European Commission

EENEE
European Expert Network on Economics of Education

Covid-19 learning deficits in Europe: analysis and practical recommendations

Analytical report

Education and Training

PPMI

Getting in touch with the EU

Europe Direct is a service that answers your questions about the European Union.
You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11

(certain operators may charge for these calls),

- at the following standard number: +32 22999696 or
- by email via:https://europa.eu/european-union/contact_en

Luxembourg: Publications Office of the European Union, 2023

PDF ISBN 978-92-76-55798-2 doi: 10.2766/881143 NC-05-22-231-EN-N

EUROPEAN COMMISSION

Covid-19 learning deficits in Europe: analysis and practical recommendations

Kristof De Witte and Maxime François

Leuven Economics of Education Research, KU Leuven

Directorate-General for Education, Youth, Sport and Culture
2023 The European Expert Network on Economics of Education (EENEE) EN

Please cite this publication as:

De Witte, K. and François, M. (2023). 'Covid-19 learning deficits in Europe: analysis and practical recommendations', *EENEE Analytical report.* doi: 10.2766/881143.

ABOUT EENEE

EENEE is an advisory network of experts working on economics of education and training. The establishment of the network was initiated by the European Commission's Directorate-General for Education and Culture and is funded by the Erasmus+ Programme. PPMI is responsible for the coordination of the EENEE network. More information on EENEE and its deliverables can be found on the network's website www.eenee.eu. For any inquiries, please contact us at: eenee@ppmi.lt.

Contractor:

PPMi

Gedimino pr. 50, LT - 01110 Vilnius, Lithuania
Phone: +370 5 2620338
E-mail: info@ppmi.lt
www.ppmi.lt

AUTHORS:

Kristof De Witte, KU Leuven (Belgium)

Maxime François, KU Leuven (Belgium)

PEER REVIEWERS:

Miroslav BEBLAVÝ, EENEE Scientific Coordinator

Ides Nicaise, KU Leuven

LANGUAGE EDITOR:

James Nixon, Freelance editor

EUROPEAN COMMISSION

Directorate-General for Education, Youth, Sport and Culture
Directorate A — Policy Strategy and Evaluation
Unit A.4 — Evidence-Based Policy and Evaluation

E-mail: eac-unite-a4@ec.europa.eu

European Commission
B-1049 Brussels

Table of contents

Foreword

Three years ago, the Covid-19 pandemic triggered the biggest disruption to our education systems in several decades. From the start of the pandemic, the European Commission has worked closely with Member States to respond to it. The European Education Area has facilitated this effort, as it sets out a clear vision and priorities for education in Europe, and provides a reinforced framework for cooperation with and between Member States and stakeholders of the education community.

In this context, understanding how Covid-19 affected pupils' learning outcomes across age, subject, gender and socio-economic background is a necessary pre-condition to identify which policy measures can effectively help reverse any learning losses. This report provides a comprehensive analysis and a clear synthesis of the research developed in this field in many European countries between 2020 and 2022.

While the size of the effects of Covid-19 was rather heterogeneous across countries and groups of pupils, researchers have identified several types of policy interventions that are proving to remedy observed learning losses. They focus on compensatory measures targeted to the groups of students whose learning outcomes were most affected by the pandemic, on investing in quality of education and on developing adequate monitoring and policy evaluation systems.

The European Commission is supporting Member States in all these policy areas. Addressing inequalities in educational outcomes is a priority of the European Education Area. The "Pathways to School Success" initiative is a step in this direction as it provides comprehensive policy guidance to reduce early leaving from education and training, to help all pupils reach the necessary level of proficiency in basic skills, and cater for the well-being of pupils. Significant support for investment in education and skills is available to Member States through the Recovery and Resilience Facility, amounting to more than 70 billion euros. On top of this, cohesion policy funding will contribute considerably to investments in quality of education in the next years. The investment focus on digital education will strengthen the resilience of our education systems. The newly created "Learning Lab on Investing in Quality Education and Training" will work with Member States to promote the use of rigorous evaluation tools and practices in education policymaking.

These examples show how much we are committed to our ambitions of opening up new opportunities and maximising learning outcomes and inclusion of all our youth.

Mariya Gabriel
Commissioner for Innovation, Research, Culture, Education and Youth

Executive summary

1. Aim

The aim of this report is threefold. Its first section provides an overall sketch of the situation across Europe and the underlying mechanisms for the differences in European countries. The second section focuses on the heterogeneities within each country. It examines the disparities among students in order to understand which of those correlate with larger learning deficits or worsening mental health. Section 3, considers the findings of the first two sections in order to discuss five policy recommendations for the short and long run.

2. The influence of COVID-19 on educational attainment in the EU

Overall, learning deficits due to the COVID-19 crisis vary between no effect at all, reported in the Nordic countries (Denmark, Finland, Sweden), and the large effects observed in Greece and Poland. In Greece, the learning deficit is estimated at 0.22 standard deviations (SD) in 2019-2020, further accumulating to 0.3 SD in 2020-2021. In Poland, an average learning deficit of 0.3 SD is observed in 2020-2021. More generally, for the countries included in this report we computed an average learning deficit around 0.11 SD. Although the value is small, it can be considered equivalent to between one and three months' learning deficit, as a broad indication.

Although the learning deficits occurred because of multiple reasons, the learning deficits observed in Europe reveal the following picture:

- **The more accustomed a country is to relying on ICT for educational purposes, the more resilient the test scores are for that country.** In line with the reports made by the OECD Education Policy Outlook (OECD 2020a, 2020b and 2020c), the PISA and TALIS databases (OECD, 2019a; OECD, 2019b), those in the Digital Economy and Society Index (DESI), as well as the index (IRDLL) developed by the Centre for European Policy Studies (CEPS), countries with advanced levels of digitalisation suffered lower learning deficits than countries with low levels of digitalisation pre-pandemic.
- Nonetheless, **advanced digitalisation is only a necessary condition for avoiding large learning deficits; a sufficient condition to reduce learning deficits is the intensive use of ICT in education prior to the pandemic.** For example, Belgium (Flanders) ranked 9th in terms of its digital economy (DESI, 2019a), but used little ICT in schools before the pandemic (OECD, 2019a). Similar patterns are seen in France and Spain (Basque Country). Moreover, if digitalisation is a resilience factor, it can also improve education outcomes. Several articles reported evidence of higher educational achievements among students who used remote learning tools both before and during the school closures (Birkelund and Karlson, 2021; König and Frey, 2022; Reimer et al., 2021; Van der Velde et al., 2021).
- **The younger the students, the larger the learning deficits observed.** In a meta-analysis, we observe a negative non-significant correlation of -0.32 between student ages and learning deficits. Regression analysis reveals that a student who was one year older is likely to have higher education outcomes (in other words, a lower learning deficit) by +0.005 SD (however, insignificant, due to a lack of power). Despite the insignificant relationship in our meta-analysis, country-specific studies observe a significant relationship between age and learning deficits (e.g. DEPP, 2020b; Ludewig et al., 2021; Molnár and Hermann, 2022; Schult et al., 2022; Tomasik et al., 2021; Blainey and Hannay, 2021).
- **The longer the school closure, the larger the learning deficit**. In line with a previous review (Patrinos et al., 2022) our meta-regression for European countries suggests that for one week longer school closure, achievements decrease by 0.007 SD (non-significant result due to a lack of power). In a separate meta-analysis, we observe a non-significant correlation of 0.615 between the length of the school closure

in weeks and the learning deficit. Despite the insignificant relationship in our meta-analysis, country-specific studies observe a significant relationship (Blainey and Hannay, 2021; Lambropoulos and Panagiota, 2022; Molnár and Hermann, 2022).

- **COVID-19 reinforces existing trends.** Analysing PISA results since 2006 indicates an average downward trend in learning outcomes since 2012 across Europe, which has been exacerbated by the COVID-19 crisis. From a quantitative perspective, this pattern is crucial since, if it is not accounted for in empirical analysis, the negative trend effect will be absorbed into the pandemic effect, leading to biased estimates. Similarly, if not accounted for, the downward trend in test scores means that the older the control cohort, the larger the estimated learning deficit.
- **Future trends are unclear.** Early simulations suggested that the learning deficits following the COVID-19 pandemic would increase over time (Angrist et al., 2021; Kaffenberger, 2020) and could lead to 3% decrease in lifetime income (Hanushek and Woessmann, 2020). Our findings are not so pessimistic, but the overall picture remains unclear. Articles measuring the effect one year after the school closures – i.e. using test data from 2020-2021 on average report better results than articles relying on test data from immediately after the school closures in 2019-2020 (Borgonovi and Ferrara, 2022; Education Policy Institute, 2021). However, these findings cannot be considered to represent a general situation. Germany, Greece and the Netherlands indicate a large worsening of results in 2020-2021, even compared with those from 2019-2020 (Haelermans et al., 2022b; Lambropoulos and Panagiota, 2022; Ludewig et al., 2022; Schult et al., 2022). Moreover, there also appears to be heterogeneity between the subjects tested (Gambi and De Witte, 2021). Overall, prior analyses and empirical evidence emphasise the needs of acting quickly to maintain a high quality education among the generation that was at school during the COVID-19 disruptions.

3. Attention to specific subgroups

In addition to heterogeneity between EU Members States, the literature review has identified multiple subgroups among whom learning deficits are more evident. Membership of each subgroup has an independent influence on learning deficits, but they also correlate with one another.

- **Socio-economic status (SES).** Across all of the articles analysed, SES is the most commonly studied variable. Low-SES students are commonly identified as those with parents who have a low level of education, living in a disadvantaged neighbourhood, or earning a low income. Students in low-SES groups are, on average, associated with more than double the learning deficit compared with average pupils (Contini et al., 2021; Engzell et al., 2021; EPI, 2021; Haelermans et al., 2022a; Maldonado and De Witte, 2021; Rose et al., 2021). These findings are even more conspicuous when comparing high- versus low-SES pupils.
- **Inequalities between strong and weak students.** The COVID-19 crisis also raised the gap between the highest- and lowest-performing students. Several papers from Denmark, Germany, Belgium (Flanders) and Italy report an increase in the polarisation of the scores (Birkelund and Karlson, 2021; Maldonado and De Witte, 2021; Schult et al., 2022). Interestingly, in Italy two articles linked inequalities in school performance with the SES of students. One found that low-SES, but high-performing students suffered more from the school closures than high-performing students from high-SES backgrounds (Contini et al., 2021) while the other one found the opposite (Borgonovi and Ferrara, 2022).
- **Gender gap.** We observe mixed evidence regarding whether school closures reinforced a gender gap in education. This mixed evidence seems to be rooted in the methodologies applied.
- **Mental health.** At first sight, the lengthy school closures have been associated with negative effects on the well-being of students, including feelings of loneliness, anxiety, depression and suicidal behaviour (Champeaux et al., 2020; Mazrekaj and De Witte, 2022). One crucial implication of this poor socio-emotional status is that the evidence

suggests it is related to greater learning deficits (Arenas and Gortazar, 2022). However, inequalities also exist in relation to such effects. For instance, more "conscientious" and "open" individuals are more likely to have experienced the school closures in a positive way, and therefore have not suffered from a decrease in their socio-emotional status (Iterbeke and De Witte, 2021). Furthermore, Champeaux et al. (2020) observe that less well-educated parents reported that school closures had more negative effects on their children compared with highly educated parents.

- **Children of parents who are essential workers.** Some essential workers may also be defined as low-paid workers who work long hours and who struggle to provide support to their children, or to have school-related interactions with them (Garbe et al., 2020; Mutch, 2021). In the EU, an important share of the essential workers during the pandemic were low-skilled workers employed mainly in commerce distribution, food processing or health (OECD, 2020e). Although these workers constituted 42% of the workforce in 2020 (Samek Lodovici et al., 2020), little attention has been paid to them except for studies in the USA and New Zealand. The description of essential workers given above is similar to that used to identify low-SES parents. This implies that figures relating to the effect that having parents who are essential workers has on children's learning deficits can be approximated by considering the results for low SES.
- **Migrants.** Most papers presented in this report did not find amplified learning deficits among students with a migration background (Arenas and Gortazar, 2022; Ludewig et al., 2022; Maldonado and De Witte, 2021; Schult et al., 2022). However, a qualitative study from Slovenia indicates that migrants reported greater difficulties in understanding the national language during remote learning compared with face-to-face classes. This, in turn, increased language barriers and led to less interaction through which to practice the national language (Gornik et al., 2020).
- **Students with special educational needs (SEN).** Evidence is mixed in the case of students with SEN. Several issues that existed prior to the pandemic have been aggravated since the beginning of the pandemic. For instance, the COVID-19 crisis increased the difficulty of these students in receiving learning support, lost access to certain specialised tools and reduction of social interactions (Koelher et al., 2022). Nevertheless, such effects may vary widely, in Germany for instance, pupils with SEN appear not to have been more impacted than other students by the COVID-19 crisis (Nusser, 2021).

4. Conclusion and recommendations

Based on the disparities between and within EU Member States, the present analysis has allowed us to formulate policy recommendations targeted at country level and at the level of students.

- **(a) Short term – Compensatory policies:** The implementation of compensatory policies, such as summer schools or tutoring programmes, is an evidence-based way to recover from the effects of the pandemic (Arcia et al., 2022). The articles covered in this report emphasise the positive outcomes and the cost-effectiveness of compensatory policies to counteract the learning deficit caused by the COVID-19 crisis (Borgonovi and Ferrara, 2022; Depping et al., 2021; EPI, 2021; Gambi and De Witte, 2021).
- **(b) Short term – Targeted compensatory policies.** Given the larger learning deficits among low-SES students, compensatory policies should focus on disadvantaged students. In addition, our analysis shows that in relation to socio-emotional skills, the current "one-size-fits-all" approach to education does not work (Iterbeke and De Witte, 2021). Instead, ways of teaching should be adapted according to the needs and preferences of the students. For instance, students with high levels of conscientiousness and low levels of extraversion self-report improved education outcomes as a result of remote learning, such that remote teaching could be maintained for this subgroup even after the pandemic. Remedial programmes should

also focus on the youngest students, as evidence indicates that younger students have suffered more from the COVID-19 crisis. In countries where the length of school closures differed by location (e.g. in Italy, Germany, the Netherlands), efforts should focus on those areas that underwent longer periods of remote teaching.

- **(c) Short and long term – Monitoring.** To implement recommendations (a) and (b) in an adequate way, standardised tests could be used to detect needs, but also to monitor whether or not progress has been made. Furthermore, questionnaires evaluating personality traits could help educators to adapt their recovery plans. For reasons of efficiency and comparability, these tests should be standardised at EU level.
- **(d) Long term – Adapt the curriculum.** Simplifying and adapting the curriculum has been suggested in order to focus on the needs and strengths of the students. The idea is to prioritise those basic skills in which learning attainments were lowered by the pandemic: numeracy, literacy, etc. On the other hand, to ensure that a focus is not lost on top-performing students, strong students could receive a more demanding curriculum.
- **(e) Long term – Investments.** The Recovery and Resilience Facility (RRF) helps EU Member States to make large investments in education. Around 14% of these investments, or EUR 71 billion, is directed towards education. However, these investments should be made in the most cost-effective way. Therefore, we recommend rigorous testing (e.g. through the use of experiments or quasi-experiments) of the impact of such investments, linking the costs of each initiative with its effectiveness. Although the report by Fack et al. (2022) reviews a number of different cost-effective measures, the present literature review signals the importance of ICT investments. Countries that used ICT hardware and software in education were better able to cope with school closures. Furthermore, ICT investments should also be targeted with respect to inequalities in educational outcomes.

Introduction

The accumulation of human capital is associated with crucial aspects of modern life. Among other aspects, income, employment and general prosperity correlate strongly with the quality and quantity of education a person receives (Chetty et al., 2014; Currie and Thomas, 2001; Hanushek and Woessmann, 2020). The school closures aimed at preventing the spread of COVID-19 seriously affected the learning process of millions of students worldwide. Because these closures prevented students from making progress at the same pace they had previously, and because knowledge and skills were forgotten, 'learning deficits' were developed. However, these learning deficits were not evenly spread among the population. Even within developed countries, such as in the European Union (EU), significant heterogeneity exists in learning deficits, both within and between the Member States.

Section 1 of this report provides a systematic, country-by-country overview of average learning deficits due to the pandemic at the level of compulsory education. This overview includes all publications up to 1 December 2022. In Section 1, differences between European countries are highlighted and, where possible, underlying reasons for these differences are explored. Due to the focus of this study on articles published in English and which use standardised tests, it lacks information with regard to the influence of the pandemic on educational attainments in almost half of the EU's 27 Member States. Specifically, no information is available regarding Austria, Bulgaria, Croatia, Cyprus, Estonia, Ireland, Latvia, Lithuania, Malta, Portugal, Romania, Slovakia, Slovenia. Section 2 documents the student characteristics that correlate with learning deficits. In addition to the socio-economic status (SES) of students, we provide an overview of observed characteristics such as special educational needs (SEN), mental health, or socio-emotional characteristics. The third section of the report explores the policy advises of these learning deficits in the short and long term.

From a methodological perspective, the present report builds on earlier literature reviews by Patrinos et al. (2022) and Moscoviz and Evans (2022). Accordingly, some of the papers presented in this report have also been discussed in these reviews. Additional papers were retrieved by using the Scopus and Google Scholar search engines, by applying the following keywords: ("COVID-19" OR "coronavirus" OR "pandemic") AND ("learning loss" OR "learning slide" OR "learning outcomes" OR "school outcomes" OR "learning deficit" OR "attainment deficit"). In the report, we focus on the geographical area of Europe. Whenever possible, we have interpreted the learning deficits in all papers in terms of standard deviations (SD). Presenting learning deficits using SD allows us to compare studies across time and geography, as the original scaling of the outcome variable is rescaled to a normal distribution with mean 0 and standard deviation of 1. Turning the estimated coefficients into months of schooling relies on approximations that are not estimated directly but are "averaged" across different studies. Therefore, learning deficits in months should not be taken as an absolute measure, but as a rough approximation. A report from the Education Endowment Foundation (EEF) in the UK provides an example in which the effect sizes noted in British and international studies have been compiled into a summary table.[1]

[1] https://d2tic4wvo1iusb.cloudfront.net/documents/toolkit/EEF-Toolkit-guide.pdf?v=1668363962.

1. Influence of COVID-19 on educational attainments in Europe

This section of the report systematically reviews the influence of COVID-19 on educational attainments in 13 EU Member States, as well as in the UK (England) and Switzerland. It focuses on educational attainments, while the subsequent section also includes non-cognitive outcomes. As significant heterogeneity can be seen in the findings, we provide an overview of potential mechanisms that might explain the differences observed. Overall, the average learning deficit across all studies presented is equal to 0.11 SD, which corresponds to a learning deficit of roughly between one and three months. More precisely, in terms of distribution, our estimated average learning deficit suggests that the median student (i.e. student at position 50 out of 100) before the pandemic would be in the 46th percentile after the pandemic. More recently, Patrinos et al. (2022) computed a higher average (0.17 SD), as they considered additional studies focusing on (non-EU) countries which were severely affected by the pandemic and had longer school closures. This section of the report is complemented by two appendices: Appendix A presents the key figures discussed in this section, while Appendix B maps the average learning deficit and weeks of school closure in 2019-2020 and 2020-2021 by country. The EU Members States are presented in alphabetical order, followed by UK (England) and Switzerland. We include the latter two non-EU countries due to their strong ties with the EU and the rich evidence available.

1.1. Belgium (Flanders)

An early report by Maldonado and De Witte (2022) focuses on Grade 6 students (11-12 years old), which corresponds to the final year of primary education. Using a panel data regression approach, they compare the results of a standardised test among Flemish primary schools before and after the pandemic. Their results suggest that immediately after the pandemic, the 2020 cohort of students obtained maths test scores that were 0.17 SD lower than those of the pre-pandemic cohort of 2019. Standardised test scores in the students' native language, Dutch, were 0.19 SD lower in 2020.

In a follow-up paper, Gambi and De Witte (2021) extended the previous sample to 2021 student assessments. One year on, the observed impact of the pandemic on educational attainments was slightly lower in maths (-0.11 SD in 2021, compared with the 2019 result of -0.17 SD), although the learning deficit was further amplified in the students' native language, Dutch (-0.24 SD). Given that the language test scores had dropped further one year on, the results of Gambi and De Witte (2021) are in line with earlier research that observes weak resilience in test scores (Belot and Webbink, 2010; Goodman, 2014). Second, the approach taken by Gambi and De Witte also allowed them to identify "the change in test scores one year after the first wave of COVID-19". This latter variable emphasises how test scores changed following the measures that were taken one year after the school closures. While in mathematics this coefficient is not significant, in Dutch it is around -0.23 SD. In other words, if the pandemic was still having an impact on students in 2021, its effect in mathematics had now been contained. In Dutch, however, the overall effect had further declined over time, leading to a total decrease in the average score of -0.47 by 2021, compared with the score in 2019.

