UNIVERSITY OF CAMBRIDGE
Faculty of Education

REAL
Research for Equitable Access and Learning

laterite
DATA | RESEARCH | ADVISORY

The effects of school closures in Rwandan secondary schools: Student retention, teacher turnover and student numeracy test scores

Leaders in Teaching Research and Policy Paper Series

October 2022

mastercard foundation

Leaders in Teaching

Authors:
Samuel Nzaramba (Laterite) led the analysis and drafting of this paper with support from Mico Rudasingwa (Laterite), under the overall guidance of Phil Leonard (Laterite). Pauline Rose (REAL Centre) and Ricardo Sabates (REAL Centre) provided feedback throughout the process.

Acknowledgements:
This work was carried out as part of Laterite and the Research for Equitable Access and Learning (REAL) Centre's work as learning partners for the Mastercard Foundation's Leaders in Teaching initiative. The authors benefited from support from the larger data and research teams at Laterite and the REAL Centre. We would like to thank the Rwandan Ministry of Education and Rwanda Basic Education Board for allowing us access to the schools. Finally, we thank the head teachers and teachers who were so generous with their time in replying to our surveys. The views expressed are those of the authors and do not necessarily reflect the views of the Mastercard Foundation.

About Laterite and the REAL Centre:
Laterite is a data, research and advisory firm dedicated to bringing high-quality research services to the most underserved markets. Based in East Africa, the firm strives to carry out impactful research that helps decision-makers find solutions to complex development problems.

The REAL Centre at the University of Cambridge pioneers research into overcoming barriers to education, such as poverty, gender, ethnicity, language and disability, and promotes education as an engine for inclusive growth and sustainable development.

Suggested citation:
Leonard, P., Nzaramba, S., Rose, P., Rudasingwa, M. and Sabates, R. (2022). *The effects of school closures in Rwandan secondary schools: Student retention, teacher turnover and student numeracy test scores.* Leaders in Teaching Research and Policy Series, April 2022. Laterite, Rwanda and REAL Centre, University of Cambridge.

Table of contents

Summary 5
Introduction 7
Methodological note 9
Findings about student retention 14
Findings about student numeracy outcomes 17
Findings about teacher turnover 25
Conclusions 26
References 29

Acronyms

CPD	Continuous Professional Development
LARS	Learning Achievements in Rwandan Schools
PCA	Principal Component Analysis
RBC	Rwanda Biomedical Centre
REB	Rwanda Basic Education Board
SD	Standard Deviations
TVET	Technical and Vocational Education and Training

The effects of school closures on student retention, teacher turnover and student numeracy outcomes in Rwandan secondary schools

The context

Following the outbreak of COVID-19, schools in Rwanda were closed for almost nine months between March and November 2020. This study gives insights into the effects of school closures on the continuation of education in Rwanda, looking at the impacts on teachers as well as school and learning outcomes. The study draws on data collected from teachers and head teachers at three time points: February 2020 (prior to school closures); and in February and May 2021 (after schools had reopened). Secondary 3 students were also assessed on their numeracy skills in February 2020 and May 2021.

Key findings

How did school closures affect student enrolment?

- In February 2021 (after schools had reopened), student enrolment had *increased* in secondary schools compared to before schools had closed, especially in Secondary 1 (S1) and Secondary 4 (S4).
- 96% of Secondary 3 (S3) students who completed numeracy assessments in February 2020 stayed in the same school through to February 2021. By May 2021, this had fallen to 89%, suggesting that dropout amongst this cohort might increase over time.
- Compared to early 2020, fewer students aged 17+ (85%, compared to 92% of students under 17) were still in school in May 2021. Students aged 17+ are older than expected for S3, due to patterns of dropout and repetition.

How were student numeracy outcomes affected?

- On average, students who re-took the numeracy assessment in May 2021 scored almost 10% higher compared to their first assessment in February 2020. Over 90% of the schools in our sample recorded an average improvement in student numeracy outcomes over this period. This is not unexpected, given that students had completed more of the curriculum in May 2021 than they had in early 2020.
- Boys slightly outperformed girls in terms of average numeracy assessment scores in both February 2020 and May 2021.
- S3 students who were the expected age for their grade (14-15 years) improved more in their numeracy scores than older students (17+). More boys than girls in our sample are overage, suggesting that the impact of being overage does not remove the gender gap on average.

Did STEM teachers return to teaching?

- 94% of STEM teachers in our sample returned to their classes as of early 2021. In addition, almost half of secondary schools increased the number STEM teachers on their payroll between early 2020 and early 2021.

Implications

- Decision-makers should continue to monitor student enrolment and dropout in upper secondary, especially among girls and older students, to better understand the longer-term impacts of school closures on the learning trajectories of students.
- Increased enrolment in specific grades (S1 and S4) could put pressure on school and teaching resources. Per capita access to resources will be a key area to monitor in these grades especially, as these students progress through the education system.

Summary

The context

Following the outbreak of COVID-19, schools in Rwanda were closed in March 2020 for almost nine months, with schools gradually re-opening in November 2020. This paper aims to gain insights into the effects of school closures on the continuation of education in Rwanda, looking at the impacts on both teacher, and on school and learning outcomes.

This paper draws on data collected as part of the Mastercard Foundation's Leaders in Teaching Initiative in 358 secondary schools across 14 districts[1] at three time points: February 2020 (prior to school closures); and in February and May 2021. Secondary 3 students were assessed on their numeracy skills in February 2020 and May 2021. Teachers and head teachers were contacted at all four time points.

Drawing on this data, the paper focuses on the extent to which students enrolled in schools once they re-opened; and whether student learning outcomes were affected by school closures. In addition, it assesses the extent to which teachers returned to their schools following the school closures, recognising that there might be reasons why they might not have returned such as moving to another school, seeking other employment opportunities or dropping out of the labour force.

Key findings

1. Student retention:

- Between February 2020 (before school closures) and February 2021 (after schools had reopened), student enrolment increased in secondary schools. Interestingly, there was a spike in enrolment in Secondary 1 (S1) and Secondary 4 (S4). These are transition grades, from primary to lower secondary school for S1; and from lower secondary school to upper secondary for S4.
- 95.7% of Secondary 3 (S3) students who completed numeracy assessments in February 2020 stayed in the same school through to February 2021. However, this decreased over time, with 89.2% of these students remaining in May 2021.

Key findings on equity dimensions:

- Fewer girls and older students returned to school after schools reopened.

[1] The 14 Leaders in Teaching Districts are: Musanze, Gicumbi, Kayonza, Rwamagana, Nyabihu, Ngororero, Rusizi, Nyamasheke, Karongi, Rubavu, Gisagara, Nyaruguru, Nyanza and Kamonyi.

