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Teaching quality in secondary education in Rwanda: Changing perspectives of STEM teachers before and after school closures

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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.

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Teaching quality in secondary education in Rwanda: Changing perspectives of STEM teachers before and after school closures

COVID-19 has dramatically affected the teaching environment globally, with schools in Rwanda closing from March-November 2020. This study examines the extent to which the closing and reopening of secondary schools affected how Rwandan secondary school STEM teachers perceived their own teaching quality once back in the classroom. Improving teaching quality is one of Rwanda's strategic priorities for enhancing economic development. The findings draw on surveys of 1,609 STEM secondary teachers across 14 districts of Rwanda in February-March 2020 (before school closures), and in March 2021 (after schools reopened).

Key findings:

- **Which perceptions of teaching quality improved?** After schools reopened, teachers were more positive about: their perceived competence in instilling Rwandan cultural values in their students; their abilities to create a positive classroom environment and to encourage student-centred learning; the availability of support and opportunities; and motivation associated with the teaching profession as a whole.
- **Which perceptions of teaching quality declined?** Teachers thought more negatively about: their own perceived knowledge and pedagogy; the importance of considering diversity in the classroom; satisfaction with resources and material; and levels of motivation associated with classroom teaching.
- **These views differed based on school- and teacher-level characteristics:**
    - Teachers who reported having a disability were more satisfied with resources and material after schools reopened.
    - Teachers in day schools were less satisfied with resources and materials compared to those in boarding schools and reported decreased knowledge and pedagogical skills.
    - The youngest, least experienced male teachers felt less motivated with the teaching profession, but were positive about their ability to encourage student-centred learning and their knowledge and pedagogical skills.

Policy implications:

- Teacher training plans could be developed for areas teachers viewed more negatively: attitudes towards diversity, levels of classroom teaching motivation, knowledge and pedagogy.
- Different interventions for school-level and pedagogy should be designed to prepare the education system against future shocks.
- Focusing resourcing and training efforts on day schools and non-schools of excellence continues to be important, given the gaps between school types in teacher perceptions of resources, materials and pedagogical skills.
- Newer teachers, who might have started their careers just before or recently after the outbreak of the COVID-19 pandemic, might benefit from additional training or support (for example, through mentoring) given their lower levels of motivation for the teaching profession. This is important given the need to attract and retain skilled teachers to the profession, as secondary enrolment continues to increase in Rwanda.
- The needs of teachers who report having a disability regarding resources, material, support and opportunities should be continually monitored.
- School leaders should consider implementing mentoring programmes where teachers who were most satisfied about their own teaching quality could mentor others.
- School leaders could monitor how any negative perceptions of teaching quality manifest themselves in the classroom, and how this might affect student achievement.

Introduction

The context

Teaching quality is one of Rwanda's strategic priorities for enhancing economic development, as evidenced by *Vision 2050*, the aim of which is to ensure high standards of living for all Rwandans via quality education, which is considered central to quality of life (Gatete, 2016). In order to achieve the goal of improving teaching quality, it is essential to measure quality teaching with a view to understanding how it is changing due to the educational interventions taking place in Rwanda. With a few exceptions (Carter, Leonard, et al., 2021; Carter, Onwuegbuzie, et al., 2021b; Iwakuni, 2017; Kim, et al., 2019), limited evidence exists on teaching quality in the context of Rwanda, especially at the secondary school level (Onwuegbuzie and Sabates, 2021).

The outbreak of the COVID-19 pandemic has dramatically affected the teaching environment in Rwanda and across the world, with schools in Rwanda closing from March to November of 2020. The Rwandan Ministry of Education (MINEDUC) responded by developing the Education Sector COVID 19 Response Plan (Republic of Rwandan Ministry of Education, 2020), which focused on ensuring continuity of learning for all students in Rwanda and ensuring that schools reopened with appropriate services and measures in place so that students could re-enter the formal education system. During school closures, the Rwanda Basic Education Board (REB) delivered a range of remote learning and professional development opportunities. At the same time, the Leaders in Teaching implementing partners (IPs) quickly shifted to delivering their programming online (Laterite and the REAL Centre at the University of Cambridge, 2020).

In this context, within the 14 districts of Rwanda in which Leaders in Teaching[1] operates, this research paper seeks to:

1) examine the extent to which closing and reopening of secondary schools in the context of COVID-19 affected perceptions of STEM teachers in Rwanda about their own teaching quality; and
2) examine associations between these changes in perceptions of teaching quality and selected socio-demographic and locational variables.

To do this, we measured perceptions among STEM secondary school teachers in Rwanda over the period of one year. The measures of teaching quality that we used were obtained from two surveys, one undertaken before the COVID-19 pandemic in February-March 2020, and one after schools re-opened, in March 2021. This analysis allowed us directly to determine the extent to which the teachers perceived that COVID-19 and the ensuing closing and reopening of secondary schools affected perceptions of their own teaching quality.[2]

The first round of data collection occurred in February and March 2020. We analysed these data to operationalise different aspects of teaching quality (Carter et al., 2021). This paper draws on data from a phone survey that we undertook in March 2021, which included 9 of the 10 indicators from the first round (with appropriate adjustments, as we explain later).

The study

This paper involves an examination of the extent to which COVID-19 and the ensuing closing and reopening of secondary schools—hereafter referred to as *the COVID-19 context*—affected perceptions of teaching quality, as reported by secondary school STEM teachers in Rwanda. In particular, we assess teachers' perceptions of their own teaching quality since the onset of COVID-19 in Rwanda, and examine the extent to which socio-demographic and locational variables (e.g. gender of teacher, age, years of experience, qualification, area of knowledge, disability status, type of school) are associated with these perceptions of teaching quality. It should be noted that all associations presented throughout this paper are correlational in nature and should not be interpreted as representing causality.

This paper involves the analysis and interpretation of data collected from 358 schools within 14 districts. A total of 1,820 STEM teachers participated in February/March 2020 and 1,931 STEM teachers participated in March 2021. However, only the 1,609 STEM teachers who participated in both years are included in this study. This is to:

- ensure that all the March 2021 teacher participants included in the final sample were those with experience as secondary school STEM teachers prior to the onset of COVID-19, and
- be able to compare directly some of the findings (e.g. pertaining to the psychometric properties of measures) to those from February/March 2020.