To contextualise these findings, even before the COVID-19 pandemic, the Flemish education system was already observing a downward trend in international educational comparisons (e.g. PISA, TIMSS, PIRLS) and national assessments (e.g. the *peilingonderzoek*) (Dockx et al., 2019). As shown by Gambi and De Witte (2021), although the attainment deficit in Dutch has grown over time, the pandemic only accelerated an existing trend. This negative trend is illustrated in Figure 1. By plotting the average PISA

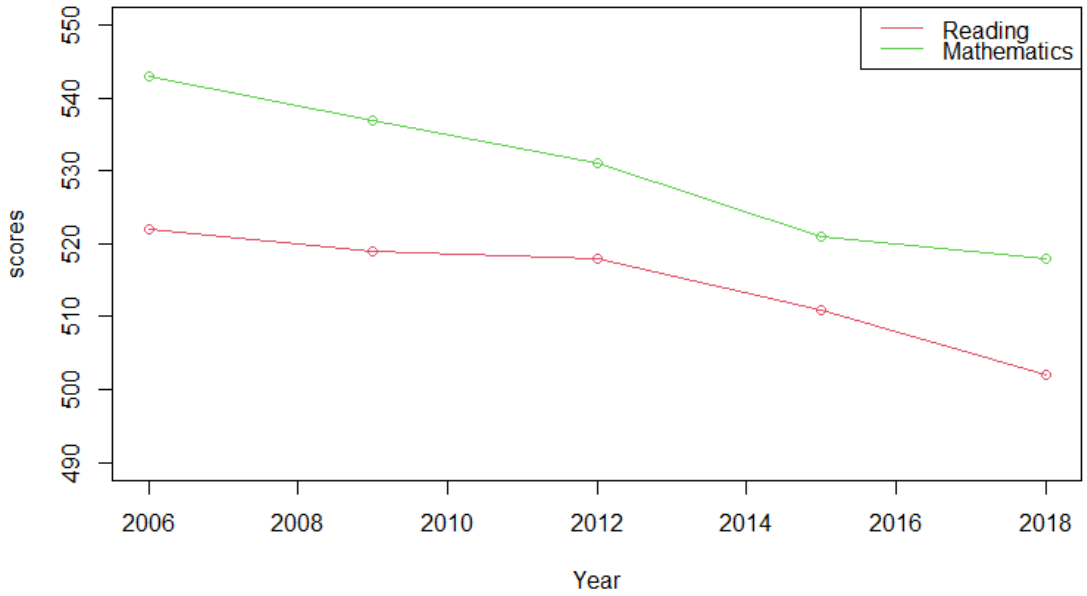
score in reading and mathematics for Flanders, it can be observed that the level of attainment in language has declined steadily since 2006. The result in mathematics shows a slightly less evident fall since 2015.

The containment of the learning deficit in mathematics in 2021 may be explained by government investment to support education and remote learning during the years 2021 and 2022. As reported by De Witte and Smet (2021), for the first four grades of Flemish primary education, up to EUR 25 per child was spent on shared devices, as well as EUR 290 per child on individual devices for the 5th and 6th grades. But despite the significant investment in education in the aftermath of the pandemic, as well as the relatively good position of Belgium in terms of digitalisation[2], the learning deficits observed in Flanders are relatively high compared with other countries and regions. This could be explained by the relatively low use of ICT in schools, in spite of the country's good performance in terms of digitalisation in general. According to the PISA database, the Belgian index for the use of ICT tools at school is around -0.18 while the average[3] for some European countries is 0.07 (OECD, 2019a). In line with this, the TALIS database indicated that in 2018, only 56% of the Flemish teachers considered themselves able to support students' learning with ICT tools. This result is one of the lowest among the countries presented in this report, and below the average of 66.9% calculated for the countries included (OECD, 2019c). A report from the Centre for European Policy Studies (CEPS) prior to the pandemic developed an Index of Readiness for Digital Lifelong Learning (IRDLL), which gathers the above figures into one single performance index. In other words, the index ranks each European country in terms of achievement in ICT use for educational purposes. Belgium was ranked 21st out of 27[4] EU Member States (Beblavý et al., 2019) in 2019. The latter finding emphasises again the role of digital learning in the range of the estimated learning deficits and the needs of Belgium to catch up its delay in this field.

Lastly, when comparing the effects observed in Flanders in comparison to the other EU Member States presented in this report, it appears that having a higher learning deficit in language than in mathematics is rather uncommon. However, better scores in mathematics compared with language (as shown for Flanders in Figure 1) are common to most EU countries (see below, Figure 5).

[2] The country ranked ninth out of 28 EU members in a ranking for the digital economy in 2019 (DESI, 2019a).
[3] This average is based on the European countries for which data were available, namely Belgium (Flanders), Czechia, Denmark, Italy, Poland, Spain (Basque Country), Switzerland and United Kingdom (England).
[4] There were 28 countries in the EU in 2019. Still, the report of the CEPS focused only on 27 countries.

FIGURE 1. Average PISA trend 2006-2018 Flanders



Note: average PISA score in reading and mathematics in Flanders between 2006 and 2018. The figure suggests lower test scores in reading than in mathematics, and a downward trend in reading since 2006.
Sources: reports from PISA (2007, 2010, 2014, 2016) and OECD (2019b).

1.2. Czechia

Korbell and Prokop (2021) estimated the influence of the pandemic on Grade 5 students (10-11 years old) using standardised tests. The test was administered both before the pandemic, in February 2020, and right after the school closures, in May 2020. As the test outcomes did not improve during this period, and scores even deteriorated for math, Korbell and Prokop (2021) conclude that the reduction in student educational attainments is equal to about three months of education, which corresponds a decrease of 0.10 SD in Czech language and 0.12 SD in mathematics. The authors admitted that their sample was not representative of the Czech school population since low-SES and least performing school were not sufficiently considered. As a result, the learning deficit observed by Korbell and Prokop (2021) might be a lower bound of the deficit in a representative sample of the Czech school population.

An analysis of the OECD Education Policy Outlook (OECD, 2020a) states that 88.7% of Czech students from disadvantaged schools had access to a computer and could use it for schoolwork, which is higher than the OECD average of 81.5%. In addition, broadband availability in the country is among the best in the EU (DESI, 2019b), which is equally important to access to ICT, and crucial in setting up remote learning. The same report ranked digitalisation in Czechia 18th out of 28 EU Member States. Given these statistics, Czechia is clearly not among the lowest-performing countries in the EU in terms of digitalisation, but neither is it among the leaders. Even so, the country's test results forced it to react: in late 2020, 74,000 ICT tools (laptops, smartphones and tablets) were bought by the government to sustain education (European Commission, s.d.). Since these investments were made after the first wave of COVID-19, they do not provide any explanation for the results of Korbell and Prokop (2021).

The relatively limited learning deficit seen in Czechia compared with Belgium (Flanders), cannot be explained solely by broadband availability. As already noted, Czechia's overall performance in digitalisation was not strong enough to be the only explanation. Similarly, PISA indices do not indicate a high level of performance in Czechia compared with other European countries. For instance, the Czech index for the use of ICT at home for schoolwork in 2018 was around -0.07, compared with an average in 2018 of 0 (OECD, 2019a). The country did not perform better in the use of ICT at school, with an IRDLL that placed the country in the 23rd position out of 27 countries (Beblavý et al., 2019). Considering the latter close (and even worse) results of Czechia compared with Belgium, the IRDLL explains even less the smaller estimated learning deficits.

1.3. Denmark

Evidence from Denmark suggests that the COVID-19 pandemic did not have a strong influence on educational attainments, although the average hides significant heterogeneity. In a sample of around 200,000 observations, Birkelund and Karlson (2021) applied a difference-in-differences (DiD) regression model based on reading and mathematics standardised tests. The research was conducted among pupils in Grades 2, 4, 6 and 8 (i.e. 8, 10, 12 and 14 years old). The youngest students experienced a learning gain in reading from the school closures, with an increase of 4.8 percentile points. Similarly, Grades 4 and 6 made gains of 5.1 and 3.0 percentile points, respectively. Conversely, Grade 8 showed an attainment deficit of -2.8 percentile points. On the basis of these findings, the authors estimate that the shortfall in education outcomes in Denmark, in terms of standard deviation, equals 0. Regarding test scores in mathematics, the results are similar to those for reading tests. Hence, the paper concluded that there has been no overall slowdown in student learning in Denmark.

These findings are remarkable, given the relatively lengthy school closures in Denmark, depending on the students' grade. Still, these findings are confirmed by Reimer et al. (2021) who evaluated the reading time spent by 4th- and 5th-grade pupils. From a graphical analysis of the time that students spend reading, they conclude that school closures resulted in a "beneficial effect" on pupils. The school closures increased the time students spend reading to a higher level at the end of the pandemic compared with the level pre-COVID.

The paper by Reimer et al. (2021) illustrates a potential mechanism by which Denmark addressed the health crisis. A key mechanism may be found in Denmark's level of preparedness before the pandemic. The Education Policy Outlook (OECD, 2020b) stated that 96.5% of students from disadvantaged schools in Denmark had access to a computer and could use it for schoolwork, while the OECD average at the time was 81.5%. Denmark's level was the highest observed in any country studied by the OECD. Similarly, the DESI (2019c) ranked Denmark fourth out of 28 EU members for its digital economy. Furthermore, in a survey, a majority of Danish teachers responded that they had successfully replaced in-class teaching with remote learning thanks to the use of applications for online communication (Danish Evaluation Institute, 2021). PISA results also indicate that Denmark is the country that uses the most ICT at school for educational purposes, with an index around 0.6 (OECD, 2019a). In addition, Denmark reported the highest share of teachers who were able to support education using ICT tools, at 88% (OECD, 2019c).

Still, the positive findings observed for younger age groups did not apply to older students from Grade 8. Danish sanitary restrictions were much more severe for older students, who had to remain out of school for 22 weeks while younger pupils had just eight weeks of school closures. Reimer et al. (2021) argue that the length of confinement – more than twice as long, for a student aged 14 years, compared with younger pupils – might explain

the difference in learning deficit. Indeed, longer school closures are associated with a higher attainment deficit (Patrinos et al., 2022). The link between the length of school closures, age, and learning outcomes will be discussed more broadly in the last subsection of Section 1.

Similarly, König and Frey (2022) ran a meta-analysis of published papers to evaluate the impact of COVID-19. This meta-regression does not reveal any significant coefficients due to its low statistical power. However, the authors do observe a common trend among countries in which positive outcomes were seen, namely in Germany (based on Spitzer and Musslick, 2021) and the Netherlands (based on Van der Velde et al., 2021). All these studies were based on remote learning apps or ICT tools that were being used by pupils *before* the pandemic, such that students were familiar with them. Due to the COVID-19 school closures, their use intensified, but there was no need for specific adaptation on the part of either teachers or students. The fact that pupils and teachers were already prepared for this type of ICT-based learning helped to prevent students from developing a learning deficit. Notably, König and Frey (2022) did not cover Denmark in their paper, and yet both Danish papers – i.e. Birkelund and Karlson (2021) and Reimer et al. (2021) – are based on online remote learning test data from an app. The former paper uses the scores of an online test undertaken by 8-year-old students. The latter uses data from a widely used online reading app, already used as an ICT tool for education prior to the pandemic.

1.4. Finland

Lerkannen et al. (2022) have studied the learning deficits of students from Grades 1 to 4 after eight weeks of school closures. The authors used ANOVA and maximum likelihood models to determine the influence of the pandemic on the learning deficits and educational trajectories of the students. Both models compared the learning achievements in mathematics and reading to a pre- and post-COVID sample. Learning deficits varied by grade. The reading skills of Grade 3 students were lower in the post-COVID sample. However, their learning trajectory was similar to the pre-COVID trend, when observing results in the 4th grade. Meanwhile, they did not show any gap or slower learning trajectory in mathematics, meaning that the pandemic had no effect on learning. Unfortunately, due to the methodological choice, it is impossible to provide figures measuring the learning deficit in the 3rd grade.

Despite the lack of precise values characterising the attainment deficit, the Finnish results appear positive. If there was a delay for the COVID-19 cohort in Grade 3, the Grade 4 results show no significant difference compared with the control cohort.

In terms of underlying mechanisms, Finland was the best-prepared country in the EU in terms of its digital economy (DESI, 2020a) and the use of remote learning. A wide variety of ICT tools are available, as are stable broadband connections, widespread 5G mobile connectivity, and a very large share of the population used the internet (90%) or had basic skills in ICT (nearly 76%). Equivalent results from the OECD (2020c) indicate that 91.8% of pupils from a disadvantaged background in Finland had access to ICT for their schoolwork, compared with the OECD average of around 81.5%. Furthermore, 80% of Finnish students are in a school whose principal considers it to have an effective online learning platform available, compared with 50% on average across all countries presented in the report (OECD, 2019a). In terms of ICT use for educational purposes, the country was ranked 3rd out of 27 in 2019 (Beblavý et al., 2019), which shows again the preparedness of the country for remote learning. All these findings allow us to conclude that, even though there is no clear significant measure of the learning deficit, there is evidence that the deficit in Finland is smaller than that in other EU Member States. Furthermore, the government spent around EUR 17 million on secondary schools in 2020 to help them reduce attainment deficits. In 2021, another EUR 67.8 million was allocated

to fight inequalities in education attainment among pupils (De Witte and Smet, 2021). Unfortunately, no information was found about summer schools or other mechanisms set up that could explain the Finnish recovery and the lack of a gap between the pre- and post-COVID learning trajectories.

1.5. France

In France, the only evidence regarding educational attainment during the pandemic is provided by the Ministry of Education (DEPP, 2020a and 2020b). Although this information has the advantage of covering nearly all students in the country[5], it also provides a limited interpretation, since it relies only on descriptive statistics and trends. DEPP (2020a and 2020b) indicated positive results from a national standardised test of pupils aged 6-7 and 10-11 years (1st and 6th grade, respectively). The test results are grouped in "pass thresholds". Being below the first threshold means that a pupil has not mastered the subject. Being below the second threshold implies that the knowledge has been acquired, but remains fragile. When a pupil is above the second threshold, the subject is considered to have been mastered. Compared with 2019, the results in 2020 indicate a decrease of between 0.9% and 2.5% in the number of first-grade students who passed the second threshold. On average, 77.5% of pupils reached the second threshold in French tests in 2020, compared with 78.1% in 2019. In mathematics, the percentage of pupils above the second threshold was around 76% in 2020, whereas it had been around 77% in 2019. As a result, it appears that the grades of young students fell slightly during the pandemic.

In terms of trends, this result is important, as students had been improving their results year on year, and the pandemic halted this positive evolution. Conversely, older students in the 6th grade performed better, and even improved their learning outcomes. In French language tests, the average percentage above the second threshold was around 88.3% in 2020, compared with 83.5% in 2019. Similarly, in mathematics, 72.2% exceeded the second threshold in 2020, while only 69% did so in 2019.

We can consider the figures from the Education Policy Outlook (OECD, 2020d) as a potential explanation to those positive outcomes in France. According to this report, at 82.1%, France is just above the OECD average of 81.5% for access to a computer, and its use for schoolwork among disadvantaged students. In addition, the DESI (2019d) report ranked France 15th out of 28 countries, and again France was around the average for the 28 EU members. Hence, despite the fact that France had invested heavily in broadband and connectivity before the COVID-19 pandemic, it is still far from top of the EU in terms of digitalisation. Furthermore, according to the TALIS database, France is the country in this report with the lowest percentage of teachers agreeing that they could support students' learning through the use of ICT tools, at just 45% (OECD, 2019c). In line with this, the IRDLL placed France only at the 18th position (Beblavý et al., 2019). These statistics seem at odds with the results presented by DEPP. Hence, instead of the current descriptive statistics analysis, further quantitative research based on standardised test scores could be considered to precisely measure the effects of the pandemic in France.

1.6. Germany

In Germany, we observe a rich literature studying the impacts of the crisis. Schult et al. (2022) have measured the influence of the COVID-19 pandemic on mathematics and reading scores in standardised tests among novice secondary school students[6]. Thanks to a dataset of 800,000 respondents, they could compare the 2020 cohort of students, who were affected by the pandemic, with aggregated results from between 2017 and 2019. The authors found a learning deficit of 0.07 SD in reading, and 0.09 SD in mathematics, after

[5] 97% of all French students in the year studied are covered by the DEPP reports.
[6] "Lernstand 5", in Germany. Students are 10–11 years old.

two months of school closures. Ludewig et al. (2022) explored the pandemic's impact on 4th-grade students, which corresponds to the last year of primary education in Germany. They applied a random effects regression based on a sample of 4,290 individuals, and compare the scores of the standardised reading test in 2021 (COVID-19 cohort) with those in 2016. Their results are more conspicuous than those observed by Schult et al. (2022). They observe that, on average, reading achievements reduced significantly by 0.14 SD for 2021 students compared with the 2016 scores. Next, Spitzer and Musslick (2021) evaluated the learning outcomes of 2,556 students in Grades 4 to 10 who were using software to improve their learning in mathematics both before and during the pandemic. As with Ludewig et al. (2022), they applied a mixed-model regression to compare the scores of pupils in relation a set of problems before and after the pandemic. They observed that respondents, who made more frequent use of the software, showed a lower rate of errors in their sets of problems. In addition, they found that students made fewer mistakes when solving challenging exercises. Spitzer and Musslick (2021) did not express their results in terms of SD, but a similar article by Förster et al. (2022) does so. They also compare the performance in reading of students in the 2019-2020 and 2020-2021 academic years with the average results from the four years prior to the health crisis. Their analysis relies on a sample of 12,037 second-grade (8-year-old) students and an invariance model. They observe an improvement in learning outcomes during the COVID-19 period. The 2019-2020 cohort outperformed the control group by between 0.08 and 0.13 SD. When comparing the 2020-2021 cohort with the control, similar findings were noted but with a smaller range: between 0.06 and 0.09 SD. Like Spitzer and Musslick (2021), the authors concluded that remote learning led to an increase in the time available to students, and thus resulted in an increase in their reading time.

The differences between the findings of Ludewig et al. (2022) and Schult et al. (2022) may be explained in two ways. First, the former paper focuses on younger students – an age group which, as already indicated before, commonly correlates with higher attainment deficits. Second, the two papers apply different methodologies. While Schult et al. (2022) compared average results between 2017 and 2019 with the COVID-19 cohort, Ludewig et al. (2022) compared the scores in 2016 with the COVID-19 cohort. According to the trend in Germany's PISA results, test scores has been decreasing in both language and mathematics since 2015. Given this declining trend, the difference in test scores between 2016 and 2021 is larger than the difference between the 2017-2019 average and 2020. As in Belgium (Flanders), we argue that the negative pre-pandemic trend reinforces pandemic-related learning deficits. Nevertheless, the highest learning deficits observed by Ludewig et al. (2022) are based on scores from the year 2021, i.e. one year after Schult et al. (2022). Hence, this raises questions about how Germany managed its recovery during the academic year 2020-2021, despite the positive findings reported by Depping (2021) in the aftermath of the implementation of summer schools.

In summary, the five German studies suggest that Germany implemented distance learning in an effective way. The underlying mechanisms explaining the positive outcomes presented by Spitzer and Musslick (2021) and Förster et al. (2022) are in line with previous findings from other EU Member States. There was an increased use of previously used ICT tools, and while Germany is not among the EU leaders in digitalization, its performance is good. According to the DESI (2021a) report, Germany is ranked 11th out of 28. Broadband access is widespread, as are basic skills in ICT. In addition, the German PISA index of ICT competence is around 0.08 in 2018, which is above the average of 0.07 (OECD, 2019a). Unfortunately, no information was reported about the exact use of ICT in relation to schoolwork for the year 2018. Nevertheless, in 2019 the index of ICT use for school, or the IRDLL, ranked Germany at the bottom of the 27 EU countries (Beblavý et al., 2019). Considering the relatively good German implementation of remote learning, these findings indicate the need for further research to better understand what exactly happened in Germany.

1.7. Greece

Greece managed its school closures differently from most other countries. The government decided to close schools in March 2020, but re-opened them again by the end of March 2020 and they remained open until the end of the academic year. Nevertheless, schools did not simply return to normal; classes were divided into two groups: during the first half of the week, one group stayed at home (without remote teaching), while the other group received in-person education; subsequently, the opposite took place in the second part of the week. As a result, Lambropoulos et al. (2022) calculated that students had lost nine weeks of face-to-face schooling during that year. In addition, in 2020-2021, students faced another 12 weeks of confinement with remote learning. Starting from this point, Lambropoulos et al. (2022) estimated a DiD model based on the results of a standardised test called the Panhellenic University Entrance Exams (PUEE). This evaluation tests the social sciences skills of individuals aiming to enter university. With a large sample (around 22,000 students each year), the authors observed a learning deficit of 0.22 SD in the school year 2019-2020, compared the school year 2018-2019. One year after the school closures, in 2020-2021, the learning deficit increased to 0.3 SD.