- Students who were present at the school and took the numeracy assessment again in May 2021 were also students who scored higher than others on the February 2020 assessment (on average).

2. Student numeracy outcomes:

- On average, student numeracy outcomes in May 2021 improved compared to numeracy outcomes at the start of the 2020 school year. S3 students who re-took the numeracy assessment in May 2021 scored 9.62% higher on the latent numeracy scale[2] - which takes into account the difficulty of the questions - compared to their first assessment in February 2020.
- Over 90% of the schools in our sample recorded an average improvement in numeracy outcomes of their students. Average learning gains in schools ranged from 0.002 points to 0.16 points on the numeracy scale.

Key findings on equity dimensions:

- Boys outperformed girls in terms of numeracy assessment scores. The gender gap in average numeracy outcomes was approximately 0.016 points on the numeracy scale in favour of boys. On average, boys outperformed girls on both numeracy assessments (February 2020 and May 2021) by about 0.02 points on the numeracy scale.
- Students who enrolled at the expected age for their grade are improved more in their numeracy scores than overage students (17 years and older in S3). The difference between overage students and non-overage students in numeracy outcome gains was about 0.03 points. More boys than girls in our sample were overage which suggests that the impact of being overage does not remove the gender gap on average.

3. Teacher turnover

- Around 94% of STEM teachers in our sample returned to their classes between early 2021 and early 2022. Almost half of secondary schools have also increased the number STEM teachers on their payroll in this period.

[2] See methodological note for a description of the latent numeracy scale

Introduction

In Rwanda, school closures were announced in March 2020, after the identification of the first COVID-19 case. Schools remained closed in Rwanda for almost nine months, with a gradual re-opening starting in November 2020. As part of its re-opening plan, the Government of Rwanda decided: (i) to shift the academic calendar to run from September to June (it previously ran from January to December); and (ii) that all students would return to the grade they were in before schools closed, effectively repeating part of a year (Carter et al. 2020).

During school closures, the Rwanda Basic Education Board (REB) and various education sector partners implemented initiatives to ensure student learning and teacher continuous professional development (CPD) could continue. These included broadcasting education programmes on national TV and radio, and online with the aim of minimizing the effects of school closure on the education system.

Once schools re-opened, early findings of studies conducted in seven high-income countries identify that children have experienced a loss in their learning or have not progressed to the extent anticipated, in comparison to earlier learning gains over a similar period. This is found across a range of subjects, grade levels, and geographical regions, although with some variation. For example, in some contexts, learning loss was more apparent for primary school students, where learning remotely during school closures could be more of a challenge. The studies also identified that inequalities widened in many contexts, such as those related to parental education and occupation, or where they lived. In one case, higher achieving students were more adversely affected (Donnelly & Patrinos, 2021).

A recent review of studies undertaken following school closures has identified that there are only a very small number in low- and lower-middle income countries with information on the effects on dropout and learning, with variability in the findings in different contexts (Evans and Moscoviz, 2022). One study in Ethiopia found that learning has progressed more slowly for primary school students compared to prior to the pandemic, with a widening in rural/urban learning gaps (Bayley et al., 2021). This study also identified that dropout from school was potentially more modest than might have been expected, with around 13% of children not re-entering school once they had re-opened, with girls and overage students particularly affected. Also in Ethiopia, Tiruneh et al. (2021) found widening gaps in numeracy achievement for children with disabilities in grades 1 and 4 of primary schools compared with children without disabilities. While there is emerging evidence on children returning to school and learning outcomes, to our knowledge, there are no studies of the extent to which teachers have returned to school following school closures in Rwanda or in other countries in sub-Saharan Africa.

To gain insights into the effects of school closures on the continuation of education in Rwanda, this paper draws on data collected as part of the Mastercard Foundation's Leaders in Teaching Initiative in 358 secondary schools across 14 districts.[3] It focuses on the extent to which students enrolled in schools once they re-opened and whether student learning outcomes were affected by school closures. In addition, it assesses the extent to which teachers returned to their schools following the school closures, recognising that there might be reasons why they might not have returned such as moving to another school, seeking other employment opportunities or dropping out of the labour force.

The analysis builds on student, teacher and school-level data collected in February 2020 prior to school closures, and follow-up data collected after the schools reopened in November 2020, and in February and May 2021.

[3] The 14 Leaders in Teaching Districts are: Musanze, Gicumbi, Kayonza, Rwamagana, Nyabihu, Ngororero, Rusizi, Nyamasheke, Karongi, Rubavu, Gisagara, Nyaruguru, Nyanza and Kamonyi.

Methodological note

This analysis uses two main types of datasets collected in 2020 and 2021 by Laterite and the REAL Centre. For students, we collected school leader reports of enrolment figures in all secondary grades (Secondary 1 to Secondary 6) and numeracy test scores for students in the third year of secondary school. With respect to teachers, we collected information on STEM teachers in schools, including their gender, years of experience and other demographic characteristics.

Student enrolment

In February 2021, we contacted school leaders in 358 schools participating in the Leaders in Teaching initiative prior to quantitative surveys conducted in February 2021. In all 358 schools we asked school leaders to report the total number of male and female students by age in all secondary grades. We asked school leaders to cross-check their reported data of student enrolment with their official student registries. School leaders did not report the number of students who left their schools, so we were unable to infer aggregate drop-out rates using these data. However, a comparison of data in 2020 (before school closures) and 2021 (after re-opening) allowed us to identify changes in total enrolment and possible school level characteristics that could have impacted these changes in the 358 schools.

Numeracy test scores

In February 2020, prior to school closures, we conducted learning assessments with 4,067 Secondary 3 (S3) students in 101 schools – all from districts in which the Leaders in Teaching programmes are active. Prior to conducting the second round of learning assessments in May 2021, we checked in with school leaders on two different occasions to determine whether the students previously assessed were still enrolled in the same schools. The first check-in with school leaders took place in February 2021 and the second check-in in May 2021 - directly before we conducted the student learning assessments. School leaders reported whether the student was in school or no longer enrolled in the school. We were not able to track students who were no longer in school to determine if they had moved to another school or dropped out. Using both sources of data on numeracy assessments which were collected in 2020 and 2021, we were able to capture both student retention as well as changes in numeracy test scores before the pandemic and after schools reopened.

To put the timing of the assessments in the context of the academic school year, the first round of learning assessments were conducted at the start of the school year in February

2020.[4] Before the second round of the assessments was conducted, the Government of Rwanda announced a change to the school calendar and consequently the second round of assessments were conducted towards the end of the school year (May 2021).