Key findings

- In our analysis of changes in teachers' perceptions of their own teaching quality after schools reopened, we refer to the following nine measures of teaching quality, each with good psychometric properties (e.g. adequate score reliability): inculcating cultural values, perceived teacher knowledge and pedagogy, attitudes towards creating a positive classroom environment, attitudes towards student-centred learning, attitudes towards diversity, satisfaction with support and opportunity, satisfaction with resources and material, level of teacher motivation associated with their classroom teaching, and level of teacher motivation associated with the teaching profession as a whole.
- After schools reopened, teachers reported more negative perceptions regarding the following 4 of the 9 teaching quality measures: perceived teacher knowledge and pedagogy, attitudes towards diversity, satisfaction with

resources and material, and levels of teacher motivation associated with classroom teaching.

- Teachers reported more positive perceptions of measures of teaching quality after schools reopened for 5 of the 9 teaching quality measures. Specifically, teachers reported stronger beliefs that it is necessary for teachers to inculcate Rwandan cultural values in their students, more positive attitudes regarding their abilities to create a positive classroom environment and to encourage student-centred learning, a greater satisfaction with support and opportunity, and a higher level of teacher motivation associated with the teaching profession as a whole.
- When disability is examined in isolation, compared to teachers who reported not having a disability, teachers who reported having a disability expressed a higher level of satisfaction with resources and material after schools reopened.
- When type of school is examined in isolation, compared to teachers in boarding schools, teachers in day schools expressed decreased satisfaction with resources and material as well as decreased perceptions of their own knowledge and pedagogical skills, after schools reopened.
- Among the key sociodemographic variables examined simultaneously, teachers who had the longest travel time from home to school were more likely to express decreased satisfaction with resources and materials, after schools reopened.
- Teachers who are male, the youngest, have the least years of teaching experience, and who report having either a Bachelor's degree (i.e. BA, BSc – not necessarily a degree in Education) or no qualification in teaching tended to indicate the most negative perceptions of the impact of the COVID-19 context on the importance of inculcating cultural values, satisfaction with resources and material, and levels of teacher motivation associated with the teaching profession as a whole. In contrast, these teachers tended to indicate the most positive perceptions of the impact of the COVID-19 context on their ability to encourage student-centred learning and their knowledge and pedagogical skills.

Methodological note

During the school closures that began in Rwanda on 14th March 2020—just three days after the first case of COVID-19 was identified in the country— MINEDUC, in consultation with its agencies and other Ministries, developed an Education Sector COVID 19 Response Plan (Republic of Rwanda Ministry of Education, 2020), which aligned with the national COVID-19 Preparedness and Response Plan. This Education Sector COVID-19 Response Plan also aligned with the Education Sector Strategic Plan (ESSP; 2018/2019–2023/2024) of the Republic of Rwanda Ministry of Education (2010), which articulates the priorities of the education sector with respect to education quality. The Education Sector COVID-19 Response Plan involved five objectives, with the first two objectives leading to the most immediate action:

Objective 1: Ensure continuity of learning for all students in Rwanda

Objective 2: Ensure that schools reopen with appropriate services and measures in place and that students re-enter the formal education system

As a result, the REB delivered remote learning through online platforms via the following three broad initiatives: (1) national radio lessons, which were scripted with technical support from various Government agencies; (2) audio-visual lessons, primarily through national television broadcasting, with priority for lessons given for subjects in which it was more essential to have visual content, such as science experiments; and (3) e-learning[3]. With respect to the latter, REB launched a YouTube channel called *REB eLearning* with content for students.[4]

Other REB initiatives included online professional development for teachers and school leaders that focused on digital skills; a support helpline for students, parents and community members; SMS (i.e., Short Message Service) devices being used to communicate, via text messages, important information and reminders for parents on the learning schedules of students; and the enhancement of digital platforms to facilitate learning among students with disabilities (e.g. Objective 4). Digital platforms were enhanced to ensure accessibility features, including text-to-speech and digital formats of communication, such as the REB scripts being translated into Braille, close-caption and Sign Language.

The Leaders in Teaching implementing partners (IPs) quickly shifted to delivering their programming online (Laterite and the REAL Centre at the University of Cambridge, 2020). Examples of IPs that accelerated transition to remote learning through online platforms initiated by the IPs include the following: The African Institute for Mathematical Sciences (AIMS); The University of Rwanda College of Education (UR-CE); VVOB Rwanda; Inspire, Educate and Empower Rwanda (IEE); and UNICEF Rwanda and Carnegie-Mellon University Africa (CMU Africa).

As noted previously, of the 1,931 STEM teachers who participated in March 2021, only the 1,609 STEM teachers who participated in both years (i.e., February/March 2020 and March 2021) are included in this study. The decision to retain only the STEM teachers who participated in both years of the research led to the exclusion of 322 STEM teachers. Therefore, it is important to assess the potential impact to the findings of excluding these teachers. It should be noted that there were some differences with regard to some major socio-demographic variables between the STEM teachers who participated in both the February/March 2020 and March 2021 data collection periods and those who participated *only* in March 2021 and who subsequently were not included in the present study. Most notably, there was a statistically significantly higher proportion of female teachers who participated in March 2021 only (33.6%) than female teachers who participated in both years (25.9%), although the effect size associated with this difference was small,[5] with female teachers being only 1.30 times more likely to participate in March 2021 only than in both years. Further, the teachers who participated in both years were statistically significantly older than were teachers who participated only in March 2021,[6] with a small effect size (Cohen's [1988] d = .21).[7] Also, the teachers who participated in both years reported statistically significantly more years of teaching experience than did the teachers who participated only in March 2021,[8] with a small effect size (d = .15). Contrastingly, there was no statistically significant (χ^2 = 0.48, p = .49) difference between the proportion of teachers who participated in both February/March 2020 and March 2021 and who reported having a disability (2.9%) and teachers who participated only in March 2021 and who reported having a disability (3.8%).[9]

The statistically significant differences in gender, age and years of teaching experience—albeit small—leave open the possibility that the findings from the current study might have been somewhat different if the teachers who participated only in March 2021 had been included. However, including the teachers who participated only in March 2021 in the current investigation was likely not justified because the teaching status of at least some of the March 2021 teachers prior to the onset of COVID-19 was unknown. For example, 7.6% of STEM teachers who participated in only the March 2021 study reported that they had only 1 year of teaching experience; this indicates that they had joined the teaching profession sometime *after* the onset of COVID-19[10], and so were not in a position to assess reliably the extent to which the school closures affected perceptions of their own teaching quality due to a lack of pre-COVID-19 in-service teaching experience which would have served as a baseline for them.