There are two underlying mechanisms for these large learning deficits. First, both of the school closures were lengthy. This is particularly true for the school year 2020-2021, with 12 weeks of school closures. Second, according to the DESI (2019e) report, Greece ranked 26th for its digital economy, one of the lowest among EU Member States. The country was not ready for remote learning: it lacked the hardware and software, and teachers did not have the skills necessary to implement online lectures. According to the PISA database, only 34% of students agreed that an online learning platform was available in 2018, compared with the OECD average of 54% (OECD, 2019a). Similarly, only 44% of students agreed that their teachers had the resources to implement digital education services, compared with 66.5% across the OECD (OECD, 2019a). Further, only 34% of students were in a school whose principal agreed that it had "an effective online learning platform" available (OECD, 2019a). The IRDLL reflects this evidence since Greece ranked low among the EU Member States (25th) in 2019 (Beblavý et al., 2019). On top of the lack of ICT tools, the country also faced several issues in implementing such tools and remote learning to cope with COVID-19. Despite 80% of disadvantaged students in Greece indicating in surveys that they had access to a computer at home for their homework, the population challenged the education authorities regarding the difficulty of getting access to the internet. More surprisingly, some also claimed to be reluctant to undertake remote learning due to the deleterious effects of radiation from computers. From the side of the teachers, there were strikes to protest against the lack of ICT equipment in schools. Although these strikes led to a significant investment in ICT, they also resulted in less teaching hours while teachers waited for materials (Lambropoulos et al., 2022).

Other evidence of Greece's "unpreparedness" with regard to digitalisation can be found in comparisons with other EU countries. Since there was no real remote learning set up during the 2019-2020 academic year in Greece, students and teachers had to adopt one a year later. As demonstrated by König and Frey (2022) and the analysis in Denmark, the more ready a country wass for the use of ICT in learning, the better able it was to face the pandemic. With regard to Greece, we should also take into account that the paper by Lambropoulos et al. (2022) is based on an end-of-secondary-school test. Following other examples such as that of France and the paper by König and Frey (2022), the effects may have been worse among younger students.

1.8. Hungary

Molnár and Hermann (2022) studies the consequences of school closures in Hungary during the years 2020 and 2021 in Hungary. They apply a linear regression model on an observation sample of 80,000 pupils in Grades 1 (age 6, i.e., in kindergarten), to 8 (age

13, i.e. the final year of primary school). Their sample gathered information since 2015, allowing them to compare pre- and post-COVID-19 learning achievements.

They observed that kindergarten pupils experienced larger learning deficits compared with their older peers. More specifically, the authors reported decreases in achievement of 0.16 SD and 0.23 SD in mathematics and language, respectively, in 2020. For lower primary school students (grades 2-4), they reported a slowdown in learning of 0.06 SD in mathematics and 0.1 in language. Among upper primary school students, they indicated impacts of -0.02 SD and -0.04 SD in mathematics and language, respectively. The year 2021 shows larger negative outcomes than the year 2020, especially among lower primary school students. In kindergarten, learning deficits of 0.1 SD in mathematics and 0.12 SD in language were reported. Similarly, upper primary school students experienced slowdowns of 0.08 SD and 0.1 SD in mathematics and language. Nevertheless, the results were much more severe among lower primary school pupils, with learning deficits in 2021 of 0.2 SD and 0.28 SD in mathematics and language.

The results for the year 2020 are in line with the previously noted negative correlation between the age of students and learning deficits. Furthermore, no specific instructions were provided for kindergartens, nor was any form of remote learning implemented, which is also at the root of such slowdowns in education achievements. Nevertheless, the pattern in 2021 is less clear. The underlying mechanism for the smaller learning deficits in kindergarten compared with lower primary school students could be related to the length of school closures. In total, schools were closed for a minimum of 16 weeks in Grade 1, while they were closed for 19 weeks and 22 weeks in lower and upper primary education. Starting from the latter explanation, the question remains on why the learning deficits are lower in upper primary education compared with lower primary. Although school closures were three weeks longer for upper students, Molnár and Hermann (2022) argue a similar case to König and Frey (2022). Specifically, they state that younger students need more attention from teachers and show greater difficulty in self-regulating their own work, resulting in greater learning deficits in the event of school closures. The latter statement also explains the findings for the year 2020, namely the larger learning deficit among younger students. In addition, Molnár and Hermann (2022) also present the issue of a lack of ICT infrastructure in lower primary education compared with upper primary. Nevertheless, no information is available about investment or summer schools provided in Hungary between 2020 and 2021 that might clarify the greater learning deficits in 2021 compared with 2020. Further research could be considered to investigate this.

When comparing the overall learning deficits seen in Hungary for the year 2019-2020 against those in other EU Member States, overall results are slightly better than the average. Surprisingly, however, the country shows more severe outcomes in the year 2020-2021. The underlying mechanisms for such an increase from one year to the next are hard to identify. One potential explanation comes from the total length of school closures in the country. Between 2019 and 2021, the average length of school closures among the countries presented in this report was around 12 weeks; in Hungary, the average length was 19 weeks. On its own, however, this is not enough to explain the country's relatively "good" results for the year 2019-2020. In addition, the 2019 DESI report ranked Hungary 23rd out of 28 for digitalisation (DESI, 2019f). This implies that prior to the pandemic, the country was missing crucial infrastructure needed to implement remote learning. In line with this, only 35% of the students were in a school whose principal agreed that it had an online learning platform available, compared with the average of 50% (OECD, 2019a). Nevertheless, in 2019 the IRDLL ranked the country at the 13th position (Beblavý et al., 2019), in the middle of the European ranking, which goes against previous indicators. Further research could be conducted to further investigate the Hungarian results.

1.9. Italy

The health crisis hit Italy more severely than many other EU Member States. The country experienced long school closures (between seven and 19 weeks, depending on the educational level and geographical location). Contini et al. (2021) explored the influence of the school closure on educational outcomes in the province of Turin by comparing a sample of 1,539 pupils in primary education (Grade 3) from the year 2018-2019 (control) and 2019-2020 (COVID-19). Their methodology relies on a DiD identification strategy, and focuses on scores in a mathematics exam provided by the research team. Their findings report a learning deficit of 0.19 SD after 15 weeks of school closures. According to the authors themselves, however, this sample from Turin is not representative of Italy as a whole, and represent an underestimate compared with other parts of Italy. For a broader picture, Borgonovi and Ferrara (2022) examined the 2018-2019 and 2020-2021 cohorts of Grades 5 and 8. The key aspect of this paper is that it covers more than 800,000 students across each province of Italy. In mathematics, their average scores of Grade 5 pupils fell by 0.016 SD, while for Grade 8 pupils it decreased by 0.07 SD. In reading, Grade 5 pupils improved their average reading scores by 0.02 SD, although the reading scores of Grade 8 students decreased by 0.03 SD.

Given the intensity of the health crisis in Italy and the early results by Contini et al. (2021), the moderate impacts found by Borgonovi and Ferrara (2022) are surprising. In addition, the literature has argued that the pandemic hit younger pupils harder, yet Borgonovi and Ferrara (2022) found the opposite. Still, the the smaller decline they noted is probably due to their focus on the year 2020-2021. They argue that, by the summer of 2020, primary schools in Italy were more open than secondary schools[7] and, most importantly, were well equipped to cope with remote learning. This could explain their finding. Indeed, the PISA database reports an index for ICT use for education of 0.09 in Italy for the year 2018, when the average across all countries was 0.07 (OECD, 2019a). However, this is not in line with the DESI ranking for Italy's digital economy. In 2019, Italy ranked 24 out of 28 EU members (DESI 2019g), and the country suffered from a widespread lack of access to the internet or to ICT tools for its pupils. The PISA results also indicate that in 2018, overall ICT competence in Italy was -0.03 compared with an average of 0.07. In other words, while ICT tools were widely used in Italian schools, the country's overall performance in terms of digitalisation was low, which made it difficult the use ICT at home. By the year 2021, the DESI report stated that, although Italy was still below the EU average, it performed well. The government made investments in 5G to improve access to the web, as well as in broadband. It can be hypothesised that every EU Member State invested in ICT as a consequence of the pandemic, which may explain why Italy remained in 24th place in 2021 (DESI, 2021b). This is in line with the IRDLL, which placed the country at the 26th position in terms of ICT use for educational purposes (Beblavý et al., 2019). Lastly, the better outcomes noted by Borgonovi and Ferrara (2022) may also be explained by the massive investments made in Italy; the government developed a EUR 1 billion plan over two years to adapt education, support parents and children, and hire new teachers (De Witte and Smet, 2021). A further EUR 510 million was invested to set up summer "bridging" programmes, but these cannot have affected the 2020-2021 results. Furthermore, one of the main advantages of the sample used by Borgonovi and Ferrara (2022) is that it covers every province in Italy. As a result, when controlling for province fixed effects, the authors observe a strong rise in inequality in test scores[8]. In other words, there is an average improvement one year after the pandemic, but not everywhere.

[7] Similar justifications were given in France (DEPP 2021a and 2021b), UK (England) (Rose et al., 2021) and Denmark (Birkelund and Karlson, 2021).

[8] For instance, in mathematics, Grade 5 students shows scores varying between -11 and +20 points compared with the mean zero.

1.10. The Netherlands

An early paper by Engzell et al. (2021) evaluates the effects of the pandemic on a large sample of pupils (about 350,000 respondents) in Grades 4 to 7 (8 to 11 years old). The authors' methodology relies on DiD and compares national standardised test scores from the year 2017 (control) with those from 2020 (COVID-19 cohort). In the paper, the authors argue that the impact is expected to be moderate as: (a) the length of school closures was quite short, at only eight weeks; (b) 99% of schools are publicly supported; and (c) the Netherlands is one of the European leaders in terms of connectivity and broadband access (DESI, 2020). In line with this last detail, the PISA database indicates an index for ICT use at school of 0.44 in 2015, when the average was 0.08 (OECD, 2019a). Yet, Engzell et al. (2021) found that the 2020 cohorts experienced, on average, a learning deficit of 0.08 SD compared with the three previous cohorts. The authors consider this equivalent to eight weeks of school lost, i.e. the length of the Dutch school closures. Similarly, Schuurman et al. (2021) estimated the learning deficit among 883 pupils from Grades 3 to 5. Their results show a stronger impact than that estimated by Engzell et al. (2021). According to Schuurman et al. (2021), the average delay in Dutch language learning is around 2.35 months, and around 2.47 months in mathematics. In addition, these authors observed that older students were less affected by the pandemic.

Haelermans et al. (2022a) studied the scores of standardised tests in Grades 1-6 of primary education, taken by a large sample of 201,187 pupils. The authors follow a DiD methodology in comparing the academic years 2017-2018 and 2018-2019 with the year of the health crisis, 2019-2020. On average, the learning deficit for the COVID-19 cohort amounts to 0.14 SD in language and 0.21 SD in mathematics. Contrary to Schuurman et al. (2021), Haelermans et al. (2022a) observe an increase in attainment deficits by age. In language, the average delay in Grade 1 amounts to 0.1 SD, while it increases to 0.19 SD in Grade 5. In mathematics, the gap is even larger, from -0.13 SD in Grade 1 to -0.33 SD in Grade 5.

In secondary education, Van der Velde et al. (2021) measured the outcomes of an online learning tool to assist 133,000 students aged between 12 and 16 years old in their learning of foreign languages. The online tool was used before the pandemic, but during the period of school closures, a huge surge in its use was reported: the number of completed exercises increased ninefold compared with the situation before the pandemic. Growth in the number of completed exercises was higher among older students, which is consistent with the literature. Similarly, the time spent in the app was higher for older students. Based on these data, the authors found no evidence of learning deficits due to the school closures. Furthermore, looking at the results achieved with the app, 16-year-old students are likely to have greater knowledge than in previous years. Obviously, although this sample is large, it is highly selective. Even so, it emphasises how delays might vary due to a range of factors.

Lastly, Haelermans et al. (2022b) report on the long-term effects on education of the COVID-19 crisis two years after the beginning of the pandemic's first wave. This study looks at the results of nearly 850,000 primary school students in standardised tests of reading, spelling and mathematics, comparing pupils' results from 2016-2017 until 2021-2022. Evidence is mixed, with students now back at their pre-pandemic level in reading, but while important delays persist in spelling and mathematics in 2021-2022.[9] Although the authors do not control for underlying trends in the education system, Haelermans et al. (2022c) note 0.43 SD lower attainments in mathematics and 0.38 SD in spelling. Conversely, the recovery in reading is confirmed by a learning improvement of 0.04 SD.

[9] The estimated learning deficit reached 0.04 in reading. The authors do not indicate whether or not this is significant, but argue that on average there is no decrease in 2020-2021, and thus conclude there is no learning deficit in reading comprehension.

In terms of ages, patterns are similar to those noted in Haelermans et al. (2022a), which again contrasts with most of the papers presented in this report.

The more conspicuous learning deficits reported in the Netherlands are intriguing, especially considering the country's privileged position prior to the pandemic. According to Haelermans et al. (2022b), such results may be explained by the uncertain situation experienced by the students. During the academic year 2020-2021, school closures were not generally mandatory in the Netherlands, and depended on the level of absenteeism in each school. Consequently, some students shifted frequently between remote and face-to-face learning, depending on shortages of teachers due to COVID-19 infections, or the degree of contamination in the whole school. This absence of a stable learning framework is indicated as being at the root of such educational delays.

In terms of comparisons with other EU countries, the better grades for older students compared with those seen among younger pupils, as noted by Schuurman et al. (2021), are consistent with other papers cited in this report (DEPP, 2020; König and Frey, 2022; Ludewig et al., 2021; Tomasik et al., 2021). Further, the analysis provided by Van der Velde et al. (2021) is close to the findings raised by König and Frey (2022) and to what has been already found in Germany and Denmark among students intensively using a remote learning app. Lastly, Engzell et al. (2021) found a higher learning deficit in Dutch language compared with mathematics, just as Maldonado and De Witte (2022) do in Flanders. This correlation is somewhat troubling, and may warrant further attention, as these studies are the only ones to present such a pattern.

1.11. Poland

Jakubowski and Wrona (2022) estimate a DiD model at student level (4,581 observations) among 83 schools, by comparing average PISA scores from 2003 to 2018 with the 2021 TICKS exam results. The latter test is similar to PISA, which the authors argue makes such a comparison possible. Both tests are taken by 15-year-old students, i.e. those in the 3rd grade of secondary school education. Jakubowski and Wrona (2022) observe a learning deficit in maths of 0.31 SD, and 0.29 SD in reading.

This negative impact of the pandemic is at odds with the high performance of Poland in international assessments such as PISA (see Figures 2a and 2b). Unfortunately, little information is available on the underlying mechanisms behind this negative impact of COVID-19. However, looking at the DESI (2019h) report, Poland ranked among the worst EU Member States in terms of digitalisation: 25th out of 28. This low score prior to the COVID-19 crisis might be at the root of the attainment deficit faced by the country as a result of the crisis. Prior to the pandemic, Poland faced deep challenges with regard to connectivity and use of the internet. For instance, 20% of the Polish population was not connected to the internet, and nearly 50% lacked basic ICT skills. In line with this, in 2018 the PISA database indicated an ICT competence index of 0.01, compared with the average of 0.07 (OECD, 2019a). Similarly in terms of digitalisation in education, the country is ranked 22nd out of 27 in 2019 by the IRDLL (Beblavý et al., 2019). Lastly, according to a report from UNESCO, Poland closed its schools for 29 weeks, while the data for other EU countries in the present report suggest closures of between 10 and 20 weeks. This information could largely explain what caused such learning deficits in Poland (Jakubowski and Wrona, 2022).

FIGURE 2a. Average PISA score in reading 2006-2018

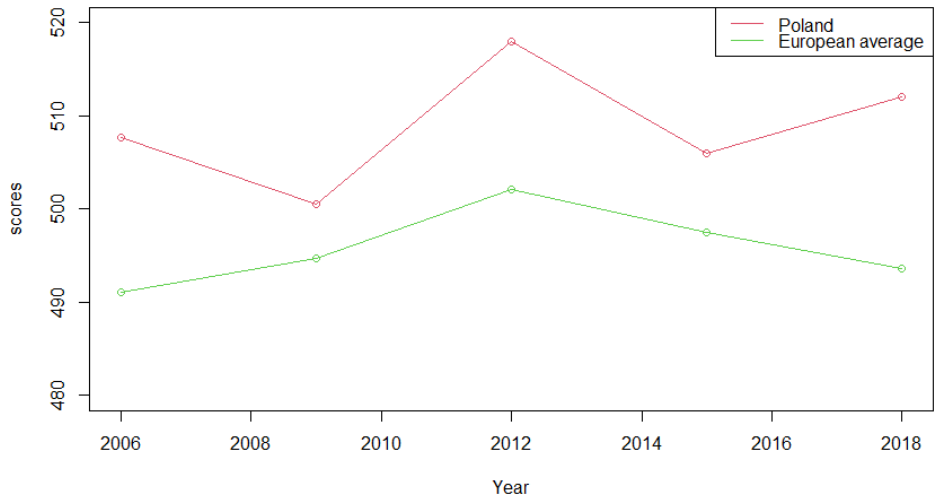
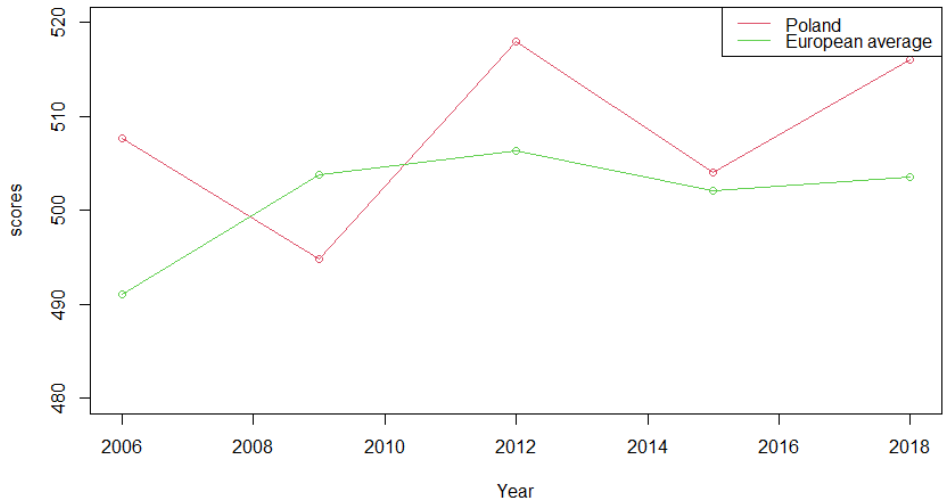


FIGURE 2b. Average PISA score in mathematics 2006-2018



Note: average PISA results between 2006 and 2018 in reading and mathematics in Poland compare with the average for selected European countries. The European average is based on Belgium (Flanders), Czechia, Denmark, Germany, Italy, Netherlands, Poland, Switzerland and UK (England). Poland performs well in education compared with the EU as a whole, reporting higher results in both language and mathematics. This achievement was made possible thanks to a reform of the education system carried out since 1999.
Sources: reports from PISA (2007, 2010, 2014, 2016) and OECD (2019b).

1.12. Spain (Basque Country)

In a recent paper, Arenas and Gortazar (2022) evaluated the effect of COVID-19 on 8th-grade students in the Basque Country, thanks to a standardised evaluation that is external to both schools and the government. The control group took the exam in 2019, prior to the pandemic; a second group took it after the COVID crisis in 2021. The authors used a DiD methodology to estimate average learning deficits among the 20,748 students that comprised their sample. The findings in mathematics are quite encouraging, with the estimated attainment deficit being around 0.075 SD for the 2021 cohort, compared with the 2019 group. With regard to languages, the exam tested students' level in both Spanish

and the Basque language, and indicates a total average shortfall in learning of around 0.046 SD.

Spain clearly suffered from the pandemic, and yet the country has performed well – especially a year after the first wave. What may potentially have led to such an outcome, is the way in which Spain dealt with the reopening of its education system. After 12 weeks of school closures during the academic year 2019-2020, nearly 99% of the schools were fully open in January 2021. The fact that face-to-face learning was provided as normal during the year 2020-2021 probably explains the Spanish catch-up. Still, the presence of some learning deficits can be explained by the country's middling performance in the use of ICT for school purpose and in digitalisation. The DESI (2019i) report ranked the country 11th, while the index of ICT use for education was at -0.13 in 2018, compared with an average of 0.07 (OECD, 2019a). The TALIS report indicated that 66% of teachers felt they could support students' education through the use ICT tools, which again is close to the computed average of 65.5%. Lastly, one should note that Arenas and Gortazar (2022) focused on the Basque country and not Spain as a whole. Hence, differences may still exist between regions in terms of results.

In summary, although the Spanish performance was not especially high prior to the COVID-19 crisis, the country managed relatively well to contain learning deficits compared with other countries that had longer school closures, such as Greece. This provides further evidence of how lengthy school closures may have adverse effects on educational achievements.