For sampling purposes, in each of the 101 schools selected to participate in learning assessments, the S3 class with the highest number of students who participated in first round of the assessment (February 2020) was selected to participate in the second numeracy assessment, and all students from that classroom present on the day of the test were assessed. In May 2021 when we conducted the second round of numeracy assessments, we were able to re-assess 2,889 students out of the 4,067 students assessed in February 2020, that is 71% of students assessed in the first round of data collection. We also collected student background information via a survey administered to all the students who took the learning assessment. The comparison of numeracy assessments over the time presented in this paper uses data from 2,889 students for whom we have information on numeracy test scores in both time periods.

There are potentially two main explanations as to why some students could not be re-assessed:

- **Students not present at the school on the day of the assessment:** At each school, learning assessments were carried out on one day and there are several reasons why a student may have not been at the school on the day of the assessment including because they: (i) were absent from school on day of assessment – for any reason; (ii) changed schools; (iii) transitioned to Technical and Vocational Education and Training (TVET); or (iv) dropped out.
- **Student present at school but not in selected S3 class:** Within each school, only one S3 class was selected to be assessed. To minimize the disruption of classroom activities and due to budget constraints, the S3 class with the highest number of students who participated in the first round of the numeracy learning assessments was selected. This implies that students who moved to a different S3 class within the same school were not re-assessed. Note that schools were encouraged to implement social distancing in classrooms to prevent the spread of COVID-19 (Rwanda Biomedical Centre (RBC), 2020). This may have resulted in some schools moving students to different classrooms.

Low-achieving students in our sample were more likely to not be reassessed on the day of the learning assessments in May 2021. Students who were re-assessed in

[4] In March 2020 immediately after the school closures due to COVID-19 pandemic, the Government of Rwanda shifted the academic calendar to run from September to June (it used to run from January to December).

May 2021 scored, on average, 0.05 points higher on the latent numeracy scale on the first numeracy assessment (February 2020) compared to students who were not re-assessed in May 2021. This difference in average numeracy scores is about 0.3 Standard Deviations (SD) (see **Error! Reference source not found.**). Our results are similar using the raw score on the LARS III assessment – with a scale of 0% correct responses to 100% correct responses, as opposed to the latent numeracy scale calculated using Item Response Theory. One potential implication of this finding to be kept in mind when interpreting the results is that we may be studying a subset of academically stronger students.

Table 1: Difference in numeracy scores from the first numeracy learning assessment (February 2020) comparing students who were re-assessed in May 2021 and students who were not re-assessed

Group	**Observations**	**Mean (latent numeracy score)**	**Standard Deviation**
Students not re-assessed in May 2021	1,178	0.42	0.13
Students re-assessed in May 2021	2,889	0.47	0.17
Difference (t-test)		-0.05***	
All students assessed in February 2020	4,067	0.45	0.16
***, **, and * indicate significance at the 1, 5, and 10 percent critical level.			

In all our results, we weighted using sampling weights calculated as the inverse probability of the participant being sampled. All our results have been reported with this weighting. For student numeracy scores, we tested to see if our results changed when we included propensity score weights which were adjusted to account for possible differences between the students we were able to reassess and those we were not able to reassess.

Learning assessment and scoring

In both the learning assessments (February 2020 and May 2021), we used the Learning Achievements in Rwandan Schools (LARS) numeracy assessment tool developed by REB. Specifically, we used the 2017 version of the LARS numeracy assessment tool, also referred to as LARS III. The numeracy learning assessment contains 30 multiple-choice questions and is administered as a paper-based questionnaire.

In this paper, we study student learning attainments in the numeracy assessments using a latent numeracy score, estimated with a two-parameter Item Response Theoretical (IRT) model. This estimate of ability takes into account both the number of questions the student answered correctly and the difficulty of the questions. The calculated latent numeracy score has been constrained to vary from 0 to 1, where 0 corresponds to no correct responses and 1 corresponds to only correct responses (mean = 0.47, SD = 0.003 for our sample). In this paper, we refer to the latent numeracy score as the numeracy assessment score. In practice, our results are very similar using the raw student score of number of correct responses out of 30 (see Table 2).

Table 2: Average latent numeracy score and raw percent score

Date	**Latent numeracy score**	**Raw percent score**
February 2020	0.47 (.003)	0.43 (0.004)
May 2021	0.52 (.003)	0.49 (0.004)

Note: Mean is reported with the standard deviation in parentheses.

STEM teacher data

In February 2020 and February 2021, we collected two types of data from STEM teachers in 358 schools across the 14 Leaders in Teaching districts in Rwanda: (i) total number of STEM teachers working at each of the 358 schools, and (ii) background characteristics of over 1,700 individual STEM teachers from the 101 schools (please see Table 3 for a summary of all the datasets collected by date).

We used two sources of data to analyse teacher turnover: (i) school leader surveys which captured the total number of STEM teachers working in 358 schools; and (ii) a roster of over 1,700 individual STEM teachers that were tracked before and after school closures in the same schools. The school leader dataset allowed us to determine whether the total number of STEM teachers increased or decreased in our sample schools. The individual dataset allowed us to estimate individual teacher turnover and study the characteristics of teachers that stayed or left.

It is important to keep in mind that the data on total number of STEM teachers is based on school leader self-reporting, not on verified school registries, so they may be subject to measurement error. More information about the data used in the analysis is included in the appendix.

Table 3: Summary of datasets collected by date

Date	Data collected
February 2020	• Header teacher survey • STEM teacher survey • Student numeracy assessments • Background student characteristics survey
February 2021	• Head teacher survey • STEM teacher survey • Listing of S3 students assessed in February 2020 at the start of Term 2
May 2021	• Listing of S3 students surveyed in February 2020 at the start of Term 3 • Student numeracy assessments • Background student characteristics survey

We note that unless otherwise stated, all reported differences in the paper are statistically significant at the 5% level.