To help identify the extent to which COVID-19 context affected perceptions of STEM teachers in Rwanda about their own teaching quality, we interviewed the same teachers who were interviewed in February and March 2020, one year after the onset of the COVID-19 pandemic and school closures, in March 2021. These interviews occurred around five months after schools had reopened. The Teacher Survey that

was administered via phone in March 2021 provided some identical response options to the questions as those asked face-to-face the previous year, but with some questions removed recognising the challenges of administrating a survey via the phone. The earlier (i.e., February/March 2020) instrument was carefully reviewed to identify response options that did not seem as relevant for the purposes of the analysis. Most significantly, whereas for this first administration, the teachers were asked to indicate their *current* perceptions of their own teaching quality (e.g. "Indicate the extent to which you agree or disagree with the following statements about being a teacher") before the onset of COVID-19, for the second administration, which occurred during the COVID-19 pandemic, the teachers were asked to indicate the extent to which the school closures affected perceptions of their own teaching quality (e.g. "To what extent did school closures affect your views towards the following statements"). This March 2021 teacher survey was split into two parts to minimise interruptions in school activities. These two parts, which were administered within three days of each other, were approximately equal in length, with each part containing items to ensure that the phone surveys would not exceed 40 minutes total (i.e., 20 minutes per round).

Measures of teaching quality

The measures used in this study were informed by sources such as existing literature and instruments used in low- and lower-middle income countries, information collected that was specific to the Rwandan context and findings from 18 focus group discussions (FGDs) conducted in Rwanda whereby perceptions of quality teaching in Rwandan secondary schools among members of the following five groups of stakeholders were explored: trainee teachers, early career teachers, late career teachers, teacher trainers and deans of studies (Carter, Onwuegbuzie, et al., 2021a, 2021b).[11]

These 10 measures were administered in the February/March 2020 data collection period (see Carter et al., 2021).[12] However, because there were two measures of cultural values (i.e., Inculcating Cultural Values Scale and Attitudes Towards Cultural Values Scale) and because of our need to shorten the instrument for the phone survey, we decided to eliminate one of these scales—namely, the Attitudes Towards Cultural Values Scale, which meant that the 9 measures were administered in the March 2021 data collection period. In describing each of these 9 measures (i.e., scales/subscales) below, it should be noted that all individual items were modified so that a higher value indicates more agreement with the statement.

1. Inculcating Cultural Values Scale (1 scale containing 6 items)

   This scale measures the teacher's level of perceived competence in inculcating Rwandan cultural values in his/her students. The cultural values that were emphasised here were as follows: honesty and integrity, participating in

community activities, showing tolerance towards others, forgiving others, respecting others, and treating each other fairly. An example of an item is *"I encourage my students to be honest and to have integrity*".

2. Perceived Teacher Knowledge and Pedagogy Scale (1 scale containing 4 items)

   This scale measures a teacher's level of perceived knowledge of the subject taught and her/his pedagogical competence. An example of an item related to teacher knowledge is "*I have enough subject knowledge to teach my classes well*"; an example of an item related to pedagogical competence is "*I provide opportunities for my students to apply their learning*".

3. Attitudes Towards Creating a Positive Classroom Environment Scale (1 scale containing 5 items)

   This scale measures a teacher's level of perceived competence in creating a positive environment for their students in their classrooms. An example of an item is *"I encourage students to believe they can do well in their school work*".

4. Attitudes Towards Student-Centred Learning Scale (1 scale containing 5 items)

   This scale measures the teacher's level of perceived competence in promoting student-centred learning in their classrooms. Two examples of an item are "*I vary my instruction to include individual, small group and whole class work*" and "*I encourage my students to ask questions*".

5. Attitudes Towards Diversity Scale (1 scale containing 4 items)

   This scale measures the degree to which the teacher has a positive attitude towards student diversity in their classrooms. Two examples of an item are "*Girls have more difficulties than other students in STEM subjects*" and "*Students with physical disabilities struggle to grasp learning concepts more than other students*".

6. Job Satisfaction: Subscale 1: Satisfaction with Support and Opportunity (containing 6 items)

   This scale measures the degree to which the teacher is satisfied with the support and opportunities that are available to them as teachers. Two examples of an item are "*I am satisfied with the support from the head teacher*" and "*I am satisfied with the opportunities for in-service training available to me*".

7. Job Satisfaction: Subscale 2: Satisfaction with Resources and Material (containing 5 items)

   This scale measures the degree to which the teacher is satisfied with the resources and materials that are available to them to teach their students. Two examples of an item are "*I am satisfied with the amount of material/resources I have access to*" and "*I am satisfied with the availability of textbooks in school for myself and all the children in my class*".

8. Classroom Teaching Motivation Subscale[13] (containing 5 items)

   This scale measures the level of teacher motivation associated with their classroom teaching. An example of an item is "*I have difficulty keeping up with all the changes in the curriculum*".

9. Macro-Level Teacher Motivation Subscale[14] (containing 7 items)

   This scale measures the level of teacher motivation associated with the teaching profession as a whole. Two examples of an item are "*My work inspires me*" and "*I am enthusiastic about my job*".