1.13. Sweden

The case of Sweden is unique in Europe, as primary schools in the country did not close (Fälth et al., 2021), and neither did universities (Casalone et al., 2021). Among adults, only some recommendations were formulated to avoid the spread of the pandemic, but no strict measures were imposed. In response, Swedish people reacted responsibly and reduced their movements (Dahlberg et al., 2020; Toger et al., 2021). In a recent paper, Hallin et al. (2022) measured the extent to which "teacher absence and pandemic-related stress factors" might have led to a slowdown in learning among primary school students (Grades 1 to 3). Research was conducted on a sample of 97,073 pupils and focused only on language skills. Their methodology relied on ANOVA tests to compare the COVID-19 cohort of students (2020-2021) with results from past academic years up to 2017-2018. Swedish pupils did not experience a learning deficit at all. Furthermore, regardless of what grade student was in, scores in reading comprehension and word decoding were systematically higher in 2020-2021 than for any other year. These conclusions strengthen the argument raised by Patrinos et al. (2022) about the positive correlation between length of school closure and attainment deficit.

1.14. Switzerland

An early study into the effects of the pandemic was conducted in Switzerland by Tomasik et al. (2021). From a learning growth model relying on a sample of 28,685 observations distributed nearly equally between primary and secondary school students[10], the authors measured how the COVID crisis had slowed down educational achievements. Specifically, their model evaluated the evolution of the learning process for 8 weeks prior to the school closure, and during the 8 weeks of remote learning. In other words, 16 weeks of learning was measured using an online tool that supported teachers in generating assessments. The authors report that the learning progress for primary school pupils was twice as fast

[10] The study considers students from Grade 3 to Grade 9 (9 to 16 years old), with 13,134 tests in primary education and 15,551 in secondary. It is important to note that the study is based on the test results, but the students are not identified.

during in-person teaching compared with remote learning. Conversely, secondary school students do not report significant differences between in-person and remote learning education, at least in their test results.

Although the primary school results are worrying, it appears that Switzerland presents relatively contained slowdowns in education, especially at secondary level. The underlying mechanisms for such results are hard to identify. According to the PISA database, Switzerland has some skills in terms of ICT. With an ICT skills index of 0.02 in 2018 compared with the average of 0.07, the country is clearly not among the European leaders – but neither is it among the worst (OECD, 2019a). Furthermore, again based on PISA information, the Swiss education system uses very few ICT tools for educational purposes. The latter index places Switzerland second to last (-0.14 against a computed average of 0.07).

Lastly, given the methodology used by Tomasik et al. (2021), it is difficult to compare Switzerland's results with those from other European countries. However, the fact that younger pupils were more affected than older ones is consistent with findings previously observed in the Netherlands, Germany, France, Hungary and the UK (England).

1.15. UK (England)

The situation in UK (England) has been studied by several researchers. The first to evaluate the learning deficit were Rose et al. (2021), who looked at a sample of 6,000 Grade 2 pupils (6-7 years old). Their research focused on the earliest stages of the pandemic, as they compared a 2017 cohort of students with a cohort from autumn 2020. Both groups took standardised tests in reading and mathematics. This paper specifically provides a measure of the slowdown in learning caused only by the first lockdown in UK (England), i.e. from March 29 till mid-June for primary schools (Ofqual, 2021)[11]. The authors found attainment deficits in both mathematics and language compared with the 2017 cohort of 0.14 and 0.17 SD, respectively. In terms of perspective, the authors associate these figures with a gap in learning of around two months.

A later report from Blainey and Hannay (2021) focused on every primary-educated pupil following the third round of school closures in UK (England), i.e. from early January to March 8, 2021[12]. Based on a standardised test and a sample of 150,000 primary school students, the authors explored the differences in test scores between 2020 and 2021. The authors standardised the test results to an average of zero and standard deviations of one. They found a significant average decrease of 0.025 SD in language and 0.033 SD in mathematics for the 2021 students compared with those of 2020. Furthermore, they found other evidence that the younger the students, the bigger this deficit was. The learning deficits noted by Blainey and Hannay (2021) in 2021 are much smaller than those noted in 2020 by Rose et al. (2021). In line with these findings, a report by the Education Policy Institute (2021) presents a picture of recovery by the English education system for the academic year 2020-2021. The report is again based on a standardised test administered to both secondary and primary school students. On the one hand, the authors report a further slowdown in learning. On the other hand, they show evidence of a catch-up during the spring and summer term, as in Blainey and Hannay (2021). Their research compared the 2018-2019 cohort with a 2020-2021 cohort of students. The latter group took the tests at the end of the summer term, by which time they had been back to school following the third school closures. The results are much better than what was previously found: -0.03

[11] In total, not counting school holidays, primary school students were out of school for 12 weeks during the year 2019-2020.
[12] In total, not counting school holidays, primary school students were out of school for 11 weeks in the year 2019-2020.

SD in reading, and -0.2 SD in mathematics in primary school. In secondary education, the learning deficit was around 0.05 SD in reading, while no information was provided in mathematics. This latter situation is also better than what had previously been found, which may be explained by the impact of schools re-opening. To bring everything into perspective, the delay in reading is around 0.9 months for the primary pupils and 1.8 months for secondary students. In mathematics, the gap is still particularly important: 2.8 months for primary pupils.

Interestingly, in the report by the Education Policy Institute (2021), the results of older students were worse than those of younger pupils, which raised the question as to how UK (England) would manage to catch up from its slowdown in learning. The first element of the answer can be found under the National Tutoring Programme (NTP), set up in November 2020. This aims to provide support to students most affected by the pandemic, thanks to academic mentors and tuition partners (NTP, 2022). Regrettably, no further information has been found regarding the effectiveness and the reach of the NTP. In addition, secondary schools remained physically closed for a longer period, which might explain the larger learning deficits among older students. In 2019-2020, primary schools were closed for 12 weeks, compared with 17 weeks in secondary education. In 2020-2021, both levels were fully closed for the same amount of time (Ofqual, 2021). Nevertheless, secondary school pupils experienced 5 weeks of alternate face-to-face teaching. In other words, classes were divided, and some groups went to school while others had to stay at home, to prevent the spread of the virus. Thus, secondary school students were more affected by the pandemic in 2020-2021 than primary students. This latter fact has probably an impact on the negative outcomes found by the Education Policy Institute.

Comparing UK (England) with EU Member States leads to unclear conclusions regarding what may have driven the severe learning deficits in UK (England). According to the PISA database, in 2018 the United Kingdom had an index of ICT use in schools of 0.08, which was above our computed average of 0.07 (OECD, 2019a). Similarly, the TALIS report indicates that 62% of teachers felt they could support their students' learning using ICT tools (OECD, 2019b), while the DESI report ranked the United Kingdom 5th in 2019, implying good performance in terms of digitalisation (DESI, 2019j). Further studies could be conducted to better understand the causes of these outcomes.

1.16. Summary of the findings and expected long-term effects

The systematic review above reveals heterogeneity in the scope and influence of the crisis in Europe. Nevertheless, some trends and similarities can be established as the main findings of this first section.

The first pattern that can be discerned is that better knowledge and more intensive use of ICT prior to the pandemic is a strong indicator of a country's performance in facing the COVID-19 pandemic. Following the reports made by the OECD Education Policy Outlook (OECD 2020a, 2020b and 2020c), the PISA and TALIS databases (OECD, 2019a; OECD, 2019b) as well as the Digital Economy and Society Index (DESI), countries at the top in terms of digitalisation on average fared better than those at the bottom. As a reminder, Finland was ranked 1st in 2019 (DESI, 2019h), the Netherlands were 3rd (DESI, 2019l),Denmark was ranked 4th (DESI, 2019c) and Germany 12th (DESI, 2019m). All these countries were far less affected than countries at the bottom of the index such as Poland, ranked 25th (DESI, 2019g) and Greece, ranked 26th (DESI, 2019e). Nevertheless, what really matters is a country's preparedness to use ICT for educational purposes, as illustrated by the Index of Readiness for Digital Lifelong Learning (IRDLL). Consider the case of Belgium, ranked 9th (DESI, 2019a) yet still seriously affected, with a very low index for ICT use in schools (-0.18) compared to the European average (0.07). Similarly,

the IRDLL considered Belgium at the 21st position in 2019 (Beblavý et al., 2019). Related patterns were also found in the Basque country and in France. Conversely, the Netherlands had the highest index for ICT in schools in 2019 (2nd), Finland was in the 3rd position while Hungary presented relatively good results (14th) (Beblavý et al., 2019). Birkelund and Karlson (2021), König and Frey (2022), Reimer et al. (2021) and Van der Velde et al. (2021) reported evidence of positive outcomes for students that were already using ICT-based remote learning tools. The previous subsections are often relying on the ICT use for educational purposes as an element that could have driven the learning deficits reported in a country. Still, it is important to recall that the technological aspects of remote learning cannot be the only thing at the root cause of these deficits. As developed in Section 2, mental health, parental distress and socio-economic status are other elements that explain the estimated slowdowns in learning achievements. Nevertheless, when conducting analyses at the country level, the digitalisation level in education is an easily observable cause of these slowdowns.

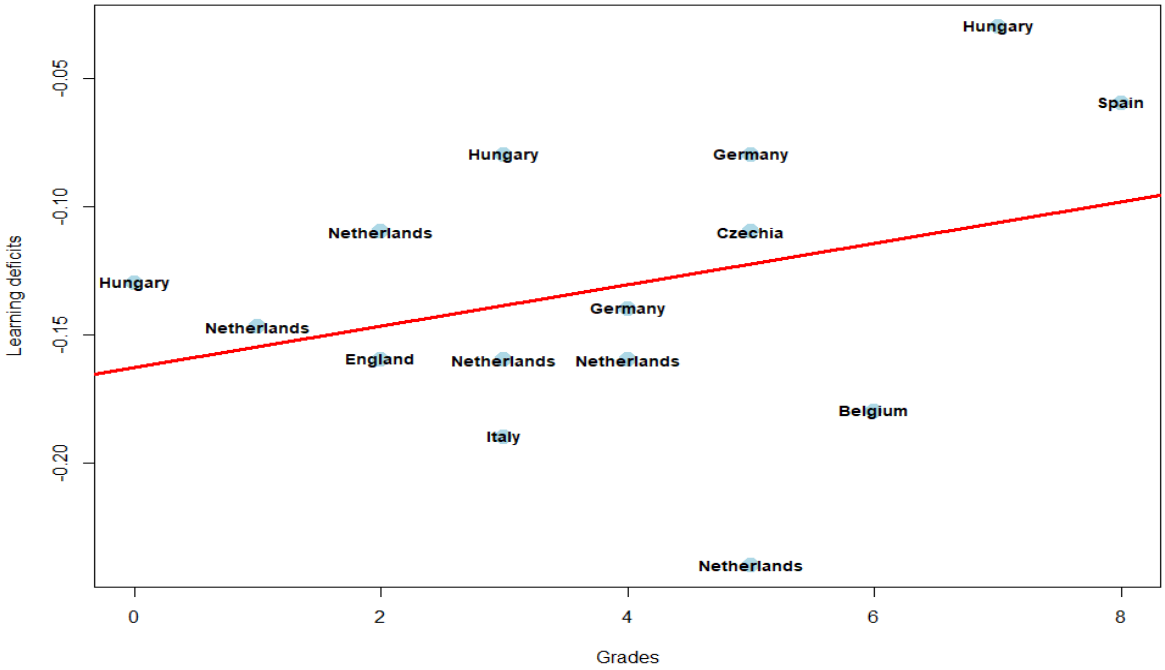
Another important tendency is that of learning deficits being more severe among younger students. This was first theorised by König and Frey (2022), who explained it as due to the difficulty for young pupils to self-regulate their work during confinement. Also, we argue that compared with older students, younger children loose more quickly automatisms in reading, writing and for calculus. In addition, several proofs of such a pattern have been found in most EU countries. For instance, in the Netherlands (Engzell et al., 2021; Schuurman et al., 2021), in Germany (Schult et al., 2022; Ludewig et al., 2021), in France (DEPP, 2020a;2020b) and in Hungary (Molnár and Hermann, 2022). Similar findings were also noted in Switzerland (Tomasik et al., 2021) and in the UK (England) (Blainey and Hannay, 2021). Where the opposite trend has been observed, this has always been explained by the same cause: a much longer period of school closures for older pupils (Borgonovi and Ferrara, 2021; Birkelund and Karlson, 2021; Molnár and Hermann, 2022; Ofqual, 2021). As an illustration, Figure 3 plots the relationship between students' age from grade 0 to 8[13] and the learning deficit they experienced following the COVID crisis. The reported results are from Belgium (Flanders), Czechia, Germany, Hungary, Netherlands, Italy, Spain (Basque country) and the UK (England). Only articles presenting their findings in terms of SD are included, which prevents us from considering countries whose results were presented differently. The graph shows a small positive correlation between age and learning deficit (around 0.32)[14], although this correlation is not significant due to the lack of observations. Since the learning deficits are presented with a negative sign in SD terms (see below, Figure 3), the positive correlation coefficient suggests an increase in learning deficits as age increases. More precisely, that as students get older, the learning deficits increase too, i.e., become smaller and lead to smaller less slowdowns in education. The overall increasing trend in red is based on the regression of the learning deficits on the students' age. One caveat applies to this graph. Poland (Jakubowski and Wrona, 2022) was not included in the observation used to draw this plot because it is considered an outlier. This choice is motivated by the assumption that the large learning deficits (-0.3) of older students (grade 9) in Poland were rather caused by the length of school closures (29 weeks). Hence, including Poland leads to bias in the correlation such that it is reversed from positive to negative. As a "robustness meta-analysis", a regression of the learning deficits on the length of school closure and age has been run. The sample is similar to that used in Figure 3, but complemented by Poland and reduced by one observation for Germany[15]. The coefficients go in the sense of our intuition: student who is one year older is likely to have higher education outcomes (or less learning deficit) by 0.005 SD, while a school closure of one week longer implies lower achievement by 0.007

[13] This entails pupils from age 5-6 years in kindergarten, up to 14-15 years old.
[14] Conducted by using a Pearson correlation test.
[15] The learning deficit reported by Ludewig et al. (2022) was removed because the authors did not report the lengths of school closures.

SD. With so few observations, these results are obviously not significant, but they add strength to our intuition. Further details concerning this regression can be found in Appendix C. In addition, the Netherlands appears five times out of 15 in the sample, which again biases the external validity of Figure 3. Nonetheless, only Haelermans et al. (2022a) is considered as a Dutch source, since it is the only Dutch paper to present learning deficits in terms of SD for each year of education. As a reminder, Haelermans et al. (2022a) is among the rare articles which found that learning deficits grew with age. As a concluding remark, Figure 3 is certainly neither unbiased nor externally valid. However, there are serious arguments to believe that the situation depicted appears realistic, and that the real effects could be even worse.

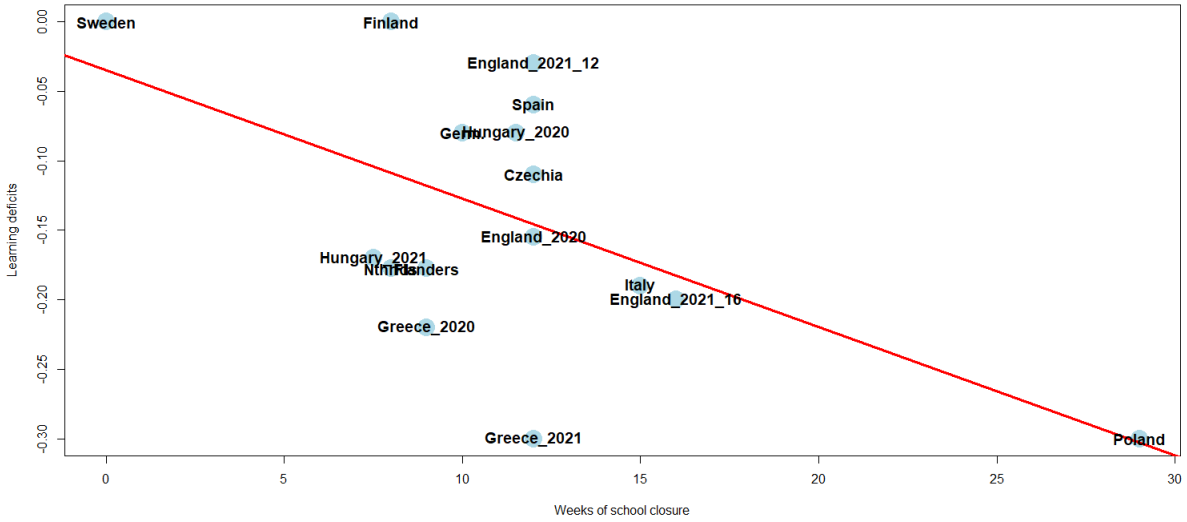
It should be noted that most of the literature is based on primary school samples, except for Poland and Greece. Hence, it is possible that the findings for these two countries, already rather negative, represent the upper limits for primary school attainment deficit.

FIGURE 3. Link between student age and learning deficits



Note: relationship between the age of students and their learning deficits following the pandemic. The graph presents a positive correlation of 0.32, suggesting that the younger the student, the more conspicuous the learning deficit. Germany, Hungary and the Netherlands are plotted several times because the of the effects pandemic were studied at different grades in these countries. In the Netherlands, for instance, Haelermans et al. (2022a) focus on Grades 1 to 5.
Sources: Arenas and Gortazar (2022); Contini et al. (2021); EPI (2021); Haelermans et al. (2022a); Korbell and Prokop (2021); Ludewig et al. (2022); Maldonado and De Witte (2021); Molnár and Hermann (2022); Rose et al. (2021); and Schult et al. (2022).

FIGURE 4. Link between length of school closures and learning deficits



Note: relationship between learning deficit and the length of school closures. Figure 4 indicates a clear negative correlation between the school closures and the education attainment estimated of –0.58. The overlapping countries are Germany and Hungary, with data from 2020, as well as the Netherlands and Flanders.
Sources: Arenas and Gortazar (2022); Contini et al. (2021); Engzell et al. (2021); Haelermans et al. (2022a); Hallin et al. (2022); Jakubowski and Wrona (2022); Korbell and Prokop (2021); Lambropoulos and Panagiota (2022); Ludewig et al. (2022); Maldonado and De Witte (2021); Molnár and Hermann (2022); Rose et al. (2021); and Schult et al. (2022).

Our third observation is that longer physical school closures correlate with larger learning deficits (Patrinos et al., 2022). As illustrated in Figure 4, the trend line in red is based on a regression of the learning deficits reported in each country and the length of the school closures. Despite the large heterogeneity, Figure 4 indicates a clear negative pattern between the length of school closures and the educational achievements. A Pearson correlation test confirms a correlation of -0.58 between the two variables. This trend could be explained by the declining motivation of students to take distance courses as the closure lasts. Also, the lack of efficiency and active learning of students during online courses, if they extend over a long period, can also be a factor accentuating the learning deficits (Lichand et al. 2022).

Fourth, school closures may have amplified pre-existing trends in education systems. Gambi and De Witte (2021) is the only study to specifically mention the significant impact of this trend prior to the crisis, and to account for it in its empirical model. More generally, Figure 5 correlates the average PISA score between 2006 and 2018 for certain European countries. Particularly with regard to reading scores, there has been a clear downward trend since 2012, just as in Belgium (Flanders). Overall, scores in mathematics appear much more stable. This graph shows how careful one must be in making conclusions when comparing post- and pre-pandemic cohorts. From a methodological perspective, the existence of this negative trend raises a serious concern: if an empirical model does not account for this evolution over time, the estimated learning deficit assigned to COVID-19 is biased and, ultimately, too high. In other words, this concern is an omitted variable bias, which makes it difficult to distinguish between what is purely an effect of the COVID-19 crisis, and what is a result of the trend over time. Furthermore, it is important to note that this bias increases, depending on how long before the pandemic the control cohort is taken from. As discussed in Section 1.6, the further back in time the control cohort, the bigger the learning deficit, since test score results become increasingly higher as we go back in

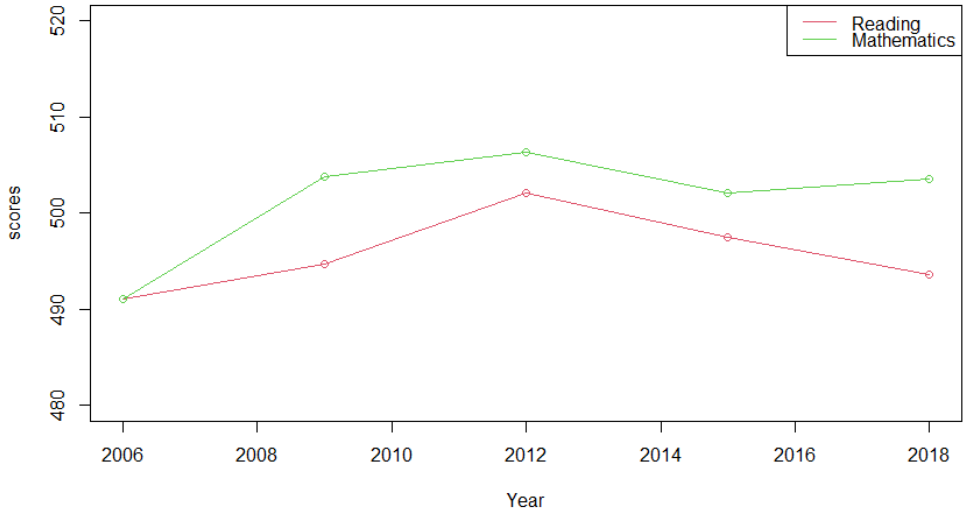
time. The latter fact is illustrated by comparing the papers of Ludewig et al. (2022) and Shult et al. (2022).