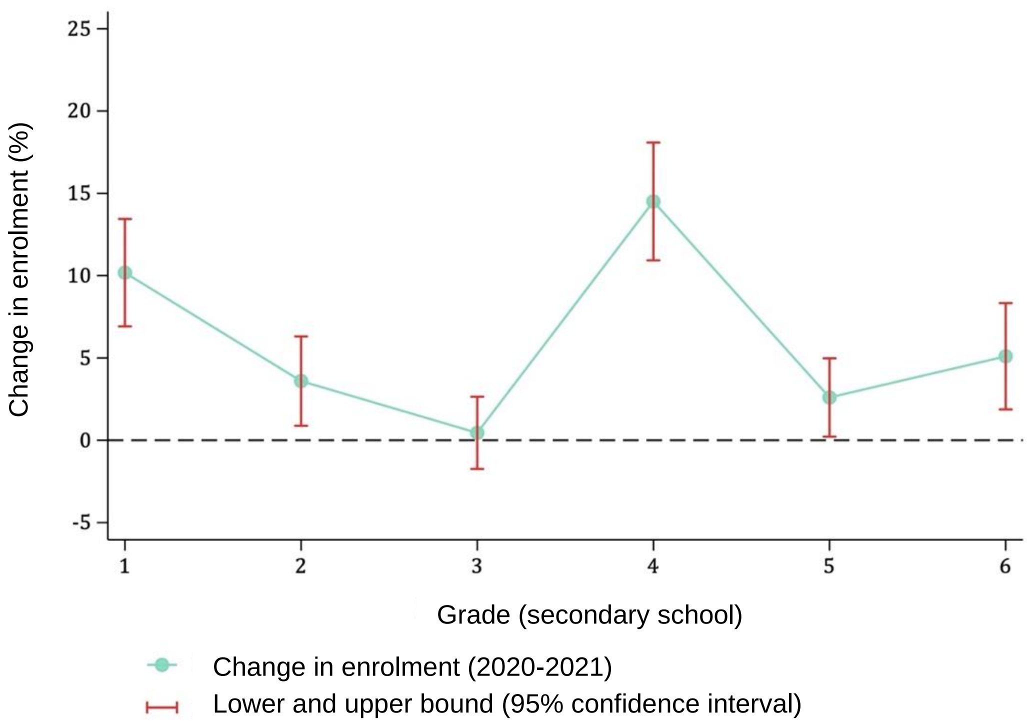
Findings about student retention

Enrolment increased in S1 and S4 following the re-opening of schools

School leaders and teachers had expressed concerns during COVID-related school closures that many students would not return once schools reopened (Carter et al. 2020). Evidence from school leaders' reporting suggests that these fears did not materialise.

In fact, total enrolment increased in S1 and S4 following the re-opening of schools. S1 and S4 represent scholastic transition points, when students move from primary to secondary school and from lower to upper secondary school, respectively. Students must pass national examinations in Primary 6 (P6) to proceed to S1, and in Secondary 3 (S3) to proceed to S4. We observed a 7% increase in enrolment in S1 and an 11% increase in enrolment in S4 before and after school closures (Figure 1). This is statistically significant at the 1% level. However, we observed little change in enrolment before and after school closures in grades S2, S3, S5 and S6, where the change in total enrolment by school varied between -1% to +3%. On average, these changes were small or statistically insignificant.

Figure 1: Average change in total enrolment, by grade, across schools in our sample



Our working assumption – which will need to be further researched – is that the increase in S1 and S4 can be explained by students that had previously dropped out re-entering the education system. This assumption is based on the fact that, when schools re-opened, students returned to the grade in which they were enrolled before school closures.

Students were not promoted from primary to secondary school or from lower secondary to upper secondary school since no national examinations took place during school closures. As such, the only plausible explanation for higher enrolment rates in S1 and S4 is that students who had passed their P6 and S3 national examinations prior to school closures, but had since dropped out, re-entered the education system and joined the pre-closure cohort. It makes sense that students would re-enter in S1 or S4 since: (i) students would naturally progress to S1 and S4 after receiving a satisfactory mark on their P6 and S3 national examinations; and (ii) most dropout occurs in the transition from primary to secondary school, or from lower to upper secondary school (Laterite, 2017). Re-entry is therefore much more likely to occur in S1 and S4 than other grades.

This increase in enrolment in S1 and S4 will also have long term implications for the education system. In 2021 there was already increased pressure on teaching resources in S1 and S4. As these students progress through the education system, pressure will increase in subsequent grades and years.

We used data collected on S3 students who took the LARS III assessment in 2020 to explore individual characteristics that could be predictive of student retention before and after school closures. We found that the majority of students returned to school during the first two terms following re-opening, but this declined in the third term, with fewer girls and older students staying in school.

We found that 95.7% of students in our sample were still enrolled in the same school in the second term of the school year in 2021. This number decreased to 89.2% by the third term. A high number of students returned to school immediately after the re-opening of schools, suggesting that at the secondary school level, COVID-related school closures did not lead to an immediate decrease in students returning to school. This is consistent with data on aggregate enrolment levels by grade in secondary school, presented above, which were also collected around the same period. However, our evidence suggests that the number of students staying in school decreased between terms 2 and 3. We do not know whether this is due to the COVID-19 shock, or whether this is a common occurrence at S3 level, since we do not have a comparison point.

Fewer girls and older students stayed in school (see Table 4). The share of girls staying in school in terms 2 and 3 was about 3 percentage points lower than boys. This is consistent with findings prior to the pandemic which showed that, from ages 15 onwards, girls in Rwanda are at a higher risk of dropout than boys (Laterite, 2017).

Older students were much more likely not to stay in school: 85.4% of students aged 17 or above stayed in school in term 3, compared to 92.4% for students below the age of 17. Given the expected school age for those in S3 is 16 years, assuming they start at the expected age of 7 and experience no repetition, we consider students aged 17 or above to be overaged. Numeracy assessment scores from early 2020 were not predictive of students returning to school, suggesting that prior low achievement does not appear to be a reason for students not returning.

Table 4: Percentage of students who stayed in school in terms 2 and 3

Percentage of students who stayed in school compared to February 2020*	**February 2021**	**May 2021**
All students (%)	95.7%	89.2%
Girls (%)	94.7%	88.6%
Boys (%)	97.0%	90.0%
Students aged 17 or above (%)	93.9%	85.4%
Students below the age of 17 (%)	97.2%	92.4%

Source: The figures were created using 3 datasets: 1) The numeracy assessments conducted in February 2020. 2) Participant listing activities conducted in February 2021 where we collected data on the enrolment status of students assessed during the 2020 numeracy assessments. 3) Participant listing activities conducted in May 2021 where we collected updated enrolment data on the students who participated in the 2020 numeracy assessments.

***** 4,067 students participated in the February 2020 numeracy assessments (the initial sample).

We note a few limitations to keep in mind regarding this study. Firstly, we might be over-estimating the percentage of students staying in school: this is because for this analysis our sample consisted only of students who were present on the day of the learning assessment in early 2020. As such, enrolment in early 2020 could have been higher than our data suggest. We anticipate return rates to be lower for the students who were not present for the 2020 numeracy assessments. We would then expect upward bias on our measure of student return rates compared to the population rate given possible selection effects. Secondly, we can comment on the number of students who stayed in school, but we cannot infer dropout, since some students might have moved to other schools.