Of the 9 measures of teaching quality that were administered in March 2021, 6 of them contained exactly the same items for the February/March 2020 data collection period. The remaining 3 measures had to be adjusted for the March 2021 data collection because most teachers were still working remotely, and these measures were administered as part of the Teacher Survey via phone surveys. The three measures that had to be adjusted, because they included items that applied only to the face-to-face teaching and learning context, were the Perceived Teacher Knowledge and Pedagogy Scale, the Attitudes Towards Diversity Scale and the Satisfaction with Resources and Material Subscale.[15] [16]

Characteristics of the STEM teachers in the sample

The majority of STEM teachers were male, younger than 35, and had less than 10 years of teaching experience. Approximately three quarters (74.1%) of the teachers in the sample were male (see Table 1). Further, slightly less than two thirds (60.3%) of the teachers were less than 35 years of age (see Table 1). Similarly, slightly more than two thirds (69.0%) of the STEM teachers had 10 years or less of teaching experience.

Table 1: Characteristics of the STEM teachers

Socio-demographic variable	Mean	Standard deviation	Minimum	Maximum
Age of all teachers	34.32	6.29	20	60
Age of female teachers	33.06	5.55	23	55
Age of male teachers	34.76	6.47	20	60
Years of teaching experience	9.23	5.84	1	39
Years of teaching experience of female teachers	8.51	5.45	1	31
Years of teaching experience of male teachers	9.48	5.96	1	39

Source: Leaders in Teaching data 2019-21

The majority of teachers either had a Bachelor's degree qualification or an Advanced Diploma in Education. Specifically, approximately 9 out of 10 teachers either had a Bachelor's degree qualification (40.6%) or an Advanced Diploma in Education qualification/Postgraduate Diploma in Education/Certificate in Teacher Training (48.4%). Interestingly, approximately 1 in 10 teachers (i.e. 11.1%) reported having no qualification in teaching.

A small percentage of teachers reported having a disability. Specifically, 2.9% of the teachers reported having a disability. The most commonly reported disability was low vision (57.4%), followed by loco-motor disabilities (36.2%). Of the remaining teachers with a disability, each of the following disabilities was represented by one teacher: blindness, hearing impairment, speech impairment, and mental health disability. No teacher reported having multiple disabilities.

The majority of teachers walked to work, and their journey took 30 minutes or less. The vast majority of teachers (75.3%) walked to their schools. The remaining travel modes used by less than 8% of the participants are as follows: public bus (7.6%), public motor car (6.4%), private bicycle (5.3%), private motor car (2.9%) and public bicycle (2.1%). Most teachers (72.2%) took 30 minutes or less to travel to work (Mean = 27.74, Standard Deviation = 25.25). This implies that these teachers took one hour or less to travel to and from their school on a daily basis.

The extent to which the COVID-19 context affected perceptions of STEM teachers in Rwanda about their own teaching quality

For each measure, a mean difference below 0 indicates that perceptions of their own teaching quality after schools reopened were more negative compared to before school closures, whereas a mean difference above 0 indicates that perceptions of their own teaching quality after schools reopened were more positive compared to before school closures. Table 2 shows that, for 4 of the 9 teaching quality measures, the responses were negative—being statistically significantly lower than 0 (all *ps* < .0001)—which indicated that perceptions of their own teaching quality pertaining to these aspects after schools reopened were more negative compared to before school closures. The four teaching quality measures that tended to yield negative responses were Attitudes Towards Diversity Scale, Classroom Teaching Motivation Subscale, Perceived Teacher Knowledge and Pedagogy Scale, and Satisfaction with Resources and Material Subscale.

Interestingly, the Attitudes Towards Diversity Scale produced the most negative responses. In fact, a series of dependent (i.e. paired) samples *t* tests comparing all the scale/subscale scores with each other revealed that the Attitudes Towards Diversity Scale responses were statistically significantly more negative than all eight other measures.

In contrast, Table 2 also reveals that, for the remaining 5 of the 9 teaching quality measures, the responses were positive—being statistically significantly higher than 0 (all *ps* < .0001)—which indicated that the school closures positively affected perceptions of their own teaching quality pertaining to these aspects. The five teaching quality measures that tended to yield positive responses were Inculcating Cultural Values Scale, Attitudes Towards Creating a Positive Classroom Environment Scale, Attitudes Towards Student-Centred Learning Scale, Satisfaction with Support and Opportunity Subscale, and Macro-Level Teacher Motivation Subscale.

Table 2: Recentred mean item rating for the 9 measures for March 2021

Scale/Subscale	**Recentred Mean (Standard Deviation)**
Inculcating Cultural Values Scale	0.70 (1.11)
Perceived Teacher Knowledge and Pedagogy Scale	-0.28 (0.96)
Attitudes Towards Creating a Positive Classroom Environment Scale	0.19 (1.16)
Attitudes Towards Student-Centred Learning Scale	0.25 (1.19)
Attitudes Towards Diversity Scale	-0.84 (0.82)
Satisfaction with Support and Opportunity Subscale	0.49 (1.06)
Satisfaction with Resources and Material Subscale	-0.11 (0.93)
Classroom Teaching Motivation Subscale	-0.45 (0.95)
Macro-Level Teacher Motivation Subscale	0.59 (0.86)

Source: Leaders in Teaching data 2020-2021
Note: The mean and standard deviation values pertain to the recentred individual item responses for each scale/subscale. These means originally represented a 5-point, Likert-format scale, with responses ranging from 1 to 5. However, for ease of interpretation, these means were recentred by subtracting 3 from each response, such that the responses ranged from -2 to 2. Therefore, for each scale/subscale, a mean difference below 0 indicates that the COVID-19 context negatively affected perceptions of their own teaching quality. For example, for the Inculcating Cultural Values Scale that contains six items, the original mean item rating of 3.70 for all teachers was recentred by subtracting 3.00 to yield a recentred mean of 0.70. This 0.70 mean indicates that the majority of teacher respondents tended to *agree* or to *strongly agree* to each of the six items, further indicating that the COVID-19 context positively affected perceptions of their own teaching quality pertaining to this scale. In contrast, for the Perceived Teacher Knowledge and Pedagogy Scale, the -0.28 mean indicates that the majority of teacher respondents tended to dis*agree* or to *strongly disagree* to each item contained within it, further indicating that the COVID-19 context negatively affected perceptions of their own teaching quality pertaining to this scale.