Fifth, in PISA tests, mathematics scores are systematically higher compared with those in reading. This is at odds with most of the research studying the learning deficits, since only three papers reported a similar pattern[16].

Lastly, the long-term consequences of the pandemic are hard to identify just two years after the crisis. Early papers simulate the long-term effect of the school closures. For instance, Angrist et al. (2021) and Kaffenberger (2020) concluded that the learning deficit following COVID-19 was going to accumulate over time. Similarly, Hanushek & Woessmann (2020) concluded that primary and secondary education pupils could expect a 3% reduction of their entire lifetime income. These effects could be even greater among low-SES individuals. These conclusions were based on a literature review about the relationship between education and labour market after the first wave of the pandemic, i.e., after three months of average school closure. Empirical evidence at this point is mixed. On the one hand, Gambi and De Witte (2021) indicate that the learning deficit in mathematics was halted in Belgium (Flanders). In Italy, Borgonovi and Ferrara (2022) report positive scores, and the Education Policy Institute (2021) reports a reduction in the attainment deficit in UK (England). In the Belgian case, summer schools, tutoring and investment are likely to be the reasons for these positive findings. On the other hand, Figures 6a to 6c show that this is not always the case. The figures present six countries that all have been the subject of studies evaluating the effect of the pandemic during the academic years 2019-2020 and 2020-2021. The purpose of this is to observe whether there is an improvement in learning attainment one year later. Unfortunately, such a figure cannot be drawn for every country due to missing information. What can be observed, however, is that there are not only heterogeneities between countries, but also depending on the subject. In mathematics, only Belgium (Flanders) managed to halt the slowdown. Meanwhile, the UK (England), Greece, Hungary and the Netherlands experienced larger learning deficits in maths from 2020 to 2021. No information was found specifically about mathematics in Germany. As for languages, Figure 6b suggests a mixed pattern. The Dutch learning deficits are reduced and the UK (England) shows a huge reduction, while the deficits in Belgium (Flanders), Germany and Hungary continued to grow in 2021. The average results (across subjects) in Figure 6c indicate mixed conclusions. Overall, Belgium (Flanders) and the UK (England) have smaller learning deficits in 2021 compared with 2020, but the opposite holds for Germany, Greece and Hungary. The huge decline of performance in Greece and Hungary from 2020 to 2021 causes the total average learning deficit in 2021 (dashed line) to be lower than that in 2020 (black line). This illustrates how investments in Belgium (Flanders) and in the UK (England) achieved positive effects in 2021. In contrast, Greece and Hungary were still hard-hit in 2021. Regrettably, no explanations were able to be found for the German situation. Lastly, Figures 6a to 6c show how the pandemic can have different effects at different educational levels depending on the country, and how each country's reaction may lead to different outcomes. As a result, these figures emphasise the need for further research to understand the effect of the COVID-19 pandemic over a longer term than just one year after the school closures. Overall, prior analyses and empirical evidence emphasise the needs of acting quickly to maintain a high quality education among the generation that was at school during the COVID-19 disruptions.

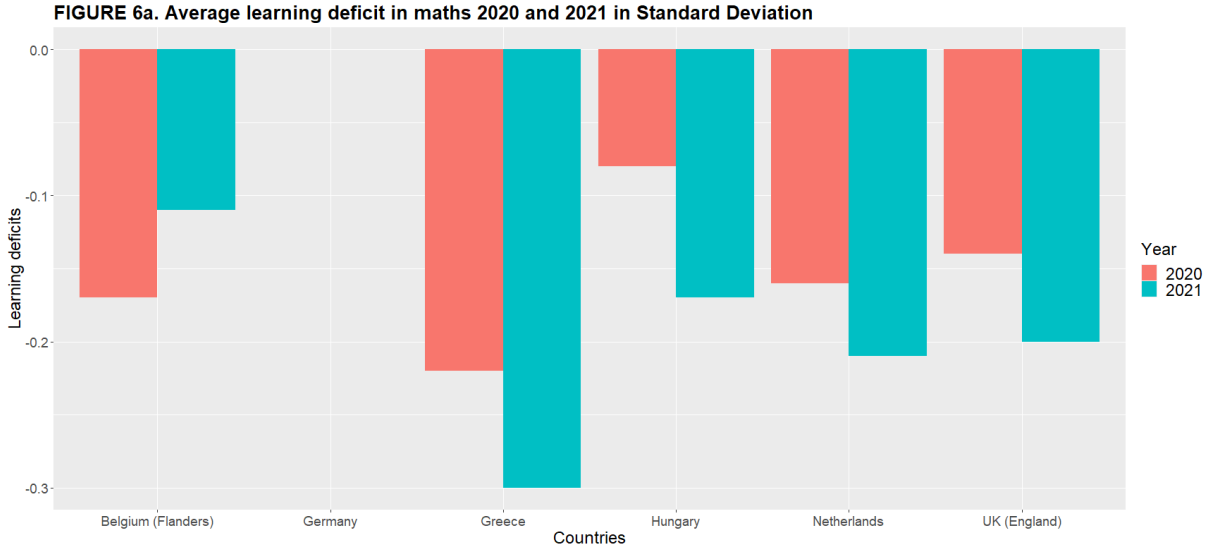
[16] Namely, Maldonado and De Witte (2021), Engzell et al. (2021) and Rose et al. (2021).

FIGURE 5. Average PISA trend 2006-2018 in Europe



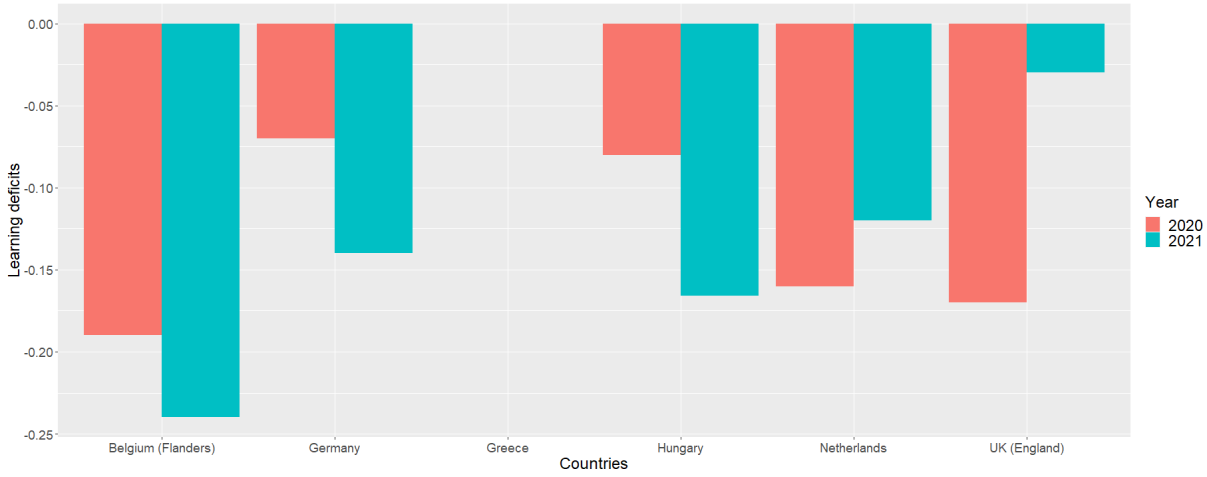
Note: plot of the evolution of the average scores in mathematics and language between 2006 and 2018 for Belgium (Flanders), Czechia, Denmark, Germany, Italy, Netherlands, Poland, Switzerland and the UK (England)). The scores for language are systematically higher than those in mathematics, which contrasts with what has been reported in most papers. In addition, the graph indicates a clear downward sloping curve in language.
Sources: Reports from PISA (2007, 2010, 2014, 2016) and OECD (2019b).

FIGURE 6a. Average learning deficit in maths 2020 and 2021 in Standard Deviation



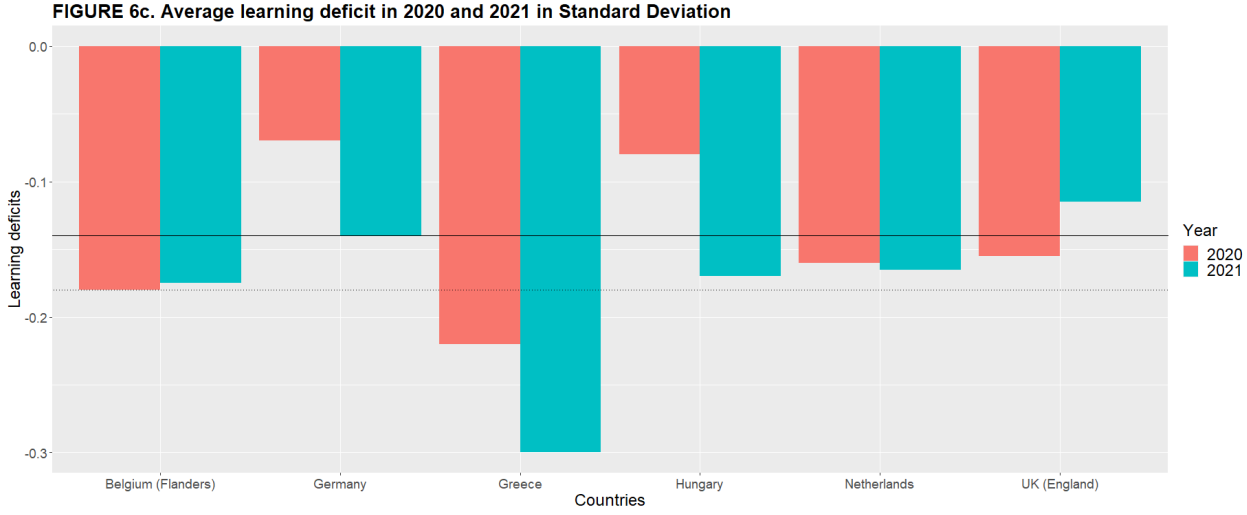
Note: average learning deficits for Belgium (Flanders), UK (England), Germany, Greece and Hungary from 2020 to 2021 in mathematics. Aside from Belgium (Flanders), each country experienced a larger learning deficit in 2021. There are missing observations for Germany.
Sources: EPI (2021); Gambi and De Witte (2021); Haelermans et al. (2022b); Lambropoulos and Panagiota (2022); Ludewig et al. (2022); Molnár and Hermann (2022); and Schult et al. (2022).

FIGURE 6b. Average learning deficit in language 2020 and 2021 in Standard Deviation



Note: average learning deficits for Belgium (Flanders), UK (England), Germany, Greece and Hungary from 2020 to 2021 in language. Aside from UK (England), each country experienced a larger learning deficit in 2021. There are missing observations for Greece.
Sources: EPI (2021); Gambi and De Witte (2021); Haelermans et al. (2022b); Lambropoulos and Panagiota (2022); Ludewig et al. (2022); Molnár and Hermann (2022); and Schult et al. (2022).

FIGURE 6c. Average learning deficit in 2020 and 2021 in Standard Deviation

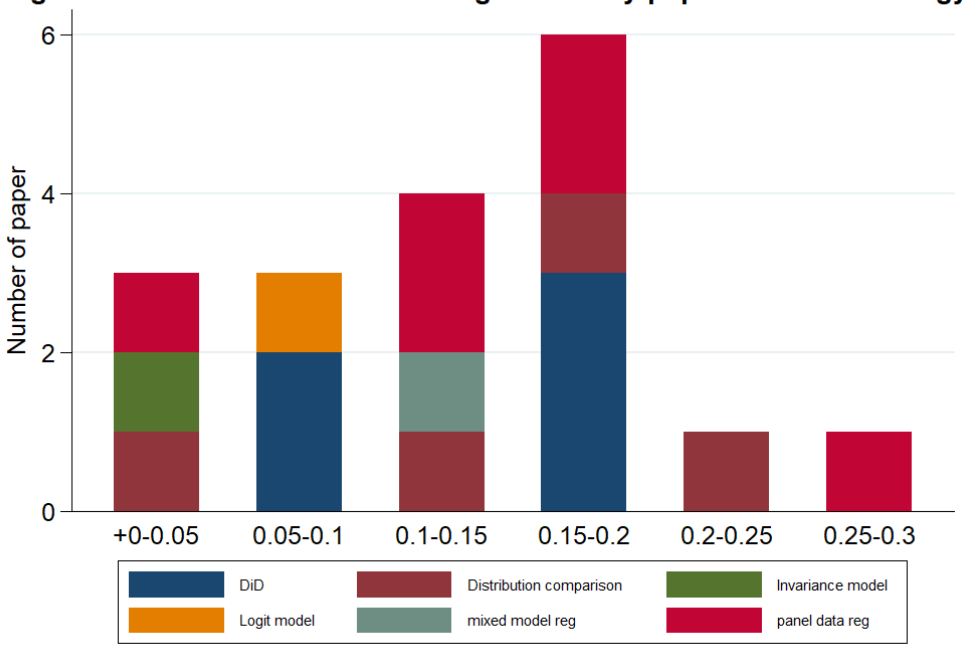


Note: average learning deficits for Belgium (Flanders), UK (England), Germany, Greece and Hungary from 2020 to 2021. The strong decline in learning outcomes in Greece from 2020 to 2021, as well as the decline in Germany, leads to a larger average learning deficit in 2021 (dotted line) than in 2020 (black line).
Sources: EPI (2021); Gambi and De Witte (2021); Haelermans et al. (2022b); Lambropoulos and Panagiota (2022); Ludewig et al. (2022); Molnár and Hermann (2022); and Schult et al. (2022).

Another potential explanation for the difference in estimated learning deficits might arise from the use of different methodologies. For 18 papers that measure the impact in SD, Figure 7 presents the distribution of the deficits depending on the applied methodology. Beside the five models considered in the figure, the remaining papers applied growth models or qualitative studies. Figure 7 indicates that the majority of papers rely on panel data regressions (6 papers), followed by a DiD specification (5 papers). Considering the few numbers of observations as well as the pattern described by Figure 7, we do not observe a specific relationship between the estimated learning deficits and the applied methodology. Although the DiD papers seem to indicate smaller learning deficits, the panel

data models are nearly normally distributed and the remaining articles are too few to draw any relevant conclusions on potential methodological bias.

Figure 7. Distribution of the learning deficits by paper and methodology



Sources: Arenas and Gortazar (2022); Borgonovi and Ferrara (2022); Contini et al. (2021); Engzell et al. (2021); EPI (2021); Förster et al. (2022); Gambi and De Witte (2021); Haelermans et al. (2022a); Haelermans et al. (2022b); Hallin et al. (2022); Jakubowski and Wrona (2022); Korbell and Prokop (2021); Lambropoulos and Panagiota (2022); Ludewig et al. (2022); Maldonado and De Witte (2021); Molnár and Hermann (2022); Rose et al. (2021); and Schult et al. (2022).

2. The influence of the COVID-19 pandemic on educational inequality and heterogeneity

In addition to the varying effects of the health crisis between EU Member States, variations can also be seen within each Member State. This section discusses the specific subgroups who have been more affected by the COVID-19 crisis.

2.1. Socio-economic status (SES)

With the physical closure of schools, students were forced learn remotely, making the socio-economic background of each student a more important factor in their learning. As such, inequalities within education systems increased. Multiple proxies have been used in the literature to define low versus high SES, leading to a great deal of heterogeneity when discussing this variable. For instance, Maldonado and De Witte (2021) examine inequalities using the education level of a child's mother, the home language, the financial support provided to the students and the neighbourhood in which the students live. Evidence of higher learning deficits was reported among students with a low-educated mother and those receiving financial support.

We will first consider the evidence from studies in which SES is defined in terms of receiving financial support. Maldonado and De Witte observed low-SES students having learning deficits of up to 0.5 SD compared with pre-pandemic levels, in both mathematics and language (Maldonado and De Witte, 2021). Similarly, in the English Education Policy Institute (2021) report, primary school pupils receiving financial support, i.e. those who were eligible for free meals, indicated a learning deficit twice as large as the estimated average. In reading, disadvantaged pupils reported a 1.9-month learning gap, compared with 0.9 months on average. In maths, there was a gap of 4.5 months, compared with 2.8 months on average. Findings were even more striking when comparing disadvantaged with non-disadvantaged pupils. Rose et al. (2021) found a similar slowdown in learning for the UK (England) when focusing on financial support. In Hungary, Molnár and Hermann (2022) measured the impact of COVID-19 on learning achievements of students from disadvantaged backgrounds, which is a precarious financial situation defined by the law. It appears that low-SES pupils in kindergarten experienced learning deficits between one-fifth and one-third greater than other students. Further slowdowns were also noticed in primary school education, particularly among lower primary students. In Denmark, Birkelund and Karlson (2021) estimated a small decrease of two percentile points in the education attainment of students whose parents were unemployed or in the bottom income quartile. Alternatively, the DEPP (2020a and 2020b) reports in France evaluated the financial situation of the parents by separating the results from public and private schools. They found that for both mathematics and reading, students at private schools performed better than students at public schools, especially for younger pupils. The type of school was also used as a proxy for SES in Spain (Basque Country). In particular, Arenas and Gortazar (2022) indicated that the learning deficits were significantly higher among public school pupils than those at private schools. It is important to note that, regardless of the country, the authors of both papers argue that the differences between public and private schools cannot be separated from the SES of the students.

The second group concerns those studies in which SES is defined in terms of the education level of parents. In Belgium, Maldonado and De Witte (2021) observe larger learning deficits of 0.5 SD in language and mathematics among such low-SES students compared with high-SES ones. In Poland, Korbell and Prokop (2021) confirmed that schools with more tertiary-educated parents reported a significantly smaller decline in education outcomes. As noted in Section 1, more information about this statement is difficult to provide, since the full report could not be accessed. In the Netherlands, Engzell et al.

(2021) noticed a decrease of 40% in the score of pupils with low-educated parents compared with the average. Similarly, Haelermans et al. (2022a) observed that learning deficits in mathematics were larger by 0.1 SD among students with low-educated parents. In Italy, Contini et al. (2021) found that the educational achievement was 0.51 SD lower for pupils with low-educated parents compared with highly educated ones. In Finland, Lerkannen et al. (2022) indicate that children whose parents have a higher education degree suffer smaller learning deficits.

In summary, since education and income correlate positively, larger education deficits are more often reported among the poorer students than among wealthier ones. Furthermore, the above numbers show how severe the gap can be for low SES students; almost twice the learning deficit of high-SES students.

2.2. Inequalities between strong and weak students

The COVID-19 crisis increased the gap between the highest- and lowest-performing students. Although the correlation between learning deficits and SES has been reported in nearly every country apart from Sweden, inequalities relating to students' performance level are less common. Maldonado and De Witte (2021) measured the gap in the distribution of test scores between the 90th percentile and the 10th percentile. They found an increase in the difference between the strongest and weakest students of 0.15 SD in mathematics and 0.09 SD in Dutch language. In Germany, Schult et al. (2022) noticed fewer top-performing students. In particular, in reading comprehension there was a decrease in the number of students with very high scores in 2020 compared to before the pandemic, while in mathematics there was an increase in the number of students with very low scores in 2020 compared with 2019. A similar pattern was reported by Birkelund and Karlson (2021) in Denmark.

In Italy, Contini et al. (2021) and Borgonovi and Ferrara (2022) focused on inequalities in school performance coupled to the SES of the students, which allows us to link this subsection to the previous one. The former paper concluded that low-SES but high-performing students were affected more by the school closure, i.e. by -0.35 SD compared with -0.16 SD for high-performing, high-SES pupils. The latter paper argues the opposite: there was no increase in the gap between low-SES but high performing students and high-SES students in mathematics and reading at Grade 8. For Grade 5 students, the same conclusion is reported only in mathematics. Furthermore, in some cases the authors noted a decrease in the gap between low-SES high-performing and high-SES high-performing pupils after school closures. This leads to an overall reduction in the effect of SES among high performing students.

Comparing the various European countries in this report allows us to explore the underlying pattern. The better results from Denmark are consistent with the finding raised in Section 1: namely, that the country was better prepared to face COVID-19 crisis, with most students already using ICT tools prior to the pandemic. This might explain how the level of polarisation in results is much lower than in Belgium or Germany. The contradictory results in Italy may be explained separately. According to Contini et al. (2021), the best-performing students from low-SES backgrounds are seeing the greatest falls in education attainment because previously, teaching in schools managed to mitigate the effects of their disadvantaged backgrounds. As a result of school closures, pupils remained in poor environments and suffered more from the harmful effects of their low SES. Conversely, Borgonovi and Ferrara (2022) hypothesise that remote learning helped to avoid some stereotypes being held by teachers, which led to them helping every student with the same level of effort. In addition, the arguments raised in Section 1 can be again invoked as external causes. The latter authors used a 2021 sample, while Contini et al. (2021) focused on 2020 and, as already discussed, Italy performed well in the reopening of its education

system. In other words, the efforts made by the country during the year 2021 successfully mitigated the effects of the COVID-19 pandemic and the inequalities it created.