Findings about student numeracy outcomes

On average, numeracy outcomes of students in our sample improved

S3 students who took the numeracy assessment in May 2021 scored on average 0.05 points higher than they did on the first round of the learning assessment in February 2020. This improvement in numeracy scores is statistically significant at the 1% level (see Table 5).

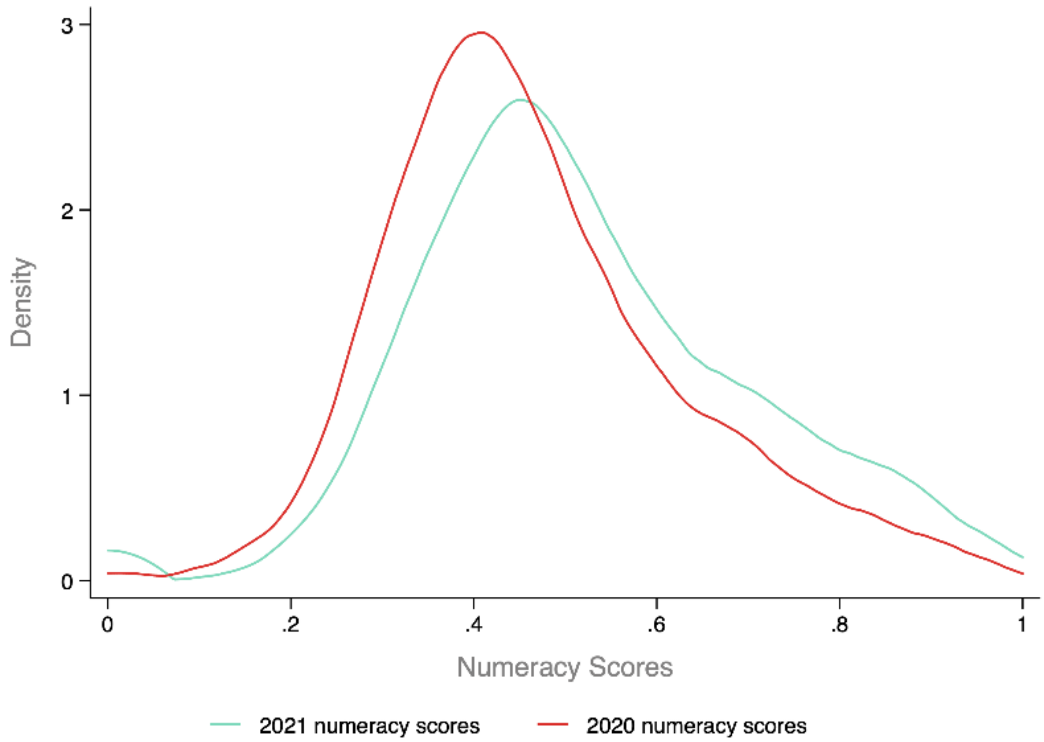
Table 5: Difference in average numeracy scores for re-assessed students between the first (February 2020) and second numeracy assessments (May 2021)

Group	Observations	Mean (latent numeracy score)	Standard Deviation
First assessment (February 2020)	2,889	0.47	0.16
Second assessment (May 2021)	2,889	0.52	0.18
Difference (t-test)		-0.05***	
***, **, and * indicate significance at the 1, 5, and 10 percent critical level.			

Note: We also computed the difference in mean numeracy assessment score using propensity score weights that account for non-random attrition between the students assessed in February 2020 and the students assessed in May 2021. We looked at whether the probability of returning was different based on their 2020 numeracy score, gender and asset quintile. We found that even with weights that accounted for non-random attrition based on these characteristics the difference in scores did not change significantly, with returning students performing better in May 2021 than in February 2020 by ~0.04 points on average.

The overall learning gains in numeracy observed in our sample are due to a large proportion of students scoring between 0.3 and 0.7 (on the numeracy scale of 0 to 1) in the 2021 assessment, compared to a large proportion of students scoring between 0.2 and 0.6 in the 2020 assessments (see Figure 2).

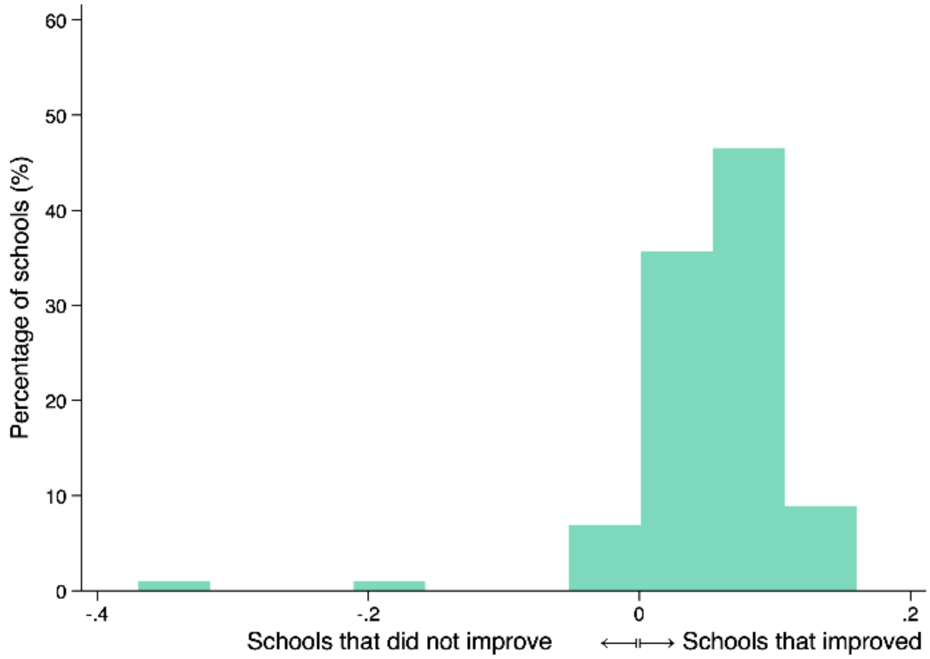
Figure 2: Distribution of student numeracy scores, comparing numeracy scores in 2020 to scores in 2021



Learning gains in numeracy were observed in majority of the schools in our sample

About 91% of the schools in our sample recorded an improvement in the average numeracy score of students. Across these schools there is little variation in average learning gains, ranging from 0.002 points to 0.16 points on the numeracy scale (see Figure 3). We observe potential learning losses in numeracy in 9 out of the 101 schools in our sample; these are all day schools located in rural areas. This is a small number given that 76% and 89% of schools in our sample are day and rural schools, respectively.

