓
Slovakia	*no significant change*	*no significant change*
Slovenia	-23 ↓	↑
Spain	-7 ↓	↑
Sweden	-12 ↓	↑
Average	-10 PIRLS points ≈ 0.1 standard deviations ≈ 25% of a regular school year	

Note: Results as reported in IEA's Progress in International Reading Literacy Study - PIRLS 2021. Changes are expressed in PIRLS scale points, which, at the first assessment in 2001, was scaled to have 500 points as centre point and a standard deviation of 100. Downward (upward) pointing arrows indicate a significant negative (positive) change in test scores compared to the previous edition of the assessment. For EU Member States not included in this table, which participated in 2021, no comparable data was available from previous assessments. Bold arrows in the left column indicate that a previously positive or constant trend (2011-2016) has been reversed to a downward trend (2016-2021).

Table A.2 **Learning deficits measured in 2020 in EU Member States**

Member State	***Age***	***Grade***	***Subject***	***Learning deficit*** *(share of a regular school year)*	***Source***
Belgium	11	6	Mathematics	-0.40	Maldonado & De Witte (2021)
Belgium	11	6	Reading	-0.50	Maldonado & De Witte (2021)
Germany	9	4	Mathematics	-0.08	Depping et al. (2021)
Germany	9	4	Reading	0.00	Depping et al. (2021)
Germany	10	5	Mathematics	-0.17	Schult et al. (2022a)
Germany	10	5	Mathematics	-0.05	Depping et al. (2021)
Germany	10	5	Reading	-0.18	Schult et al. (2022a)
Germany	10	5	Reading	0.13	Depping et al. (2021)
Italy	8	3	Mathematics	-0.47	Contini et al. (2022)
Netherlands	6	1	Mathematics	-0.33	Haelermans et al. (2022)
Netherlands	7	2	Mathematics	-0.32	Haelermans et al. (2022)
Netherlands	7	2	Reading	-0.16	Haelermans et al. (2022)
Netherlands	8	3	Mathematics	-0.42	Haelermans et al. (2022)
Netherlands	8	3	Reading	-0.41	Haelermans et al. (2022)
Netherlands	8	4	Mathematics	-0.13	Engzell et al. (2021)
Netherlands	8	4	Reading	-0.12	Engzell et al. (2021)
Netherlands	9	4	Mathematics	-0.66	Haelermans et al. (2022)
Netherlands	9	4	Reading	-0.29	Haelermans et al. (2022)
Netherlands	9	5	Mathematics	-0.18	Engzell et al. (2021)
Netherlands	9	5	Reading	-0.21	Engzell et al. (2021)
Netherlands	10	5	Mathematics	-1.53	Schuurman et al. (2021)
Netherlands	10	5	Mathematics	-0.82	Haelermans et al. (2022)
Netherlands	10	5	Reading	-0.62	Schuurman et al. (2021)
Netherlands	10	5	Reading	-0.50	Haelermans et al. (2022)
Netherlands	10	6	Mathematics	-0.24	Engzell et al. (2021)
Netherlands	10	6	Reading	-0.20	Engzell et al. (2021)
Netherlands	11	6	Mathematics	-0.64	Schuurman et al. (2021)
Netherlands	11	6	Reading	0.56	Schuurman et al. (2021)
Netherlands	11	7	Mathematics	-0.14	Engzell et al. (2021)
Netherlands	11	7	Reading	-0.17	Engzell et al. (2021)
Netherlands	12	7	Mathematics	-0.62	Schuurman et al. (2021)

Netherlands	12	7	Reading	-0.51	Schuurman et al. (2021)
Sweden	7	1	Reading	0.12	Hallin et al. (2022)
Sweden	7	1	Reading	0.45	Hallin et al. (2022)
Sweden	8	2	Reading	0.05	Hallin et al. (2022)
Sweden	8	2	Reading	0.12	Hallin et al. (2022)
Sweden	9	3	Reading	0.18	Hallin et al. (2022)
Sweden	9	3	Reading	0.21	Hallin et al. (2022)
Average 2020				*-0.24*	

Note: Estimates from EU Member States selected by Betthäuser et al. (2023), sorted by Member State, age, grade, and subject. An average learning progress of 0.4 standard deviations per year is assumed (Hill et al., 2008).

Table A.3 **Learning deficits measured in 2021 in EU Member States**

Member State	***Age***	***Grade***	***Subject***	***Learning deficit*** *(share of a regular school year)*	***Source***
Belgium	11	6	Mathematics	-0.35	Gambi & De Witte (2021)
Belgium	11	6	Reading	-0.75	Gambi & De Witte (2021)
Denmark	7	2	Reading	0.20	Birkelund et al. (2021)
Denmark	8	3	Mathematics	0.05	Birkelund et al. (2021)
Denmark	9	4	Reading	0.22	Birkelund et al. (2021)
Denmark	11	6	Mathematics	-0.03	Birkelund et al. (2021)
Denmark	11	6	Reading	0.13	Birkelund et al. (2021)
Denmark	13	8	Mathematics	-0.03	Birkelund et al. (2021)
Denmark	13	8	Reading	-0.11	Birkelund et al. (2021)
Germany	10	5	Mathematics	-0.18	Schult et al. (2022b)
Germany	10	5	Reading	-0.04	Schult et al. (2022b)
Germany	11	4	Reading	-0.35	Ludewig et al. (2022)
Italy	10	5	Mathematics	-0.36	Bazoli et al. (2022)
Italy	10	5	Mathematics	0.09	Borgonovi & Ferrara (2022)
Italy	10	5	Reading	0.08	Borgonovi & Ferrara (2022)
Italy	10	5	Reading	0.14	Bazoli et al. (2022)
Italy	13	8	Mathematics	-0.73	Bazoli et al. (2022)
Italy	13	8	Mathematics	-0.35	Borgonovi & Ferrara (2022)
Italy	13	8	Reading	-0.19	Borgonovi & Ferrara (2022)
Italy	13	8	Reading	0.00	Bazoli et al. (2022)
Italy	18	13	Mathematics	-0.68	Bazoli et al. (2022)

Italy	18	13	Reading	-0.79	Bazoli et al. (2022)
Netherlands	8	1-5	Mathematics	-0.31	Haelermans et al. (2021)
Netherlands	8	1-5	Mathematics	-0.26	Haelermans (2021)
Netherlands	9	2-5	Reading	-0.43	Haelermans et al. (2021)
Netherlands	9	2-5	Reading	-0.17	Haelermans (2021)
Spain	13	8	Mathematics	-0.20	Arenas & Gortazar (2022)
Spain	13	8	Reading	-0.14	Arenas & Gortazar (2022)
Spain	13	8	Reading	0.00	Arenas & Gortazar (2022)
Sweden	7	1	Reading	0.14	Hallin et al. (2022)
Sweden	8	2	Reading	0.12	Hallin et al. (2022)
Sweden	9	3	Reading	0.12	Hallin et al. (2022)
Average 2021				*-0.16*	

Note: Estimates from EU Member States selected by Betthäuser et al. (2023), sorted by Member State, age, grade, and subject. An average learning progress of 0.4 standard deviations per year is assumed (Hill et al., 2008).

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