2.3. Gender gap

Evidence regarding the gender gap in learning deficits is mixed, making it difficult to draw conclusions. For instance, the DEPP (2020a and 2020b) reports from France noted that boys in the 6th grade made stronger improvements than girls in their 2020 scores, compared with 2019. Overall, despite girls still outperforming boys, this strong improvement in boys' results led to a decrease in the gender gap in France in 2020. For 1st-grade pupils, however, results are similar between 2019 and 2020: higher grades for girls in French; better results for boys in mathematics. Overall, COVID-19 did not seem to increase the gender gap in France. Equivalent results were also found in the Netherlands, Germany and Belgium (Haelermans et al., 2022a; Engzell et al., 2021; Förster et al. 2022; Maldonado and De Witte, 2021). In Italy, Borgonovi and Ferrara (2022) concluded that the gender disparities were reduced following the COVID-19 crisis.

On the other hand, in the Netherlands, Schuurman et al. (2021) found higher learning deficits for boys compared with girls, while Contini et al. (2021) observed higher deficits for girls compared with boys. Specifically, Contini et al. (2021) estimated a learning deficit of 0.29 SD for girls, while among boys it amounted to 0.13 SD.

With respect to non-cognitive outcomes, Mendolia et al. (2021) argue that girls were more affected in terms of their mental health. Based on a sample of 21,000 observations from the UK and a DiD methodology, the authors explored the effect of the COVID-19 crisis on the mental well-being of students between 10 and 15 years old. On average, they found that the "total emotional and behavioural difficulties" of girls increased significantly, by 0.28 SD more than boys. The effect was even larger among girls from disadvantaged backgrounds[17], reinforcing the findings of Contini et al. (2021). Similarly, a recent study conducted in Germany by Ravens-Sieberer et al. (2022) measured the impact on mental health of the three COVID-19 waves using a logistic regression on a sample of 2,097 students aged between 7 and 17 years old. They noticed that girls were 1.2 to 2 times more at risk of reporting a low level of mental health-related quality of life. Similar patterns are also noticed in qualitative analyses conducted in Belgium and Finland (OECD/EU, 2022).

Conversely, Koehler et al. (2022) analyse multiple surveys and datasets to conclude that, on average, boys were more affected than girls. Male students were more likely to leave school, play videogames and were less involved in their learning process (Carrasco and Pibermat, 2021). However, based on worldwide analysis, they also noted other papers reporting an increasing risk of early pregnancies or exploitation among girls (UNESCO, 2020). Overall, they summarise their findings by arguing that both boys and girls were affected, but in different ways.

Conflicting evidence makes it difficult to draw conclusions, but the methodologies employed by authors may explain certain results. Haelermans et al. (2022a) could not find any gender issue because no differentiation was made between SES level and gender effect in their DiD model. Consequently, the effect of gender is drowned out by the greater impact of the low-SES variable. In line with this, Borgonovi and Ferrara (2022) did not add an interaction term between the gender and SES background, resulting in the absence of gender gap evidence. Conversely, Mendolia et al. (2021) followed a similar methodology to that used by Contini et al. (2022), and noted evidence of increasing gender gaps. Ravens-Sieberer et al. (2022) used another methodology that did not leave out other

[17] They found a higher increase of 0.37 SD for girls from low-SES compared with low-SES boys, against a higher increase of 0.22 of SD for high-SES girls.

control variables, and found a significant increase in the gender gap. Lastly, Engzell et al. (2021) used a DiD and an interaction between SES and gender and did not find any evidence of increase in the gender gap. In relation to the last of these articles, Schuurman et al. (2021) argue that it may be explained by the number of observations in the sample. Engzell et al. (2021) is based on a sample of 350,000 respondents, while there are only 883 observations in the sample used by Schuurman et al. (2021). Hence, according to them, an increase in gender gap might exist, but this phenomenon is drowned out by the number of observations. Similarly, Borgonovi and Ferrara (2022) was based on 800,000 respondents.

Overall, the gender gap seems to have increased in a significant way for girls in mathematics and mental well-being, especially for girls from disadvantaged backgrounds. On the other hand, boys face a higher risk of high school drop-out. Ultimately, both are affected but probably in different ways.

2.4. Mental health and cognitive heterogeneity

The previous subsection highlighted differences in mental health issues between boys and girls (Mendolia et al., 2021; Ravens-Sieberer et al., 2022). Arenas and Gortazar (2022) studied mental health during the pandemic by using a questionnaire that explored the cognitive outcomes of respondents. Their analyses suggests that a poorer level of mental health is significantly associated with greater learning deficits following the school closures.

Further evidence of this comes from Champeaux et al. (2020), who compared mental health outcomes in France and Italy using a panel data regression model. Their purpose was to measure the psychological impact of the school closures and the effect of remote learning on education, using a sample of 3,769 Italian and 3,183 French children. It is important to note that the effects of the pandemic on pupils' psychology and learning outcomes are measured using a questionnaire for parents. This means that they do not measure the actual impact of the COVID-19 crisis on children's mental well-being and learning outcomes, but rather parents' perceptions of it. In both countries, school closures negatively affected the socio-emotional status of the children. However, this effect was reported to be twice as high in Italy as in France. Interestingly, in relation to remote learning, parents noticed a less negative effect on their children. This implies that interactions via remote learning helped students to cope with school closures (Champeaux et al., 2020).

In line with this, a report conducted by the OECD/EU (2022) notices similar findings in other European countries. For instance, in Belgium, the share of individuals aged between 18-29 years old reporting anxiety symptoms increased from 12% in 2018 to 28% between April 2020 and June 2022. On the contrary, countries less exposed to the pandemic, such as Denmark, report smaller increases: from 16.2% prior the pandemic to 21.1%. However, Sweden did not report any learning loss (Fälth et al., 2021) and shows the highest rising of depressions symptoms, namely, from 9.5% to 42.5% during the pandemic. Furthermore, it appears that compared to adults, young people were mentally more affected by the health crisis. In 2019, an average of 6% of the 15-24 years old individuals in the EU reported depression symptoms, while it was 7% among adults. The pandemic completely reversed this finding. In most of the EU Member States, the share of young people subject to depression is at least 50% of the total population. Finally, the report suggests a general improvement in the year 2022, although specific countries still show larger shares of 18-29 years old people reporting anxiety or depression feelings compared to the pre-pandemic figures.

Ravens-Sieberer et al. (2022) indicate that the percentage of students reporting a low level of mental health-related quality of life increased from 15% before COVID-19, to 40% and then 48% during the first and second waves of the pandemic. During the last wave, this figure decreased to 35%. For each wave, the difference between each result is significant. In addition, Champeaux et al. (2020) and Ravens-Sieberer et al. (2022) made a link between mental health and SES. Both reported that students from low-SES backgrounds experienced larger negative effects due to school closures compared with high-SES students. For instance, disadvantaged students were 2.1 to 2.7 times more likely to experience a low level of mental health-related quality of life (Ravens-Sieberer et al., 2022). Lastly, evidence suggests that the younger the student, the more mentally affected they were. Ravens-Sieberer et al. (2022) report that 14 to 17-year-old students were 0.3 to 0.6 times less likely to present a low level of mental health-related quality of life.

From a broader point of view, a systematic review of the literature by Mazrekaj and De Witte (2022) notes several effects of school closures on the mental health of children. Among other effects, they reported that the school closures were associated with an increase in loneliness among children. This in turn leads to more anxiety and depression, and suicidal behaviour. Their review also found evidence of a growing use of social media and more sedentary behaviour during shutdown, leading again to the risk of anxiety and depression. Alternatively, children appear to be affected by the behaviour of their families – i.e. evidence indicates that the way in which "parents cope with the COVID-19 affects the psychosocial development of their children" (Mazrekaj and De Witte, 2022, p. 7).

From a more cognitive perspective, psychological personality traits affected the well-being of students as well as their expected learning outcomes during the health crisis. Iterbeke and De Witte (2021) measured how the Big Five personality traits[18] played a role in how students experienced the pandemic. Their methodology relied on an Ordinary Least Square (OLS) regression conducted among a sample of 347 Flemish students in secondary school. These personality traits were defined in relation to each respondent by using a survey created prior to the crisis. Another survey was sent out at the end of the first school closures to evaluate respondents' feelings about the pandemic. In general, this study showed that more "conscientious" and "open" students were likely to experience the school closures positively, while "neurotic" students reported negative experiences. No significant conclusions were found for "agreeableness" and "extraversion". In terms of expectations regarding school results, the authors concluded that higher level of conscientiousness was associated with higher expected attainment, while the opposite was found for more extraverted students.

In summary, mental health and the COVID-19 crisis appear to be related in several aspects. As shown by Arenas and Gortazar (2022), a poor level of mental health correlates with lower learning attainment after the pandemic. The school closures and the atmosphere during the health crisis resulted in a reduction in students' overall mental well-being (Champeaux et al., 2020; Mazrekaj and De Witte, 2022; Mendolia et al., 2021; Ravens-Sieberer et al., 2022). Furthermore, younger students, women and low-SES individuals correlate with poorer socio-emotional status (Champeaux et al., 2020; Ravens-Sieberer et al., 2022). Nevertheless, although such an assessment is correct on average, it may not be valid for every student. Iterbeke and De Witte (2021) showed that more "conscientious" and "open" individuals were more likely to experience the school closures positively, and therefore not to suffer from poorer mental health.

[18] The Big Five framework personality traits are: extraversion, agreeableness, conscientiousness, neuroticism and openness (to experience).

2.5. Children of essential workers

This group of students has not been extensively studied, and to the best of our knowledge, no research exists from EU Member States. Still, this question remains highly relevant since a wide range of very distinct professions were highly active during the pandemic, from nurses to bakers and cashiers. In this subsection, we limit the essential workers we consider to low-paid workers who worked for long hours during the pandemic. As an illustration, the European Parliament indicated that 42.2% of workers aged between 20 and 64 in 2020 were categorised as essential workers (Samek Lodovici et al., 2020). In addition, the authors found that essential workers were sensitive to an important increase in "stress, increased verbal harassment, discrimination and physical violence" (Samek Lodovici et al., 2020, p. 61). Other evidence exists in the USA and in New Zealand, respectively, from Garbe et al. (2020) and Mutch (2021). Both papers interviewed parents. In both studies, essential workers struggled to provide support to their children regarding homework, or even to have interactions with them (Garbe et al., 2020; Mutch 2021).

Based on an OECD report, a large share of essential workers in Europe are low-skilled workers employed mainly in commerce distribution, food-processing or health (OECD, 2020e). As noted in Section 2.1, several papers have shown how a lack of time spent with children, poverty and low education can affect students' education attainment. In other words, most of the essential workers were also in the category of low-SES parents. This means that figures for the impact of COVID-19 on education deficits among the children of essential workers can be approximated by considering the effects of low SES. This is in line with the papers from the USA and New Zealand, which reported such workers as having difficulties supporting their children (Garbe et al., 2020; Mutch, 2021).

Lastly, a link between essential workers and pupils' mental health also appears in the findings of Samek Lodovici et al. (2020). Evidence of increasing stress among essential workers leads the authors to assume that this could psychologically affect their children. This is consistent with Mazrekaj and De Witte (2022), who discussed how the psychological effects on children depended on how their parents were coping with the COVID-19 crisis. Again, no significant figures could be found in relation to this, which emphasises the need for further research on the effects of the crisis on essential workers.

2.6. Migrant background

In 2020, 8.2% of the EU's population was born outside its borders (Koehler et al., 2022). Nonetheless, most of the papers cited so far do not report a significant increase in learning deficits for students with a migrant background. In Germany, Ludewig et al. (2022) did not find any significant effect, but Schult et al. (2022) and Förster et al. (2022) noticed a small decrease in achievements for schools with a large share of students of migrant background. Similar findings were reported in the Netherlands (Haelermans et al., 2022a) and in the Basque country (Arenas and Gortazar, 2022), although the effect was not significant. In Belgium (Flanders), Maldonado and De Witte (2021) measured the impact of COVID-19 on students who did not speak Dutch at home, and found no effect on learning achievements.

Compared with quantitative studies, qualitative ones relate more negative consequences of the pandemic on students with migrant backgrounds. In a series of interviews conducted in Slovenia, Gornik et al. (2020) stated that remote learning increased language barriers which, consequently, lead to a number of issues for migrant students. Overall, the main challenges were increased difficulties in becoming integrated, and a lack of social interactions in the national language. Due to the school closures, it was harder for immigrant students to follow courses given in the national language, implying difficulties not only in learning the language, but also the course content. Such increased language barriers, together with less social interaction, in turn further worsened the language barriers faced by these students. For instance, Gornik et al. (2020) spoke about the

obstacles faced after the introduction of remote learning, with most of the migrant pupils interviewed reporting greater difficulties with understanding during remote learning compared with face-to-face classes. In addition, the implementation of remote learning was also a challenge, given that migrants often have fewer financial resources, leading to an increase in school drop-out (Koelher et al., 2022). In addition to this, according to a report by the OECD (2020e), 14% of essential workers in Europe are immigrants. In certain EU capitals, this figure is much higher – reaching, for instance, 50% of all essential workers in Brussels. Learning deficits among the children of essential workers have already been discussed, so the prevalence of this type of work among migrants suggests more negative impacts of the pandemic on children with migrant backgrounds. One can therefore conclude that immigrant students were more vulnerable to learning deficits due to the COVID-19 crisis.

While qualitative research revealed important effects of the pandemic among students with migrant backgrounds, the results of quantitative research are much more subtle. The underlying mechanism for such a pattern might have been anticipated at the light of what has already been explained in Section 2.3. Haelermans et al. (2022a), Ludewig et al. (2022) and Arenas and Gortazar (2022) studied the effect of a migration background on top of another indicator, SES. Hence, after taking into account the crucial effect of SES, no significant coefficients were found for migration background, because everything was covered by the SES variable. This is consistent with the previous discussion regarding essential workers: such workers are generally less educated, less skilled and therefore poorer than average, leading to a low SES indicator. As a result, it is possible that migrant children have suffered an even greater negative effect of the COVID crisis, but these numbers are hidden among those affected by low SES. Further quantitative research should be conducted to explore the link between immigration and low-SES effects. In addition, the comment made by Contini et al. (2021) with regard to the gender gap and the importance of interaction terms in empirical models could also apply here. For instance, if papers include a variable capturing the interaction between migrant background and the (lower) educational level of parents, conclusions might be different. Nevertheless, the consequences of COVID-19 on the learning deficits of migrants' children can be approximated with reasonable accuracy by considering the results of SES effects, as suggested with essential workers.

2.7. Students with special educational needs (SEN)

Few quantitative studies have measured the effect of the COVID-19 crisis in terms of learning deficits among SEN students. However, Koelher et al. (2022) found several surveys and interviews addressing multiple aspects of the difficulties faced by pupils with SEN. The evidence suggests that remote learning induced severe concerns on three distinct levels.

The first concerns the complicated implementation of individualised learning support. This was already a problem before the pandemic, and has been exacerbated by it. Indeed, students with SEN require special attention from teachers and yet –in the example of Scotland, for instance – 50% of teachers disagreed with the statement that they managed to meet those additional needs (Education Institute of Scotland, 2020). Similar figures were also reported in the USA (Hamilton, Kaufman, & Diliberti, 2020). In addition, because COVID-19 prevented trained staff from delivering the necessary support, this resulted in additional pressure on parents. Surveys report notable feelings of unpreparedness and an increasing incidence of parental burnout and exhaustion. From the perspective of students, the burden faced by parents has limited their capacity to support their children's learning process, making these children even more vulnerable.

Second, pupils with SEN sometimes rely on specialised tools provided by the school to support their learning process. For instance, talking calculators, text magnifiers, etc. are crucial for many children to make full use of ICT. As a consequence of the school closures, students lost access to these tools without the possibility to acquire them. This led students with SES to give up some courses because they could not access them. For instance, online applications used for remote learning were not adapted for SEN, or such children simply did not have the adapted materials at home to follow these courses. Again, this is evidence of a bigger deficit in learning among SEN pupils compared with other students.

Lastly, well-being crucially depends on social interactions, especially for pupils with SEN. Again, this is a pre-existing challenge before the pandemic that has been aggravated by it. Koelher et al. (2022) found evidence that remote learning and the loss of social interactions with peers had a negative impact on the mental health of these students, particularly because individuals with SEN crucially rely on school for their social interactions. As a result, the worsening of socio-emotional well-being is associated with bigger learning gaps, in line with the discussion in the earlier sub-section on mental health.

However, this situation might be more nuanced. In Germany, Nusser (2021) focuses on how low-achieving students and those with SEN cope with remote learning. Her methodology is based on a panel data regression model applied on a sample of 1,430 observations. She regresses the parents' perceptions of learning outcomes and the difficulty for their children to work during school closures on several independent variables. Among others, these variables were dummies for the group of students with SEN, for the low-achieving group, etc. Importantly, fixed effects such as parents' level of education were included. Contrary to Koelher et al. (2022), Nusser (2021) shows that the group with SEN spent 35 hours/week on schoolwork and received on average 11 hours of support from their parents. In comparison, the low-achieving group spent 16 hours per week and received an average of 5 hours of support. However, those results vary greatly, since high SD are reported. In addition, the same analysis shows that the parents of the SEN group did not have much difficulty in motivating their children to work. Lastly, the panel data regression indicated slightly different conclusions from those of Koelher et al. (2022). Their model found that having a child with SEN did not affect parents' perceptions of the difficulties faced by their children regarding schoolwork. Instead, the education level of the parents had a much more significant effect on such perceptions. Despite the latter finding, the authors still found that, on average, parents who had a child with SEN expected lower learning outcomes at the end of the pandemic compared with parents of low-achieving pupils. In general, Nusser (2021) shows that from a wider perspective, having children with SEN does not affect the challenges such children had to face, although they worked more than low-achieving pupils during the COVID-19. However, it shows that parents were still worried about the learning outcomes after the pandemic.

Given this mixed evidence, the question remains regarding the overall impact of the pandemic on students with SEN. Similarities can be found to the discussions regarding the gender gap and the migrant disparities. In both situations, the effect of the pandemic did not depend on gender or migrant status, because the main effect was dependent on the variable of SES. Since the analysis applied by Nusser (2021) follows the same methodology, the same explanation can apply. More specifically, no effects were identified for the SEN variable, because the effect of parents' educational level was too significant. As suggested by Contini et al. (2021), the interaction between educational level and SEN could be relevant. Also, the dependent variable concerns the perceptions of parents regarding the difficulties faced by their children during remote learning, not their learning loss. In other words, the results might be crucially different if the learning deficit after school closures was used as the variable explained. Nevertheless, a common feature exists among both papers: Nusser (2021) mentions parents' worries about the school outcomes of their children with SEN, in comparison to low-achieving pupils. This is in line with what

Koehler al. (2022) report about the difficulties of supporting children, and the level of unpreparedness mentioned by parents. In both articles, parents are worried about their children's learning attainments. Lastly, the evidence reported by Koehler et al. (2022) provides a good illustration of the various effects of the school closures on the SEN group.

In summary, SEN students probably experienced a strong learning loss. The pandemic also increased the anxiety of the parents of SEN students about their children's school outcomes. Nevertheless, this effect may vary – in Germany, for instance, pupils with SEN appear not to be more impacted by the COVID-19 crisis than other students. Further research should be considered to derive significant figures on the educational achievements of students with SEN.

3. Policy implications and recommendations

Section 1 indicated that the pandemic did not affect the EU's Member States in a homogeneous way: Belgium (Flanders), Greece, Poland and Italy reported much higher learning deficits compared with, for instance, France and Sweden. As education outcomes have been shown to have long term implications in terms of economic growth, income and well-being, this pattern of divergence in educational outcomes that arose due to the pandemic should be closed as soon as possible to maintain economic and social cohesion in the EU. In addition to inequalities between EU Member States, the literature reviewed in Section 2 has observed an increase in inequality within countries. For these reasons, the recommendations of the present report favour targeted policies for countries, but also with regard to individual students. This section presents five policy recommendations to mitigate the COVID-19 effects on education in the short and long term.