Figure 3: Difference in average numeracy scores (2020 vs 2021) in S3 in Rwandan secondary schools



Note: The histogram above shows the difference between average numeracy scores in the first (February 2020) and second (May 2021) numeracy assessment for all schools in the sample. The height of the bar represents the proportion of schools with that difference in average numeracy scores.

Factors associated with learning gains in numeracy in Rwandan secondary schools

In this section, we explore how student and school-level factors are associated with learning gains in numeracy in S3 in Rwandan secondary schools at the end of the school year.

First, we document the association between student level factors such as age, gender and household socio-economic status and learning gains in numeracy using a regression model that assumes fixed effects at the school level.[5] Secondly, we study the association between learning gains in numeracy and school-level characteristics including the availability of school facilities, student to STEM teacher, and student to classroom ratios, using a mixed model with random effects at the school level. In both regression models,

[5] Fixed effects models considers that school averages are fixed and that the school characteristics – such as size of student body, location - affect all students in the same way. In this study our results are consistent whether we use fixed or random effects.

we take account of prior achievement in the first-round assessment scores. We also include school level fixed effects modelling school levels effects as time invariant.[6]

The role of student-level factors in explaining the learning gains in numeracy in May 2021

At the end of the academic year, on average, boys in S3 continued to show higher performance in numeracy outcomes than girls. The gender gap in average numeracy scores is approximately 0.016 points on the numeracy scale (see Table 6). On average, boys outperformed girls on both rounds of the numeracy assessment (in February 2020 and May 2021) by about 0.02 points on the numeracy scale. Boys and girls, however, seem to have been improving at roughly the same rates between February 2020 and May 2021. The difference in learning gains between boys and girls holds even when controlling for age (whether student is overage or not), household wealth quintiles and whether the school has A-levels or not.

Overage students (17 years and older) lagged behind younger (16 and under) students in learning gains in numeracy outcomes. The difference between overage students and non-overage students in numeracy outcome gains was about 0.03 points on the numeracy scale, statistically significant at the 1% level (see Table 6). In our sample, 43% of boys were overage compared to 30% of girls, a statistically significant difference of 13 percentage points. Overage enrolment disproportionately affected students from low-income families; we estimate that about 76% of students from the poorest quintile are overage, compared to 46% of students in the highest quintile.

Prior performance in the numeracy assessment was a strong predictor of current numeracy outcomes. Students who performed well on the first numeracy assessment in February 2020 also scored the highest in the second numeracy assessment in May 2021. Numeracy scores of students increased by approximately 0.62 points on average on the numeracy scale for every point increase on the first numeracy assessment (see Table 6).

---

[6] We also explore how these results change when we model school levels effects as random variables as opposed to time invariant. See page 20 - 22

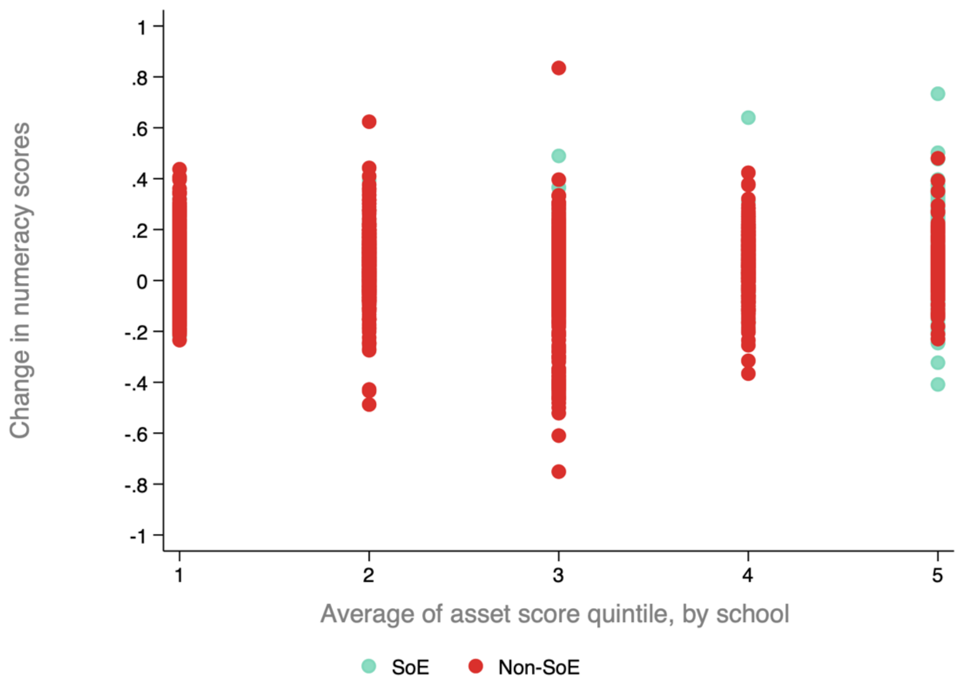
Table 6: Association between numeracy learning gains and individual student and household characteristics, estimated using a regression with fixed effects at the school level

Variables	**Model 0**		**Model 1**		**Model 2**	
	Coefficient	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Lagged latent numeracy score (February 2020 numeracy assessment)	0.621***	(0.02)	0.604***	(0.02)	0.601***	(0.03)
Gender						
Boy			0.015***	(0.00)	0.016***	(0.00)
Overage Student						
Yes			-0.026***	(0.00)	-0.025***	(0.00)
Asset Quintile						
Quintile 2					-0.000	(0.01)
Quintile 3					-0.006	(0.01)
Quintile 4					-0.001	(0.01)
Quintile 5					-0.002	(0.01)
Lives with Mother						
Yes					-0.007	(0.01)
Lives with Father						
Yes					0.003	(0.01)
Mother can read and write						
Yes					0.005	(0.01)
Father can read and write						
Yes					0.001	(0.01)
Constant	0.229***	(0.01)	0.243***	(0.01)	0.230***	(0.02)
Number of Observations	2889		2889		2889	
* p<0.05, ** p<0.01, *** p<0.001						

Note: To deal with missing values in our explanatory variables we have created a 'missing' dummy variable for the gender, overage and asset quintile variables and include this dummy in the regression. For the household environment controls, such as lives with mother, lives with father, and mother can read and write, we have between 77 – 567 missing values in these variables. Therefore, we define the variables lives with mother, lives with father, mother can read and write and father can read and write to be equal to 1 if the student responded "Yes" to the question and 0 if the student responded "No" or the value is missing. Point estimates do not change much if observations with any missing values are dropped from the analysis.