There is no difference in changes in perceptions of their own teaching quality between male teachers and female teachers for all 9 measures. Examining gender in isolation from all other socio-demographic and locational variables (i.e. univariate analyses) revealed that, for all 9 measures, there is no difference between male teachers and female teachers with respect to the extent to which they perceived that the COVID-19 context affected perceptions of their own teaching quality (see Table 3). This finding indicates that there are no gender differences with respect to the effect on perceptions of their own teaching quality. Whereas for six of the measures, the male teachers indicated a more positive or less negative response, the reverse was true for the remaining three measures (i.e. Inculcating Cultural Values Scale,

Satisfaction with Support and Opportunity Subscale, Macro-Level Teacher Motivation Subscale), with female teachers indicating a more positive response.

There is no difference in changes in perceptions of their own teaching quality between teachers who report having a disability and teachers who report not having a disability for all 9 measures when each scale/subscale is examined in isolation. When examining disability status in isolation from all other socio-demographic and locational variables, there is no difference in changes in perceptions of their own teaching quality between teachers who report having a disability and teachers who report not having a disability with regard to 8 of the 9 measures (see Table 4). However, the one exception was that, whereas teachers who report having a disability reported *positive* perceptions with respect to the Satisfaction with Resources and Material Subscale, teachers who report not having a disability reported *negative* perceptions with regard to this variable, yielding a statistically significant difference (p = .005), with a medium effect size (d = .42).

There is a difference in perceptions of teaching quality trends between teachers at day schools and teachers at boarding schools for 4 of the 9 measures. Of the 9 measures, there is a statistically significant univariate difference in perceptions between teachers of day schools and those of boarding schools (see Table 5) with respect to the following 2 measures: Perceived Teacher Knowledge and Pedagogy Scale and Satisfaction with Resources and Material Subscale. Specifically, with respect to the Perceived Teacher Knowledge and Pedagogy Scale, although teachers representing both types of schools indicated a negative response, the perceptions of teachers of boarding schools were statistically significantly less negative (d = .24). With regard to the Satisfaction with Resources and Material Subscale, whereas teachers of day schools indicated negative perceptions, teachers of boarding schools indicated positive perceptions. Therefore, the perceptions of teachers of day schools were statistically significantly more negative with a large effect size (d = .84).

Interestingly, teachers of day schools indicated either a more negative or less positive response than did teachers of boarding schools for 8 of the 9 measures (i.e. except the Macro-Level Teacher Motivation Subscale). Using Onwuegbuzie and Levin's (2005) Binomial Test of Trend[17], the probability that 8 or more of the 9 measures yielded a more negative/less positive response among the teachers of day schools was .02, indicating that the trend was statistically significant, with an effect size of 0.89 (i.e. 8/9). Therefore, the COVID-19 context, in general, is associated with a consistently more adverse impact in perceptions of their own teaching quality among teachers of day schools.

There is no difference in changes in perceptions of their own teaching quality between teachers of small schools and teachers of large/very large schools for all 9 measures. Secondary school teachers' perceptions have been found to vary as a function of school size within the COVID-19 context because budgets for facilities are allocated based on school size (Boonmoh et al., 2022). However, in the present study, there is no difference between teachers of small schools and teachers of large/very large schools with respect to the extent to which they perceived that the COVID-19 context affected perceptions of their own teaching quality (see Table 6). This finding indicates that there are no size of school differences with respect to the effect on perceptions of their own teaching quality. Whereas for four of the measures (i.e. attitudes towards diversity, levels of teacher motivation associated with classroom teaching, perceived teacher knowledge and pedagogy, and satisfaction with resources and material, respectively), teachers of small schools indicated a less positive or more negative response, the reverse was true for the remaining five measures (i.e. inculcating cultural values, level of teacher motivation associated with the teaching profession as a whole, satisfaction with support and opportunity, attitudes towards student-centred learning, and attitudes towards creating a positive classroom environment, respectively), with teachers of large/very large schools indicating a more positive or less negative response.

Table 3: Mean difference by the gender of the teacher for each of the 9 measures

Mean (Standard Deviation)					
Scale/Subscale	**Male teachers**	**Female teachers**	**Difference**	***t* value**	***d***
Inculcating Cultural Values Scale	0.69 (1.13)	0.72 (1.08)	-0.03	-0.51	0.03
Perceived Teacher Knowledge and Pedagogy Scale	-0.26 (0.96)	-0.35 (0.96)	0.11	1.62	0.09
Attitudes Towards Creating a Positive Classroom Environment Scale	0.20 (1.17)	0.14 (1.13)	0.06	-0.96	0.06
Attitudes Towards Student-Centred Learning Scale	0.29 (1.18)	0.13 (1.19)	0.16	2.40	0.14
Attitudes Towards Diversity Scale	-0.83 (0.84)	-0.88 (0.76)	0.05	1.05	0.06
Satisfaction with Support and Opportunity Subscale	0.46 (1.08)	0.56 (0.99)	-0.10	-1.66	0.10
Satisfaction with Resources and Material Subscale	-0.12 (0.73)	-0.13 (0.70)	0.01	0.25	0.01
Classroom Teaching Motivation Subscale	-0.42 (0.96)	-0.52 (0.90)	0.10	1.86	0.10
Macro-Level Teacher Motivation Subscale	0.56 (0.87)	0.65 (0.84)	-0.09	-1.76	0.11

Source: Leaders in Teaching data 2019-21

Note: For each scale/subscale, the mean difference in Column 4 was obtained by subtracting the female mean scale/subscale differences from the male mean scale/subscale differences. Therefore, a positive difference indicates that male teachers indicated a less negative/more positive response, whereas a negative difference indicates that male teachers indicated a less positive response.