3.1. Short term – Compensatory policies: summer schools, tutoring and additional tutoring during breaks

A first recommendation is the implementation of compensatory policies such as summer schools or tutoring programmes as a relevant way to recover from the pandemic's effects. The papers presented provide evidence of the effectiveness of such interventions. In Belgium (Flanders), Gambi and De Witte (2021) examined the impact of providing summer schools. Their findings are encouraging: while postcode areas with a summer school reported severe learning deficits in 2020 in Dutch language and mathematics (of 0.27 SD and 0.22 SD, respectively), the attainment deficit was halted for both subjects in 2021. This suggests that summer schools were implemented in the areas with the strongest learning deficits, and that they were effective. In postcode areas with a summer school, a non-significant decrease (0.02 SD) was reported in Dutch language, while in mathematics, a non-significant increase was noted (0.07 SD). In other words, while attainment deficits still exist in comparison to the pre-COVID-19 situation, these results suggest that that they can be mitigated through summer schools. Similarly, in Germany, Depping et al. (2021) found that additional courses during the summer holidays and the use of remote learning during school closures led to positive outcomes. In reading, the COVID-19 cohort reported better results than the control cohort (a difference of 0.05 SD), and a small learning deficit was noted in mathematics (0.02 SD). However, these figures should be approached with caution, as the authors admit their sample was likely to have underrepresented weaker students. In Italy, Borgonovi and Ferrara (2022) reported better results and improvements in scores for the year 2020-2021 compared with the findings of Contini et al. (2021). Again, these positive outcomes were explained by the large investments made to support education (De Witte and Smet, 2021). However, on a more technical note, most of these positive outcomes resulting of summer schools were based on correlations and not on an exact causal relations.

3.2. Short term – Targeted compensatory policies

As discussed in Section 2, some students were much more affected than others. To ensure compensatory policies are efficient, it is necessary to adapt them to the needs of each student. In more general terms, it has been shown that SES was at the root of many disparities between students. Educational gaps by gender, among migrants, for the children of essential workers and those with special education needs are all related to the SES of the student. Hence, as was carried out in Belgium (Flanders), summer schools and tutoring programmes should firstly be set up in zones with a high proportion of disadvantaged students. Evidence from both Gambi and De Witte (2022) and Postlbauer et al. (2022) show that such remedial actions reach the students who are most at risk of learning deficits.

In terms of socio-emotional skills, Iterbeke and De Witte (2021) concluded that the current "one size fits all" approach to education does not work. Instead, methods of teaching should be adapted depending on the needs and preferences of the students. For instance, students with a high level of conscientiousness and a poor level of extraversion report higher results as a result of remote learning. Hence, retaining some elements of remote learning could be a promising idea. On the other hand, students with SEN mentioned their difficulties in following remote learning sessions due to a lack of materials. Thanks to the recent ICT investments in most EU countries, this may improve in the short run.

Lastly, the findings of this review suggest that tutoring and summer school programmes should target the youngest students, who were more affected by the school closures. Where the length of school closures differed within a country, additional remedial actions could also be provided to students at those schools that were closed for a longer period.

Most of the evidence presented in this report verifies the link between more conspicuous learning deficits and areas with a high proportion of low-SES students or lengthy school closures. Consequently, this report recommends that, in terms of the prioritisation of efforts, these areas should be the first to experience targeted compensatory polices. Even though these zones were certainly not the only ones to suffer during the pandemic, they have the most documented learning gaps. Hence, the targeting of compensatory policies towards these zones will ensure the usefulness of such policies.

3.3. Short and long term – Monitoring

To implement Recommendations 3.1 and 3.2, standardised tests should be used to detect where needs exist, and to monitor progress. Data collected at national level in different EU Member States could also be pooled, such that cross-country evaluations and the sharing of good practices becomes possible. This would require that such tests should be standardised at EU level to allow comparisons to be made between countries, as in the PISA evaluations. This latter issue would require that, in practical terms, monitoring would be conducted at both EU level and the level of individual Member States. In doing so, active collaboration and information sharing would occur. Furthermore, questionnaires evaluating personality traits could help educators and governments to adapt their recovery plans better suit students' needs.

3.4. Long term – Adapting the curriculum

Although remedial actions such as summer schools may mitigate the learning deficit, they might not reverse the learning deficits yet. Therefore, it has been suggested to simplify and adapt curricula to focus again on the needs and strengths of students. The idea behind this is to prioritise crucial skills in which learning attainments were lowered by the pandemic: numeracy, literacy, etc. In practice, this could involve additional classes for students with greater learning needs. On the other hand, to ensure there is no loss of focus on the top-performing students, as reported in Belgium (Flanders) by Gambi and De Witte (2022), strong students could receive an adapted curriculum with a greater number of subjects, or a deepened curriculum. This policy advice contrasts with the present trend towards broadening the curriculum rather than deepening it. As a result of this prevailing trend, teachers are under pressure to cover more subjects, while students lack the time to think about and digest what they learn (Beatty and Pritchett, 2015; Glewwe et al., 2009). This fourth recommendation empowers educators. Since they are the most involved and closest to students' learning, they are also in the best position to define students' needs.

3.5. Long term – Investment

The Recovery and Resilience Facility (RRF) supports EU Member States to make significant investments in education. Around 14% of these investments, or EUR 71 billion, is directed

towards education (Fack et al., 2022). However, these investments should be made in the most cost-effective way. We therefore recommend testing in a rigorous way (e.g. by using experiments or quasi-experiments) the impact of investments, and linking the effectiveness of each initiative with its costs.

Although the report by Fack et al. (2022) reviews a number of cost-effective measures, our review of the literature signals the importance of investments in ICT. Countries that used ICT hardware and software in education were better able to cope with school closures. Furthermore, some positive outcomes were even obtained through the use of ICT tools in terms of education attainment or mental health (Birkelund and Karlson, 2021; Champeaux et al., 2020; Lerkannen et al., 2022; Spitzer and Musslick, 2021; Van der Velde et al., 2021). With respect to inequality in education outcomes and in line with section 3.2, ICT investments should be targeted. For instance, students with SEN reported a lack of access to ICT tools. Spitzer and Musslick (2021) indicate that a combination of software and traditional learning methods is particularly efficient in narrowing education gaps between students. The DESI reports provide a good starting point to determine which investments should be made by each country in terms of internet broadband and the use of ICT. Besides from those investments in the "hardware", the IRDLL (Beblavý et al., 2019) provided relevant country-by-country recommendations of investments to develop ICT for educational purposes. Investing in the professional development of teachers in terms of ICT might be as needed as laptops and internet broadband. Indeed, if the latter are certainly crucial, *having* them is not enough to efficiently *use* them and to include ICT in education. This aspect and therefore the investment needed varies a lot depending on the countries. The latter recommendation was also suggested by Beblavý and Kazlauskaitė (2021) in a previous EENEE report. Besides from trainings addressed for teachers, trainings to use ICT tools for vulnerable parents group could also be developed in order to, again, prevent the widening of inequalities between high and low-SES. In the end, EU Member States should use the momentum that exists thanks to the Recovery and Resilience Facility to increase the use of ICT in education.

Conclusion

This report provides a systematic, country-by-country review of learning deficits following the COVID-19 health crisis. Its findings suggest significant variation both within and between countries, depending on multiple elements. First, the length of the school closures. The longer the absence of in-person teaching, the more conspicuous the learning deficits. Second, the level of preparedness for the use of ICT was indicated as a strong factor of resilience against the COVID-19 crisis. Although the effectiveness of remote teaching appears to have varied between countries, it helped to mitigate achievement deficits. Third, more harm was done to the education outcomes of younger students as a result of the school closures. Given their low meta-cognitive skills, younger students had greater difficulties in planning their work. Fourth, the COVID-19 pandemic seems to have exacerbated the (downward) trend in the cognitive outcomes of European education systems.

In addition, the impact of the pandemic was unequal within countries. Section 2 describes the heterogeneous results for different subgroups within the population. Among others, this section describes learning deficits among students with a migrant background, those whose parents are essential workers, and students with SEN. However, the overriding conclusion is that the SES of students is the most significant variable correlating with learning deficits. In almost all cases, low SES is related to other aspects that, together, induce further learning deficits or more mental health issues.

Lastly, the report makes five policy recommendations. The first of these is targeted remedial actions, as tutoring programmes and summer schools have allowed education systems to mitigate the initial learning deficits. These policies should target disadvantaged students or those who endured longer periods of school closure. Second, special attention should be given to younger students. Third, students' educational outcomes should be monitored to help educators identify the students' needs in the short term and to measure the evolution of learning outcomes in the medium/long term. Fourth, the curriculum could be adapted such that it becomes more focused. Lastly, additional cost-effective investments, e.g. in ICT hardware and software, should be made to foster the learning process of students, but also to prepare our education systems for potential crises in the future.

Appendix A – Key findings

Country	Sample size	Length of school closure	Main findings	Sources
Belgium (Flanders)	N ≈ 1,400 schools	9 weeks	▪ 2019-2020: Average learning deficit in language of 0.19 SD ▪ 2019-2020: Average learning deficit in mathematics of 0.17 SD	Maldonado and De Witte (2021)
	N ≈ 2,200 schools	9 weeks	▪ 2020-2021: Average learning deficit in language of 0.24 SD ▪ 2020-2021: Average learning deficit in mathematics of 0.11 SD	Gambi and De Witte (2021)
Czechia	N = 88 schools	12 weeks	▪ 2019-2020: Average learning deficit in language of 0.1 SD ▪ 2019-2020: Average learning deficit in mathematics of 0.12 SD	Korbell and Prokop (2021)
Denmark	N ≈ 200,000 students	8 (primary education) and 22 (secondary education) weeks	▪ 2020-2021: Average learning gain for grade 2 around 4,8 percentile points ▪ 2020-2021: Average learning gain for grade 4 around 5,1 percentile points ▪ 2020-2021: Average learning gain for grade 6 around 3.0 percentile points ▪ 2020-2021: Average learning deficit for grade 8 around 2.8 percentile points ▪ Authors' conclusion: No slowdown in student learning	Birkelund and Karlson. (2021)
Finland	N = 542 students	8 weeks	▪ 2019-2020: Small learning deficit reported in language ▪ 2019-2020: No average learning deficit in mathematics ▪ 2020-2021: No learning deficit was recovered in the year following the COVID-19	Lerkannen et al. (2022)

France	N = 111 schools	8 weeks	▪ 2019-2020: 0.6% less students master their language in the 1st grade ▪ 2019-2020: 1% less students master mathematics in the 1st grade	DEPP (2020a)
		8 weeks	▪ 2019-2020: 4.8% more students master their language in the 6th grade ▪ 2019-2020: 3.2% more students master their mathematics in the 6th grade	DEPP (2020b)
Germany	N = 12,037	11weeks	▪ 2019-2020: Average learning improvement in reading of 0.08-0.13 SD in the 2nd grade ▪ 2020-2021: Average learning improvement in reading of 0.06-0.09 SD in the 2nd grade	Förster et al. (2022)
	N = 111 schools	8 weeks	▪ 2019-2020: Positive results in mathematics from students using a software tool prior and during the pandemic	Spitzer and Musslick (2021)
	N ≈ 800,000 students	10 weeks	▪ 2019-2020: Average learning deficit in language of 0.07 SD in the 5th grade ▪ 2019-2020: Average learning deficit in mathematics of 0.09 SD in the 5th grade	Schult et al. (2022)
	N = 2,556		▪ 2020-2021: Average learning deficit in language of 0.14 SD in the 4th grade	Ludewig et al. (2022)
Greece	N = 22,000 students	9 weeks in 2019-2020 12 weeks in 2020-2021	▪ 2019-2020: Average learning deficit in social science knowledge of 0.22 SD for end of secondary school students ▪ 2020-2021: Average learning deficit in social science knowledge of 0.3 SD for end of secondary school students	Lambropoulos and Panagiota (2022)

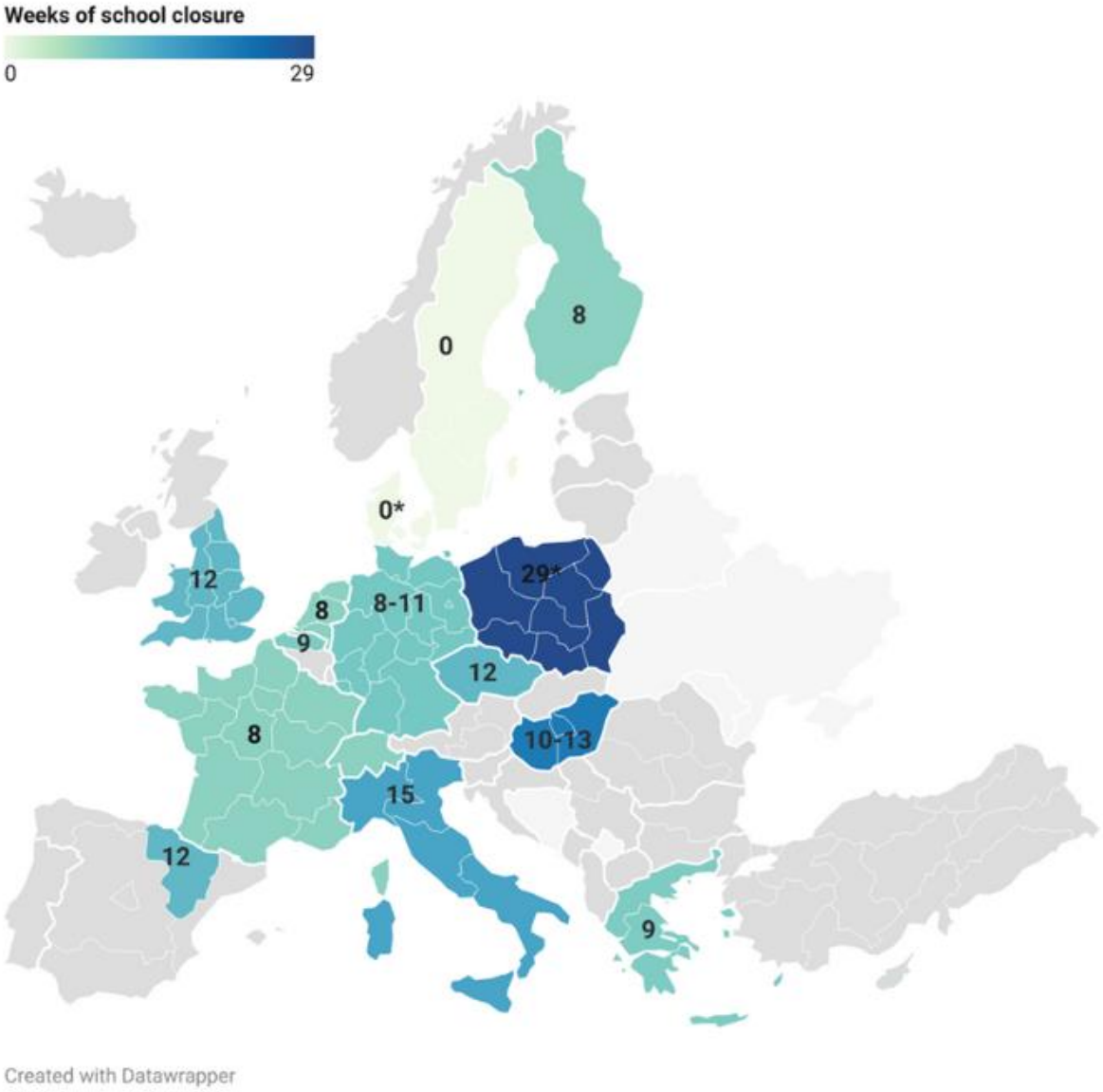
Hungary	N ≈ 80,000 students	10 weeks (kindergarten) 13 weeks (primary education) 6 weeks (kindergarten and lower primary education) 9 weeks (upper primary education)	▪ 2019-2020: Average learning deficit in language of 0.1 SD and 0.16 SD in mathematics for kindergarten students ▪ 2019-2020: Average learning deficit in language of 0.1 SD and 0.06 SD in mathematics for lower primary school students ▪ 2019-2020: Average learning deficit in language of 0.04 SD and 0.02 SD in mathematics for upper primary school students ▪ 2020-2021: Average learning deficit in language of 0.12 SD and 0.23 SD in mathematics for kindergarten students ▪ 2020-2021: Average learning deficit in language of 0.28 SD and 0.2 SD in mathematics for lower primary school students ▪ 2020-2021: Average learning deficit in language of 0.1 SD and 0.08 SD in mathematics for upper primary school students	Molnár and Hermann (2022)
Italy	N = 1,539 students N ≈ 800,000 students	15 weeks Between 7 and 19 weeks	▪ 2019-2020: Average learning deficit in mathematics of 0.19 SD ▪ 2020-2021: Grade 5 students: Average learning deficit in mathematics of 0.016 SD and average learning gain of 0.02 in reading ▪ 2020-2021: Grade 8 student: Average learning deficit in mathematics of 0.07 SD and average learning deficit of 0.03 in reading	Contini et al. (2021) Borgonovi and Ferrara (2022)
The Netherlands	N ≈ 350,000 students	8 weeks	▪ 2019-2020: Average learning deficit in language of 3.14 percentile points ▪ 2019-2020: Average learning deficit in mathematics of 3.05 percentile points	Engzell et al. (2021)

	N = 883 students	8 weeks	▪ On average, the total learning deficit is estimated at 0.08 of SD ▪ 2019-2020: Decreased average score by 5.3 points in reading ▪ 2019-2020: Decreased average score by 10.3 points in mathematics	Schuurman et al. (2021)
	N = 201,187 students	8 weeks	▪ 2019-2020: Average learning deficit in language of 0.145 SD ▪ 2019-2020: Average learning deficit in mathematics of 0.21 SD	Haelermans et al. (2022a)
	N ≈ 133,000 students	8 weeks	▪ 2019-2020: Improvements reported in mathematics by using an ICT tool to practice exercises	Van der Velde (2021)
	N ≈ 850,000 students	8 weeks More than 8 weeks in total	▪ 2019-2020: Average learning deficit in reading of 0.11 SD ▪ 2019-2020: Average learning deficit in spelling of 0.21 SD ▪ 2019-2020: Average learning deficit in mathematics of 0.16 SD ▪ 2020-2021: Average learning deficit in reading of 0.04 SD ▪ 2020-2021: Average learning deficit in spelling of 0.20 SD ▪ 2020-2021: Average learning deficit in mathematics of 0.21	Haelermans et al. (2022b)
Poland	N = 4,581 students	29 weeks	▪ 2020-2021: Average learning deficit in language of 0. 29 SD ▪ 2020-2021: Average learning deficit in mathematics of 0.31 SD	Jakubowski and Wrona (2022)
Spain (Basque countries)	N = 20,748 students	12 weeks	▪ 2020-2021: Average learning deficit in language of 0. 046 SD	Arenas and Gortazar (2022)

			▪ 2020-2021: Average learning deficit in mathematics of 0.075 SD	
Sweden	N = 97,073 students	No closure	▪ 2020-2021: No learning deficit reported	Hallin et al. (2022)
Switzerland	N = 13 134 N = 15 551	8 weeks	▪ 2019-2020: Learning process significantly twice higher during in-person classes than in remote learning for primary school students ▪ 2019-2020: No significant effect reported for secondary school students	Tomasik et al. (2021)
UK (England)	N ≈ 6,000 students N ≈ 150 000 schools N = 105 327 students for language N = 6 485 students for mathematics	12 weeks 11 weeks Between 12 and 16 weeks	▪ 2019-2020: Average learning deficit in language of 0. 17 SD ▪ 2019-2020: Average learning deficit in mathematics of 0.14 SD ▪ 2020-2021: Average learning deficit in language of 0. 025 SD ▪ 2020-2021: Average learning deficit in mathematics of 0.033 SD ▪ 2020-2021: Average learning deficit in language of 0.03 SD ▪ 2020-2021: Average learning deficit in mathematics of 0.2 SD	Rose et al. (2021) Blainey and Hannay (2021) EPI (2021)

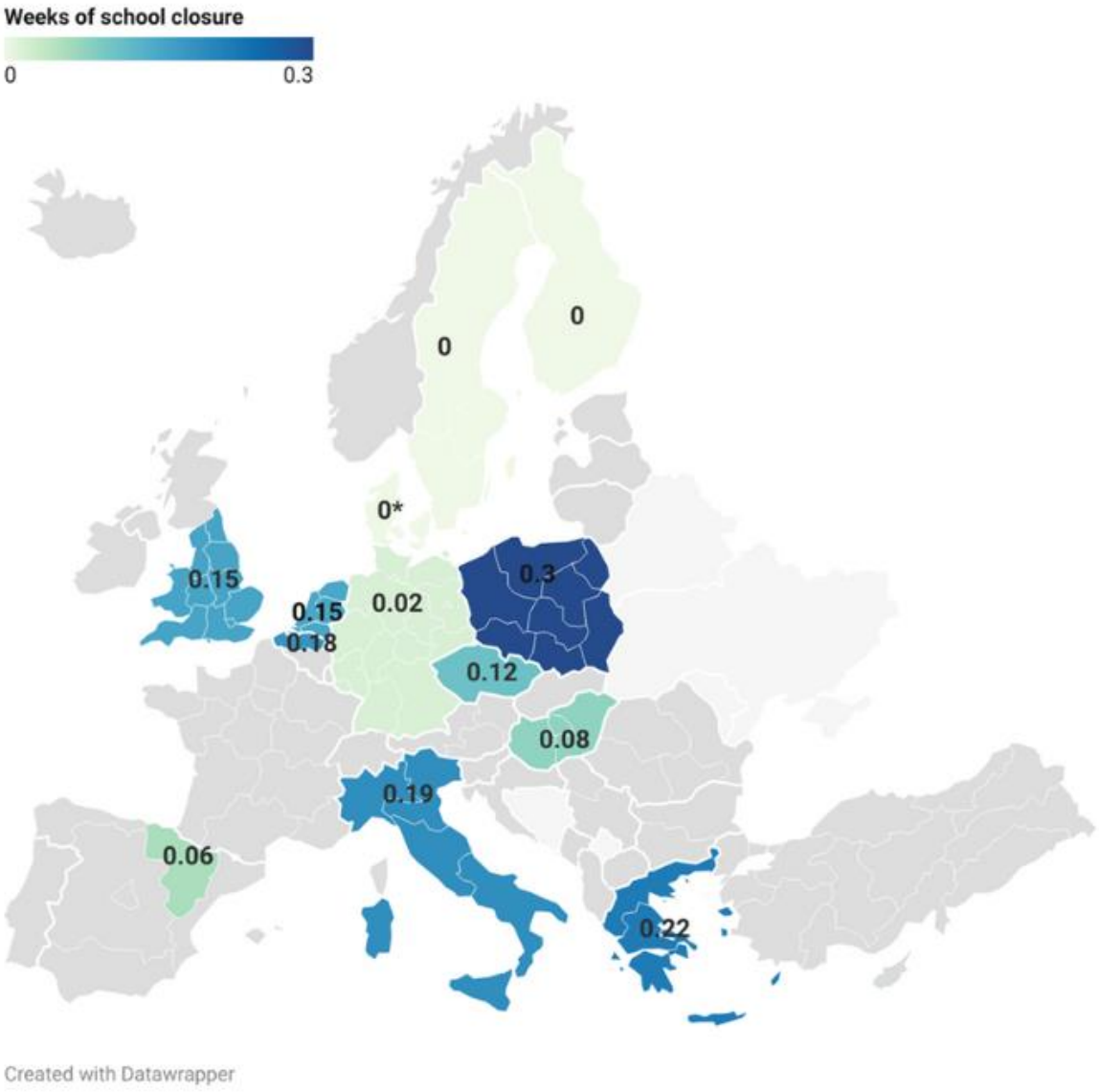
Appendix B - Maps

Figure 1. Map of the total weeks of school closure, 2019-2020



Note: the above figure is based on the results reported in Appendix A and focuses on the year 2019-2020. Poland and Denmark are marked by an asterisk (*) because it was not possible to determine the number of weeks closed in 2019-2020. Countries in grey are missing observations.