Within a given school, variations in student household background characteristics such as household income level appear not to have been associated with differences in student learning gains in numeracy in S3, at the end of the school year. Within schools, we observed little variation in learning gains in numeracy across student household socio-economic status – captured by an asset index (see methodological note), in both schools of excellence and non-schools of excellence. It is important to note that students in schools of excellence come from wealthier families than students in non-schools of excellence, on average.

Figure 4: Change in numeracy scores (2020 vs 2021) by average wealth quintile, by school, comparing schools of excellence non-schools of excellence



The role of the school environment in explaining between-school differences in learning gains in numeracy

In this section, we explore the association between school-level factors and learning gains in numeracy using a model with random effects. We now treat unobservable school characteristics as random variables.[7] We use this model to explore what impact between school unobservable differences have when the assumption about their correlation with

[7] Random fixed effect at school-level implies that the model considers school-level characteristics to be randomly sampled from a population of schools, unlike in a fixed effects model where the school characteristics are fixed.

observable characteristics is changed. Random effects models come with assumptions (Clarke et al., 2010) that we adjusted for in the model. We make two adjustments to the model to ensure that the *random effects assumption*[8] holds:

1. **We conducted analysis for schools of excellence and non-schools of excellence separately:** This is because entry into schools of excellence in the Rwandan context is more competitive than at non-schools of excellence.
2. **Our model considered additional school characteristics that capture information about the school selection process:** We included controls for the average age of students, asset index of students, a school facilities index, student-to-STEM-teacher ratio, student-to-classroom ratio, and whether a school offers A-levels. We controlled for the average age of all students because more competitive schools are likely to have fewer overage students. The asset index of students plays a role in determining the type of school they go to with wealthier students choosing to go to the more competitive and highest performing schools. The school facilities index is created using the first component of a Principal Component Analysis (PCA) applied to 15 different school-level facilities such as a library, outdoor kitchen, etc. (see methodological section for more details). The level of school facilities can influence a parent's choice of school. The student-to-STEM teacher and student-to-classroom ratios can be seen as indicators of resource adequacy at the school and this too can influence parents' choice of school. Whether the school has A-levels (upper secondary)**,** in the Rwandan context, is highly correlated with having more qualified teachers[9] and these schools are generally also better equipped in terms of facilities.

We observed variations in the school-level factors included in the model, however, we did not see association between these variables and differences in numeracy learning gains between schools of excellence and non-schools of excellence. The school characteristics mentioned above (and included in the model) did not explain the differences in numeracy learning gains across non-schools of excellence, as well as across schools of excellence. Table 7 presents the regression results of a random effects model for non-schools of excellence. Results for schools of excellence show a similar pattern.

---

[8] The random effects assumption implies that unobserved school characteristics - such as teacher quality and quality of school facilities - are not correlated with student, family or observable school characteristics included in the model. However, due to the competitive selection of students into Rwandan Secondary, this assumption is likely not true.

[9] In Rwandan Secondary Schools, in order to be qualified to teach at upper-secondary school level, teachers require A0-level education - this corresponds to a Bachelor's degree or above.

Table 7: Association between numeracy learning gains and individual, household and school characteristics in non-schools of excellence, estimated using a regression with random effects at the school level

Variable	Model 0		Model 1		Model 2	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Lagged latent numeracy score (February 2020 numeracy assessment)	0.613***	(0.03)	0.610***	(0.03)	0.610***	(0.03)
Gender						
Boy	0.012*	(0.00)	0.012*	(0.00)	0.012**	(0.00)
Asset Quintile						
Quintile 2	0.005	(0.01)	0.005	(0.01)	0.005	(0.01)
Quintile 3	0.001	(0.01)	0.001	(0.01)	0.001	(0.01)
Quintile 4	0.005	(0.01)	0.005	(0.01)	0.005	(0.01)
Quintile 5	-0.001	(0.01)	-0.000	(0.01)	-0.001	(0.01)
School Characteristics						
Average age of students	0.024	(0.01)			0.028	(0.01)
Average assets index of students	0.004	(0.01)			0.004	(0.01)
School facilities index			0.061	(0.04)	0.080*	(0.04)
Student to STEM teacher ratio			-0.000	(0.00)	-0.000	(0.00)
Student to classrooms ratio			-0.000	(0.00)	-0.000	(0.00)
Does the school have A-level?			-0.009	(0.01)	-0.012	(0.01
Yes			-0.002	(0.01)	-0.005	(0.01)
Constant	-0.214	(0.21)	0.197***	(0.05)	-0.283	(0.22)
Number of observations	2149		2149		2149	
* p<0.05, ** p<0.01, *** p<0.001						

Note: The overage dummy included in the fixed effects model is not included in this regression because it would be highly correlated with the average age of students. The missing data imputation described in table 4 is repeated for the regression analysis presented here. Our point estimates do not change much if we drop observations with any missing value.

Findings about teacher turnover

We explored the effect of school closures on STEM teacher retention as this could have an impact on teaching quality and student outcomes in our sample schools. We used the data we collected on the 1,700 STEM teachers we tracked before and after school closures to measure teacher turnover across 358 schools. We found that STEM teacher turnover in our sample was low, with an estimated 6% of teachers leaving their schools between February 2020 and February 2021.

Additionally, we used our school leader reports of the total number of STEM teachers on a school's payroll and found that almost 50% of the schools in our sample reported an increase in the number of STEM teachers. We found that the total number of STEM teachers increased in 47% of schools and decreased in 19% of schools, with no change in 34% of schools. This increase could be explained by a recent government recruitment drive to improve the student-to-teacher ratio in classrooms and to cater for the new classrooms that were constructed to reduce over-crowding (Buningwire, 2020). The increase in the number of STEM teachers was highest in schools that also included A-levels.

These findings are consistent with the high STEM teacher retention rates estimated at the individual level. We found that 94% of STEM teachers returned after school closures, with age and gender being the most significant predictors of increased retention. Older and female teachers were slightly more likely to still be present after school closures than other teachers. We also found that teacher retention was higher in urban schools and public schools.