* $p <$ the Bonferroni-adjusted alpha level of .0056

Table 4: Mean difference by the disability status of the teacher for each of the 9 measures

Mean (Standard Deviation)					
Scale/Subscale	**Teachers with a disability**	**Teachers without a disability**	**Difference**	***t* value**	***d***
Inculcating Cultural Values Scale	0.66 (1.16)	0.71 (1.11)	0.05	0.28	0.04
Perceived Teacher Knowledge and Pedagogy Scale	-0.19 (1.02)	-0.28 (0.96)	-0.09	-0.62	0.09
Attitudes Towards Creating a Positive Classroom Environment Scale	0.39 (1.15)	0.18 (1.16)	-0.21	-1.18	0.18
Attitudes Towards Student-Centred Learning Scale	0.44 (1.29)	0.25 (1.18)	-0.19	-1.10	0.16
Attitudes Towards Diversity Scale	-0.92 (0.78)	-0.84 (0.82)	0.08	0.61	0.10
Satisfaction with Support and Opportunity Subscale	0.80 (1.02)	0.48 (1.06)	-0.32	-2.01	0.30
Satisfaction with Resources and Material Subscale	0.17 (0.68)	-0.13 (0.72)	-0.30	-2.84*	0.42
Classroom Teaching Motivation Subscale	-0.44 (0.93)	-0.45 (0.95)	-0.01	-0.10	0.02
Macro-Level Teacher Motivation Subscale	0.56 (0.85)	0.59 (0.86)	0.03	0.25	0.04

Source: Leaders in Teaching data 2019-21

Note: For each scale/subscale, the mean difference in Column 4 was obtained by subtracting the mean scale/subscale differences of the teachers with a disability from the mean scale/subscale differences of teachers without a disability. Therefore, a positive difference indicates that teachers with a disability provided a less positive/more negative response, whereas a negative difference indicates that teachers with a disability provided a more positive/less negative response.

* $p <$ the Bonferroni-adjusted alpha level of .0056

Table 5: Mean difference by the teacher's type of school for each of the 9 measures

Mean (Standard Deviation)					
Scale/Subscale	**Teachers of a day school**	**Teachers of a boarding school**	**Difference**	***t* value**	***d***
Inculcating Cultural Values Scale	0.68 (1.12)	0.81 (1.05)	-0.13	-1.57	0.12
Perceived Teacher Knowledge and Pedagogy Scale	-0.32 (0.96)	-0.09 (0.94)	-0.23	-3.09*	0.24
Attitudes Towards Creating a Positive Classroom Environment Scale	0.15 (1.17)	0.35 (1.10)	-0.20	-2.18	0.17
Attitudes Towards Student-Centred Learning Scale	0.21 (1.19)	0.43 (1.12)	-0.22	-2.42	0.19
Attitudes Towards Diversity Scale	-0.87 (0.82)	-0.75 (0.76)	-0.12	-1.88	0.15
Satisfaction with Support and Opportunity Subscale	0.47 (1.07)	0.48 (1.01)	-0.01	-0.02	0.00
Satisfaction with Resources and Material Subscale	-0.22 (0.69)	0.36 (0.70)	-0.58	-10.84*	0.84
Classroom Teaching Motivation Subscale	-0.48 (0.96)	-0.30 (0.87)	-0.18	-2.52	0.19
Macro-Level Teacher Motivation Subscale	0.59 (0.87)	0.57 (0.81)	0.02	0.35	0.03

Source: Leaders in Teaching data 2019-21

Note: For each scale/subscale, the mean difference in Column 4 was obtained by subtracting the mean scale/subscale differences of the teachers of a day school from the mean scale/subscale differences of teachers of a boarding school. Therefore, a positive difference indicates that teachers of a boarding school indicated a less positive response, whereas a negative difference indicates that teachers of a boarding school indicated a more positive/less negative response.

* $p <$ the Bonferroni-adjusted alpha level of .0056

Table 6: Mean difference by size of school of the teacher for each of the 9 measures

Mean (Standard Deviation)					
Scale/Subscale	**Teachers of small schools**	**Teachers of large and very large schools**	**Difference**	***t* value**	***d***
Inculcating Cultural Values Scale	0.67 (1.17)	0.71 (1.10)	-0.04	-0.60	0.04
Perceived Teacher Knowledge and Pedagogy Scale	-0.27 (0.99)	-0.28 (0.95)	0.01	0.23	0.02
Attitudes Towards Creating a Positive Classroom Environment Scale	0.26 (1.20)	0.17 (1.15)	0.09	1.25	0.08
Attitudes Towards Student-Centred Learning Scale	0.36 (1.23)	0.22 (1.17)	0.14	1.87	0.12
Attitudes Towards Diversity Scale	-0.85 (0.87)	-0.84 (0.81)	-0.01	-0.10	0.01
Satisfaction with Support and Opportunity Subscale	0.41 (1.16)	0.50 (1.03)	-0.09	-1.32	0.08
Satisfaction with Resources and Material Subscale	-0.17 (0.70)	-0.11 (0.72)	-0.06	-1.36	0.09
Classroom Teaching Motivation Subscale	-0.35 (0.98)	-0.48 (0.94)	0.13	2.10	0.13
Macro-Level Teacher Motivation Subscale	0.62 (0.89)	0.58 (0.85)	0.04	0.87	0.06

Source: Leaders in Teaching data 2019-21

Note: For each scale/subscale, the mean difference in Column 4 was obtained by subtracting the mean scale/subscale differences of the teachers of large and very large schools from the mean scale/subscale differences of teachers of small schools. Therefore, a positive difference indicates that teachers of small schools indicated a more positive/less negative response, whereas a negative difference indicates that teachers of small schools indicated a less positive/more negative response.

* $p <$ the Bonferroni-adjusted alpha level of .0056

Methods of analysis for examining relationships between teaching perceptions and selected socio-demographic and locational variables

In the following sections, we examine associations between teachers' perceptions of their own teaching quality during a period of the COVID-19 context (dependent variable set) and selected socio-demographic and locational variables (predictor variable set). For this purpose, we use canonical correlation analysis to examine the relationships between these two sets of variables. A canonical correlation analysis is utilised to examine the relationship between two sets of variables when each set contains more than one variable (see Thompson, 1984).