Figure 2. Map of average learning deficits in 2019-2020, in standard deviations



Note: this figure is based on the results reported in Appendix A by averaging each country's standard deviations for the year 2019-2020. Countries marked by an asterisk (*) use the data from 2020-2021. Countries in grey are missing observation or without values in standard deviations.

Appendix C – Regression results

Table 1. Estimates of the meta OLS regression

	Estimate	SE	Lower bound	Upper bound
Intercept	-0.09	0.04	-0.18	-0.004
Grade	0.005	0.008	-0.012	0.023
Weeks	-0.007	0.004	-0.015	0.002
N			12	

Note: the intercept is significant at the 10% level. The adjusted R-squared equals 0.21, which indicates the weakness of this model. The small number of observations used as a sample in this regression explains these poor outcomes.

References

Angrist, N., de Barros, A., Bhula, R., Chakera, S., Cummiskey, C., DeStefano, J., ... & Stern, J. (2021). Building back better to avert a learning catastrophe: Estimating learning loss from COVID-19 school shutdowns in Africa and facilitating short-term and long-term learning recovery. *International Journal of Educational Development*, *84*, 102397.

Arcia, G., de Hoyos, R., Patrinos, H., Sava, A., Shmis, T., & Teixeira, J. (2021). Learning Recovery after COVID-19 in Europe and Central Asia.

Arenas, A., & Gortazar, L. (2022). Learning loss One Year After School Closures. *Esade Working Paper*.

Belot, M., & Webbink, D. (2010). Do teacher strikes harm educational attainment of students? *Labour*, 24(4), 391–406.

Beblavý, M., Baiocco, S., Kilhoffer, Z., Akgüç, M., & Jacquot, M. (2019). *Index of Readiness for Digital Lifelong Learning-Changing How Europeans Upgrade Their Skills* (No. 25419). Centre for European Policy Studies.

Beblavý, M., Kazlauskaitė, D. (2021) 'Policy measures to monitor and mitigate the negative impacts of COVID-19 and COVID-19 related policy measures on education', EENEE report, Luxembourg: Publications Office of the European Union. doi: 10.2766/49698.

Birkelund, J.F., & Karlson, K.B. (2021). No evidence of a major learning slide 14 months into the COVID-19 pandemic in Denmark.

Borgonovi, F., & Ferrara, A. (2022). A Longitudinal Perspective on the Effects of COVID-19 on Students' Resilience. The Effect of the Pandemic on the Reading and Mathematics Achievement of 8th and 5th Graders in Italy. *The Effect of the Pandemic on the Reading and Mathematics Achievement of 8th and 5th Graders in Italy (February 3, 2022)*.

Carrasco, S., & Pibernat, M. (2020). Impact of the pandemic on third-country national secondary school students in Spain. Barcelona: learning4citizenship. Retrieved October 3, 2022, from https://intered.org/es/recursos/informe-impacto-de-lapandemia-de-la-COVID-19-en-el-alumnado-de-secundaria-nacional-de

Champeaux, H., Mangiavacchi, L., Marchetta, F., & Piccoli, L. (2022). Child development and distance learning in the age of COVID-19. *Review of Economics of the Household*, 1-27.

Chetty, Friedman, J.N., & Rockoff, J.E. (2014). Measuring the impacts of teachers, [part] II: teacher value-added and student outcomes in adulthood. *The American Economic Review*, *104*(9), 2633–2679. https://doi.org/10.1257/aer.104.9.2633

Contini, D., Di Tommaso, M.L., Muratori, C., Piazzalunga, D., & Schiavon, L. (2021). The COVID-19 pandemic and school closure: learning loss in mathematics in primary education.

Dahlberg, M., Edin, P.A., Grönqvist, E., Lyhagen, J., Östh, J., Siretskiy, A., & Toger, M. (2020). Effects of the COVID-19 pandemic on population mobility under mild policies: Causal evidence from Sweden. *arXiv preprint arXiv:2004.09087*.

Danish Evaluation Institute (2021). Grundskolers erfaringer med nødundervisning under COVID-19 pandemien [Primary schools' experiences with emergency education during the

COVID-19 pandemic]. Danmarks Evalueringsinstitut. https://www.eva.dk/grundskole/grundskolers-erfaringer-noedundervisning-under-COVID-19-pandemien

De Witte, K., & Smet, M. (2021). 'Financing education in the context of COVID-19', *EENEE Ad hoc report* no. 03/2021.

Depping, D., Lücken, M., Musekamp, F., & Thonke, F. (2021). Kompetenzstände Hamburger Schüler* innen vor und während der Corona-Pandemie [Alternative pupils' competence measurement in Hamburg during the Corona pandemic]. In: D. Fickermann & B. Edelstein (eds.), Schule während der Corona-Pandemie. Neue Ergebnisse und Überblick über ein dynamisches Forschungsfeld (pp. 51–79). Waxmann. https://doi.org/10.31244/9783830993315.03

Digital Economy and Society Index (2019a). *Belgium.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019b). *Czechia.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019c). *Denmark.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019d). *France.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019e). *Greece.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019f). *Hungary.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019g). *Italy.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019h). *Poland.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019i). *Spain.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019j). *United Kingdom.* Retrieved October 24, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019k). *Finland.* Retrieved December 22, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019l). *The Netherlands.* Retrieved December 22, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2019m). *Germany.* Retrieved December 22, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

Digital Economy and Society Index (2020a). *Finland.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2020

Digital Economy and Society Index (2020b). *Netherlands.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2020

Digital Economy and Society Index (2021a). *Germany.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021

Digital Economy and Society Index (2021b). *Italy.* Retrieved September 28, 2022, from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021

Direction de l'évaluation, de la prospective et de la performance (DEPP) (2020a), "Evaluations 2020 Repères CP, CE1 : Premiers résultats", Série Études, No. 2020-E04, novembre 2020, Ministère de l'Education nationale, de la Jeunesse et des Sports, Paris. https://www.education.gouv.fr/evaluations-2020-reperes-cp-ce1-premiers-resultats-307122

Direction de l'évaluation, de la prospective et de la performance (DEPP) (2020b), "Évaluations de début de sixième 2020 : Premiers résultats", Série Études, No. 2020-E05, novembre 2020, Ministère de l'Education nationale, de la Jeunesse et des Sports, Paris. https://www.education.gouv.fr/evaluations-de-debut-de-sixieme-2020-premiers-resultats-307125

Dockx, J., Van Landeghem, G., Aesaert, K., Van Damme, J., & De Fraine, B. (2019). Begrijpend lezen van het vierde naar het zesde leerjaar. Herhalingsmeting van PIRLS in 2018 vergeleken met PIRLS 2016.

Education Institute of Scotland. (2020). Teaching During the Covid-19 Shutdown. Education Institute of Scotland. Retrieved from https://www.eis.org.uk/Content/images/corona/SurveyResults.pdf

Education Policy Institute. (2021). Understanding progress in the 2020/21 academic year: Interim findings. Department for Education UK. Renaissance Learning. https://epi.org.uk/publications-and-research/learning-loss-report-understanding-progress-in-the- 2020-o-2021-academic-year/

Engzell, P., Frey, A., & Verhagen, M.D. (2021). Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences*, *118*(17), e2022376118.

European Commission. (s.d.). *Croatia's recovery and resilience plan.* Retrieved November 16, 2022 from https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility/croatias-recovery-and-resilience-plan_en

Fack, G., Agasisti, T., Bonal, X., De Witte, K., Dohmen, D., Haase, S., Hylen, J., McCoy, S., Neycheva, M., Pantea, M.C., Pastore, F., Pausits, A., Poder, K., Puukka, J., & Velissaratou, J. (2022). Investing in our future : quality investment in education and training. *Publications Office of the European Union.* *https://data.europa.eu/doi/10.2766/45896*

Förster, N., Forthmann, B., Back, M.D., & Souvignier, E. (2022). Effects of the COVID-19 pandemic on reading performance of second grade children in Germany. *Reading and Writing*, 1-27.

Gambi, L., & De Witte, K. (2021). The resiliency of school outcomes after the COVID-19 pandemic. Standardised test scores and inequality one year after long term school closures. *FEB Research Report Department of Economics*.

Garbe, A., Ogurlu, U., Logan, N., & Cook, P. (2020). COVID-19 and remote learning: Experiences of parents with children during the pandemic. *American Journal of Qualitative Research*, *4*(3), 45-65.

Glewwe, P., Kremer, M., & Moulin, S. (2009). Many children left behind? Textbooks and test scores in Kenya. *American economic journal: Applied economics*, *1*(1), 112-35.

Goodman, J. (2014). *Flaking out: Student absences and snow days as disruptions of instructional time* (No. w20221). National Bureau of Economic Research.

Gornik, B., Dežan, L., Sedmak, M., & Medarić, Z. (2020). Distance learning in the time of the COVID-19 pandemic and the reproduction of social inequality in the case of migrant children. *Druzboslovne Razprave*, *36*.

Haelermans, C., Korthals, R., Jacobs, M., de Leeuw, S., Vermeulen, S., van Vugt, L., ... & de Wolf, I. (2022a). Sharp increase in inequality in education in times of the COVID-19-pandemic. *Plos one*, *17*(2), e0261114.

Haelermans, C., Abbink, H., Baumann, S., Bijlsma, I., Havermans, W., Jacobs, M., Van Vugt, L., & Van Wetten, S. (2022b). Leergroei begrijpend lezen in tweede COVID-jaar hersteld, spelling en rekenen-wiskunde nog niet. NCO Factsheet No. 2022-2.

Haelermans, C., Van Wetten, S., Abbink, H., Baumann, S., Hendrickx, S., Hendrikse, A., Jacobs, M., & Meijer, R. & Van Vugt, L. (2022c). Balans na twee en een half jaar: Nog steeds grote vertraging voor spelling en rekenen-wiskunde. NCO Factsheet No. 2022-5.

Hamilton, L., Kaufman, J., & Diliberti, M. (2020). Teaching and learning through a pandemic: Key findings from the American Educator Panels Spring 2020 COVID-19 Panels. Rand Corporation. Retrieved from https://www.rand.org/pubs/research_reports/RRA168-2.html

Hanushek, E. A., & Woessmann, L. (2020). The economic impacts of learning losses. OECD Education Working Papers, 225. Pp. 24. https://doi.org/10.1787/debad1c1-en

Iterbeke, K., & De Witte, K. (2022). Helpful or harmful? The role of personality traits in student experiences of the COVID-19 crisis and school closure. *Personality and Social Psychology Bulletin*, *48*(11), 1614-1632.

Jakubowski M. (2019). Warszawska Edukacja w Świetle PISA. *Evidence Institute Policy Institute Note 4*, Warsaw.

Jakubowski, M., Gajderowicz, T., Wrona, S. (2022). Achievement of Secondary School Students After Pandemic Lockdown and Structural Reforms of Education System Results from TICKS 2021 Assessment in Warsaw. *Evidence Institute Policy Note 1*, Warsaw. https://www.evidin.pl/wp-content/uploads/2022/01/POLICY-NOTE-1-2022-EN.pdf

Kaffenberger, M. (2021). Modelling the long-run learning impact of the COVID-19 learning shock: Actions to (more than) mitigate loss. *International Journal of Educational Development*, *81*, 102326

Koehler, C., Psacharopoulos, G., & Van der Graaf, L. (2022). 'The impact of COVID-19 on the education of disadvantaged children and the socio-economic consequences thereof', *NESET-EENEE report*, Luxembourg: Publications Office of the European Union. doi: 10.2766/929570

Korbel, V., & Prokop, D. (2021). Czech students lost 3 months of learning after a year of the COVID-19 pandemic. Prague: PAQ Research.

Lambropoulos, H., Panagiota, V.S., & Karatzia-Stavlioti, E. (2022).The impact of the COVID-19 pandemic on learning in Greece: Investigation of the University entrance exams. *European Journal of Education Studies*, *9*(4).

Lerkkanen, M.K., Pakarinen, E., Salminen, J., & Torppa, M. (2022). Reading and math skills development among Finnish primary school children before and after COVID-19 school closure. *Reading and Writing*, 1-26.

Lichand, G., Doria, C. A., Leal-Neto, O., & Fernandes, J. P. C. (2022). The impacts of remote learning in secondary education during the pandemic in Brazil. *Nature Human Behaviour*, 1-8.

Lodovici, M.S., Ferrari, E., Paladino, E., Pesce, F., Torchio, N., & Grippa, A. (2022). Revaluation of working conditions and wages for essential workers.

Ludewig, U., Kleinkorres, R., Schaufelberger, R., Schlitter, T., Lorenz, R., König, C., & McElvany, N. (2022). COVID-19 Pandemic and Student Reading Achievement–Findings from a School Panel Study.

Maldonado, J.E., & De Witte, K. (2022). The effect of school closures on standardised student test outcomes. *British Educational Research Journal*, *48*(1), 49-94.

Mathews, J. (2022). Experts say schools could recover pandemic losses by 2028. What then?. *The Washington Post.* Retrieved October 10, 2022.

Mazrekaj, D., & De Witte, K. (2022). *The Impact of School Closures on Learning and Mental Health of Children: Lessons from the COVID-19 Pandemic*. [Unpublished manuscript].

Mendolia, S., Suziedelyte, A., & Zhu, A. (2022). Have girls been left behind during the COVID-19 pandemic? Gender differences in pandemic effects on children's mental wellbeing. *Economics Letters*, *214*, 110458.

Molnár, G., & Hermann, Z. (2022). Short-and long-term effects of COVID-related kindergarten and school closures on first-to eighth-grade students' school readiness skills and mathematics, reading and science learning. *Learning and Instruction*, *83*, 101706.

Moscoviz, L., & Evans, D.K. (2022). Learning loss and student dropouts during the COVID-19 pandemic: A review of the evidence two years after schools shut down. Center for Global Development, Working Paper, 609.

Mutch, C. (2021). COVID-19 and The Exacerbation of Educational Inequalities in New-Zealand. *Perspectives in Education*, *39*(1), 242–256. https://doi.org/10.18820/2519593X/pie.v39.i1.15

Nusser, L. (2021). Learning at home during COVID-19 school closures–How do German students with and without special educational needs manage?. *European Journal of Special Needs Education*, *36*(1), 51-64.

OECD (2007). *PISA 2006 Results*. Paris: OECD.

OECD (2010). *PISA 2009 Results: Executive Summary*. Paris: OECD.

OECD (2014). *PISA 2012 results in focus: What 15-year-olds know and what they can do with what they know*. Paris: OECD.

OECD (2016). *PISA 2015 results in focus*. Paris: OECD.

OECD (2019a). *PISA Database*. Paris: OECD. https://www.oecd.org/pisa/data/2018database/

OECD (2019b). *PISA 2018: Insights and Interpretations*. Paris: OECD.

OECD (2019c). *TALIS Database.* Patis: OECD. https://www.oecd.org/education/talis/talis-2018-data.htm

OECD (2020a), "Education Policy Outlook in the Czech Republic", *OECD Education Policy Perspectives*, No. 11, OECD Publishing, Paris. https://doi.org/10.1787/6363ab1d-en

OECD (2020b), "Education Policy Outlook in Denmark", *OECD Education Policy Perspectives*, No. 12, OECD Publishing, Paris. https://doi.org/10.1787/3288629c-en

OECD (2020c), "Education Policy Outlook in Finland", *OECD Education Policy Perspectives*, No. 15, OECD Publishing, Paris.

OECD (2020d), "Education Policy Outlook in France", *OECD Education Policy Perspectives*, No. 15, OECD Publishing, Paris.

OECD (2020e), "COVID-19 et travailleurs essentiels: quel rôle jouent les immigrés dans votre région?", *OECD COVID-19 key policy responses.* Retrieved 4 October 2022, from https://www.oecd.org/coronavirus/policy-responses/COVID-19-et-travailleurs-essentiels-quel-role-jouent-les-immigres-dans-votre-region--c3e86dd1/#biblio-d1e641

Ofqual (2021), "Learning during the pandemic: quantifying lost time", *Ofqual Research and Analysis,* 12 July 2021.

Patrinos, H.A., Vegas, E., & Carter-Rau, R. (2022). An Analysis of COVID-19 Student Learning Loss.

Postlbauer, A., Helm, C., & Große, C.S. (2022). Educational inequality and COVID-19: Who takes advantage of summer schools and other remedial measures?. *Zeitschrift für Bildungsforschung*, 1-30.

Pritchett, L., & Beatty, A. (2015). Slow down, you're going too fast: Matching curricula to student skill levels. *International Journal of Educational Development*, *40*, 276-288.

Ravens-Sieberer, U., Erhart, M., Devine, J., Gilbert, M., Reiss, F., Barkmann, C., ... & Kaman, A. (2022). Child and adolescent mental health during the COVID-19 pandemic: results of the three-wave longitudinal COPSY study. *Journal of Adolescent Health*, *71*(5), 570-578.

Schult, J., Mahler, N., Fauth, B., & Lindner, M.A. (2022). Did students learn less during the COVID-19 pandemic? Reading and mathematics competencies before and after the first pandemic wave. *School Effectiveness and School Improvement*, 1-20.

Spitzer, M., & Musslick, S. (2021). Academic Performance of K-12 Students in an Online-learning Environment for Mathematics Increased During the Shutdown of Schools in Wake of the COVID-19 Pandemic. EdArXiv. https://edarxiv.org/jncwt/

Toger ,M., Kourtit, K., Nijkamp, P., & Östh, J., (2021), Mobility during the COVID-19 pandemic: A Data-Driven Time-Geographic Analysis of Health-Induced Mobility Changes, Sustainability; 13(7):4027. 10.3390/su13074027

Tomasik, M.J., Helbling, L.A., & Moser, U. (2021). Educational gains of in-person vs. distance learning in primary and secondary schools: A natural experiment during the COVID-19 pandemic school closures in Switzerland. *International Journal of Psychology*, *56*(4), 566-576.

UK Government (2022). *National Tutoring Programme: guidance for schools, 2022 to 2023.* Retrieved September 27, 2022, from https://www.gov.uk/government/publications/national-tutoring-programme-guidance-for-schools-2022-to-2023/national-tutoring-programme-guidance-for-schools-2022-to-2023

UNESCO (2020). Adverse consequences of school closures. UNESCO.

Van der Velde, M., Sense, F., Spijkers, R., Meeter, M., & van Rijn, H. (2021, August). Lockdown learning: Changes in online foreign-language study activity and performance of Dutch secondary school students during the COVID-19 pandemic. In *Frontiers in Education* (Vol. 6). Frontiers Media SA.

(This page is intentionally left blank)

Finding information about the EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

Publications Office
of the European Union