Conclusions

- The majority of Secondary 3 students in our sample who participated in learning assessments returned to school after schools reopened. However, we are seeing signs of a decline in enrolment by the third term, particularly among girls and older students. It is unclear whether this drop in number of students returning to school is linked to the COVID-19 pandemic, or if it is something that would have happened anyway. We recommend that decision-makers continue to monitor this.
- We identified an increase in the total number of students enrolled in S1 and S4 in our sample (not just those who participated in learning assessments). Our hypothesis is that this increase has been driven by students returning to school who had dropped out of school prior to school closures. This increase could put pressure on resources if it is not accompanied with a corresponding increase in teaching resources and school infrastructure for those grades. This might have implications for years to come, as these "additional" students progress through the education system.
- At the same time, we predict that dropout rates will increase in the wider population of schools because of the effect of COVID-19 and school closures. However, this flow of previously enrolled students back into the education system could push against any slowdown in national secondary enrolment that might result from future higher dropout rates linked to the effect COVID-19 and school closures (Laterite and the REAL Centre, 2021).
- While overall student numeracy outcomes improved over the past year, learning gaps have been accentuated. We observed that existing learning gaps across gender (in favour of boys) and age (in favour of students who are not overage for their grade) have become more noticeable after the school closures.
- The low estimated teacher turnover rates for STEM teachers at secondary school level are encouraging. We did not detect an increase in student-to-teacher ratios resulting from COVID-19 school closures in the schools in our sample.

Appendix

Sample for the numeracy learning assessment

The sample for the second round of numeracy assessments (using the LARS III instruments) comprised the 101 schools that participated in the first round of the assessment and an additional five schools that were not previously assessed. In total, 3,551 students from 106 schools were assessed in May 2021, all located in the 14 Leaders in Teaching districts (see Table 8).

Table 8: Number of observations in the first and second round of numeracy learning assessments

Phase	Date of Data collection	Schools interviewed	Number of students interviewed	Number of schools re-assessed
Round one numeracy assessment	February 2020	101	4,067	2,889
Round two numeracy assessment	May 2021	106	3,551	
School Characteristic survey (to head teachers)	February 2020	360		

Using Principal Component Analysis (PCA), we create two composite scores which we use in our analysis.

- **A household assets index, as a proxy for wealth.** This index is derived from a PCA applied to 13 different household assets, including whether the household own chairs, a table, a bed, a bench, a mobile phone, a television, a radio, a fridge, a bicycle, a motorbike, a car, has pumped water and access to electricity. The weights of this PCA are tuned using data from Rwanda's Fifth Integrated Household Living Survey (EICV 5, from 2016/2017). We transfer the PCA model to the student survey, where data was collected on the very same 13 household asset variables and use it to predict a household assets index. The score we obtain can be thought of as a weighted score of assets. We use this as an approximation of the relative wealth of students in our sample. This index can be divided into wealth quintiles.

- **A school's facilities index**. In February 2020, we collected data on 15 different school-level facilities, including whether schools had a library on site, an indoor and outdoor kitchen, a cafeteria, art and music classrooms, medical facilities, a computer room, and labs. We create a facilities index using the first component of a PCA applied to these 15 different variables. The higher the index the more diverse the mix of facilities schools have to offer.

References

Bayley, S., Wole, D., Ramchandani, P., Woldehanna, T., and Yorke, L. (2021). Socio-Emotional and Academic Learning Before and After COVID-19 School Closures: Evidence from Ethiopia. *RISE Working Paper Series,* 21/082. Available at: https://doi.org/10.35489/BSG-RISE-WP_2021/082

Buningwire, W. (2020). REB to recruit 7,200 teachers ahead of schools reopening in September. *KT Press*, 16 June. Retrieved from: https://www.ktpress.rw/2020/06/reb-to-recruit-7200-teachers-ahead-of-schools-reopening-in-september/

Carter, E., Leonard, P., Nzaramba, S., and Rose, P. (2020). Effects of school closures on secondary school teachers and school leaders in Rwanda: Results from a phone survey. *Leaders in Teaching Research and Policy Series,* November 2020. Laterite, Rwanda and REAL Centre, University of Cambridge. Available at: https://bit.ly/39qKJCh

Clarke, P., Crawford, C., Steele, F., and Vignoles, A. (2010). The Choice Between Fixed and Random Effects Models: Some Considerations for Educational Research. *CMPO Working Paper series No. 10/240,* June 2010. Available at: http://repec.ioe.ac.uk/REPEc/pdf/qsswp1010.pdf

Donnelly, R., and Patrinos, H.A. (2021). Learning loss during Covid-19: An early systematic review. *Prospects,* 2021. Available at: https://doi.org/10.1007/s11125-021-09582-6

Evans, D., and Moscoviz, L. (2022) Learning loss and student dropouts during the COVID-19 pandemic: A review of the evidence two years after school shut down. *Center for Global Development,* 2022. Available at: https://www.cgdev.org/publication/learning-loss-and-student-dropouts-during-covid-19-pandemic-review-evidence-two-years

Laterite. (2017). *Understanding dropout and repetition in Rwanda: Full report for MINEDUC and UNICEF*. Kigali, Rwanda. Available at: https://bit.ly/30kQSf4

Laterite and the REAL Centre. (2021). *Understanding teaching quality in Rwandan secondary schools: Learning from the Leaders in Teaching initiative in 2020.* Laterite, Rwanda and REAL Centre, University of Cambridge. Available at: https://www.educ.cam.ac.uk/centres/real/publications/Annual%20Learning%20Synthesis_%20Understanding%20teaching%20quality%20in%20Rwandan%20secondary%20schools-%20Learning%20from%20the%20Leaders%20in%20Teaching%20initiative%20in%202020.pdf

Rwanda Biomedical Centre. (2020). *Health guideline for school re-opening. Kigali, Rwanda*. Available at: https://www.mineduc.gov.rw/fileadmin/user_upload/Mineduc/ANNOUNCEMENTS/Health_guidelines_for_schools_reopening_2.pdf

Tiruneh, D., Singal, N. Sabates, R. and Teferra, T. (2021). Disability and learning in Ethiopia: What has changed as a result of the COVID-19 pandemic. *RISE Programme Blog,* 12 May. Available at: https://riseprogramme.org/blog/disability-learning-ethiopia-what-changed-pandemic

Research for Equitable Access and Learning

UNIVERSITY OF CAMBRIDGE
Faculty of Education

REAL Centre
Faculty of Education
University of Cambridge
184 Hills Road, Cambridge,
CB2 8PQ, UK
@REAL_Centre
www.educ.cam.ac.uk/centres/real
Email: realcentre@educ.cam.ac.uk

laterite
DATA | RESEARCH | ADVISORY

Laterite
House 33, KG 584 St
Kibiraro II Village
Nyarutarama, Remera
Gasabo District, Kigali

@Laterite_Africa
www.laterite.com

All details correct at the time of going to print, October 2022.