The nine perceptions of teaching quality variables are:

- inculcating cultural values
- perceived teacher knowledge and pedagogy
- attitudes towards creating a positive classroom environment
- attitudes towards student-centred learning
- attitudes towards diversity
- satisfaction with support and opportunity
- satisfaction with resources and material
- classroom teaching motivation
- macro-level teacher motivation

The eight socio-demographic and locational variables comprise the following variables:

- gender (dichotomous)
- age (ratio scale)
- years of teaching experience (ratio scale)
- travel time (ratio scale)
- qualifications (different dichotomisations; e.g. Bachelor's degree versus advanced diploma)
- disability status (dichotomous; i.e. report having a disability versus report not having a disability)
- type of school (dichotomous; i.e. day school versus boarding school)
- size of school (dichotomous; i.e. small versus large and very large)[18]

Predictors of the changes in perceptions of their own teaching quality associated with the COVID-19 context

Relationship between changes in the perceptions of teaching quality measures and the socio-demographic and locational variables

The analysis reveals that the relationship between the socio-demographic and locational variables and the changes in perceptions of teaching quality variables are best characterised by two sets of relationships (see Appendix Table 1).

The first set indicates that type of school and travel time simultaneously predict changes in satisfaction with resources and material. More specifically, this set of relationships (i.e. Function 1 of Appendix Table 1) revealed the following relationships that occurred as a result of the COVID-19 context in Rwanda:

- Teachers in day schools and teachers with the longest travel time from home to school tend to indicate the most negative perceptions regarding satisfaction with resources and material after schools reopened.

Interestingly, based on the size of the coefficients (Appendix Table 1),[19] type of school is by far the best predictor of the changes in perceptions of their own teaching quality. These findings are summarised in Table 7.

Table 7: Relationship between the extent to which the COVID-19 context affected perceptions of their own teaching quality and the socio-demographic and locational variables among STEM teachers in Rwanda: Relationship 1

	Day schools	Longest travel time
Satisfaction with resources and material	↓	↓

Source: Leaders in Teaching data 2019-21

The arrows pointing downwards indicate the relatively more negative perceptions, compared to their counterparts.

Gender, age, years of experience, and qualifications simultaneously predict inculcating cultural values, attitudes towards student-centred learning, perceived teacher knowledge and pedagogy, satisfaction with resources and material, and levels of teacher motivation associated with the teaching profession as a whole. More specifically, this second set of relationships (i.e. Function 2 of Appendix Table 1) revealed the following relationships that occurred as a result of the COVID-19 context in Rwanda:

- Male teachers, the youngest teachers, and teachers with the least years of experience tend to indicate the most negative perceptions regarding their competence in inculcating cultural values in their students, their satisfaction with resources and material, and their levels of teacher motivation associated with the teaching profession as a whole, after schools reopened.

- After schools reopened, teachers who report having either a Bachelor's degree (i.e. BA, BSc) or no qualification in teaching, as opposed to an Advanced/Postgraduate Diploma in Education/Certificate in Teacher Training, tend to indicate the most negative perceptions regarding their competence in inculcating cultural values, their satisfaction with resources and material, and their levels of teacher motivation associated with the teaching profession as a whole.

- After schools reopened, male teachers, the youngest teachers, teachers with the least years of experience, and teachers who report having either Bachelor's degree qualification or no qualification in teaching (as opposed to an Advanced/Postgraduate Diploma in Education/Certificate in Teacher Training) tend to indicate the most positive perceptions regarding their abilities to encourage student-centred learning and the most positive perceptions of their own knowledge and pedagogical skills.

Table 8: Relationship between the extent to which the COVID-19 context affected perceptions of their own teaching quality and the socio-demographic and locational variables among STEM teachers in Rwanda: Relationship 2

	Male teachers	Young teachers	Teachers with the least years of experience	Teachers who report having either Bachelor's degree qualification or no qualification in teaching
Teacher's level of perceived competence in inculcating values in his/her students	↓	↓	↓	↓
Satisfaction with resources and material	↓	↓	↓	↓
Levels of teacher motivation associated with the teaching profession as a whole	↓	↓	↓	↓
Perceptions regarding their abilities to encourage student-centred learning	↑	↑	↑	↑
Perceptions regarding their own knowledge and pedagogical skills	↑	↑	↑	↑

Source: Leaders in Teaching data 2019-21

The arrows pointing downwards indicate the relatively more negative perceptions, compared to their counterparts, whereas the arrows pointing upwards indicate relatively more positive perceptions, compared to their counterparts.

Conclusion, implications, and opportunities for further research

In this paper, we sought to examine the extent to which the COVID-19 context affected perceptions of their own teaching quality, as reported by secondary school STEM teachers in Rwanda, as well as the socio-demographic characteristics of STEM teachers who reported the greatest effect on perceptions. Our findings suggest clearly that teachers are reporting changes in their perceptions of teaching quality measures. Whereas for 4 of the 9 teaching quality measures, the teachers indicated that the COVID-19 context negatively affected their perceptions of teaching quality, for the other 5 teaching quality measures, they indicated that these events positively affected perceptions of their own teaching quality. This finding provides compelling evidence of the differential impact of the COVID-19 context on perceptions of their own teaching quality—thereby highlighting the multidimensional, multifaceted, and complex nature of teaching quality.

Positive perceptions of teaching quality emerged despite changes to the teaching environment that resulted from the COVID-19 context. The following perceptions of teaching quality emerged as being positive, despite the COVID-19 context: inculcating cultural values, attitudes towards creating a positive classroom environment, attitudes towards student-centred learning, satisfaction with support and opportunity, and level of teacher motivation associated with the teaching profession as a whole. The findings pertaining to attitudes towards creating a positive classroom environment, attitudes towards student-centred learning, satisfaction with support and opportunity are particularly noteworthy, bearing in mind the potential of these perceptions to be negatively affected both by remote learning and by face-to-face teaching in the context of social distancing measures, wearing of masks, and/or other changes which might have resulted from the new COVID-19 regulations that were in place.

Negative perceptions of teaching quality associated with the COVID-19 context, as reported by the Rwandan secondary school teachers, are more related to a variable at the system level than variables at the teacher level. Our findings also suggest that five teacher-level variables—namely, gender, age, years of teaching experience, travel time from home to school, and qualifications—are related to changes in perceptions of teaching quality. However, one system-level variable—namely, type of school (i.e. day school versus boarding school)—plays an especially important role in the changes in perceptions of teaching quality associated with remote teaching during the COVID-19 context. This finding indicates that changes in perceptions of teaching quality associated with the COVID-19 context are more related to variables at the system level than at the teacher level.

When examined in isolation, the disability status of a teacher is associated with positive perceptions of one area of teaching quality. When examined alongside the other socio-demographic and location variables—that is, multivariately via the canonical correlation analysis—teachers who report having a disability are not related to any of the perceptions of teaching quality variables. However, when examined in isolation—that is, univariately—teachers who report having a disability have reported positive perceptions relating to satisfaction with resources and material, with a medium effect size. Resources and material for teachers who report having a disability is likely to have been even more challenging to design and to implement under the short timeframe between the pandemic being recognised and school closures, and then between school closures and schools reopening. Bearing in mind that this scale measures the degree to which teachers are satisfied with the resources and materials that are available to them to teach their students, the finding regarding this scale appears to be a positive one because it suggests that the resources and materials provided for online teaching were more satisfactory than were the resources and materials provided for face-to-face teaching in school prior to COVID-19 which was documented by Carter et al. (2021). In addition, this finding might suggest a *floor effect* for the STEM teachers wherein those who deemed the resources and materials for the face-to-face teaching prior to the onset of COVID-19 to be inadequate, are more positive about the resources and materials for remote teaching that stemmed from REB's three broad initiatives (i.e. national radio lessons, audio-visual lessons and e-learning).

Boarding schools and day schools emerge as two groups of schools that have differential changes in perceptions of teaching quality as the result of the COVID-19 context. The finding that teachers in day schools tend to indicate the most negative perceptions with respect to satisfaction with resources and material might be related to the structural differences between day schools and boarding schools, differences in resources, and number of students, among other aspects. In any case, the type of school context appears to be vital in explaining the role that the COVID-19 context played in teachers' perceptions of their own teaching quality.

Teachers who are male, the youngest, and have the least years of teaching experience tended to indicate the most negative perceptions of the impact of the COVID-19 context on levels of teacher motivation associated with the teaching profession as a whole. The finding that male teachers, alongside the youngest and newest teachers, tend to indicate the most negative perceptions with respect to levels of teacher motivation reveals both a gender context and an age context in terms of motivation levels. Moreover, these findings suggest that the COVID-19 context had the greatest negative impact for these three groups of teachers (i.e. male, young and newest).

Policy Implications

The findings have led to the following policy implications that have been subdivided into the following two levels: school level and school leadership.

School Level

1. The results regarding these nine measures could be used to develop training plans for teachers that focus on areas where they indicated the greatest negative perceptions of teaching quality, namely: attitudes towards diversity, levels of classroom teaching motivation, perceived teacher knowledge and pedagogy, and satisfaction with resources and material.
2. Perceptions of teaching quality varied both at the school-level (i.e. type of school) and at the teacher-level (i.e. gender, age, years of teaching experience, travel time from home to school, qualifications, and disability status). Therefore, policy makers should consider distinguishing interventions for the school-level from interventions at the teacher-level (i.e. pedagogy) in an attempt to facilitate robust preparations in the event of future school closures—consistent with Objective 5 of the Education Sector COVID-19 Response Plan, namely preparing the resilience of the education system against future shocks.
3. That teachers who report having a disability have reported positive perceptions relating to satisfaction with resources and material is an encouraging finding. However, this might be suggestive of a *floor effect* as mentioned earlier, indicating an improvement in comparison to pre-COVID, face-to-face teaching resources and suggesting that effort is still needed in this area. Notwithstanding, the needs of teachers who report having a disability regarding resources and material and support and opportunities continually should be monitored, especially bearing in mind that they represent a vulnerable population—consistent with Objective 4 of the Education Sector COVID-19 Response Plan.

School leadership

1. School leaders might consider implementing mentoring programmes whereby teachers who indicated the most positive effect of the COVID-19 context on perceived teaching quality can mentor those teachers who have been identified as indicating the most negative effect on perceived teaching quality.
2. School leaders could consider monitoring how negative perceptions of teaching quality as a result of school closures manifest themselves in the classroom, and, especially, how they might affect student achievement.

Potential areas for further research on teaching quality in Rwanda secondary schools could include the following:

1. Collecting qualitative data (e.g. semi-structured interviews, focus group discussions) to further explain the negative perceptions of teaching quality.
2. Investigating the relationship between these measures of perceived teaching quality and student outcomes.
3. Investigating the relationship between the effect of school closures on teaching quality and student outcomes.

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Appendix

Appendix Table 1: Canonical correlation analysis: Canonical solution for the two statistically significant functions: Relationship between the eight socio-demographic and location variables and nine teaching quality variables

Variable	**Function 1[a]**		**Function 2[b]**	
Socio-demographic and location variables	**Standardised Coefficient**	**Structure Coefficient**	**Standardised Coefficient**	**Structure Coefficient**
Age	-0.13	-.09	-0.14	-.53*
Gender	0.08	.20	-0.71*	-.66*
Travel time	0.18	.32*	0.07	-.02
Years of experience	0.11	-.03	-0.56*	-.63*
Qualifications	0.12	-.01	0.25	.31*
Disability status	-0.22	-.24	0.06	-.01
Type of school	-0.92*	-.94*	-0.12	-.05
Size of school	0.13	.01	-0.11	-.16
Teacher quality variables				
Creating a positive classroom environment	-0.19	-.25	0.11	.22
Inculcating values	0.24	-.15	-0.31*	-.02
Student-centred learning	-0.21	-.25	0.54*	.40*
Teacher knowledge and pedagogy	-0.11	-.23	0.57*	.55*
Attitudes toward diversity	-0.07	-.18	-0.13	.09
Satisfaction with Resources and Material	-0.94*	-.90*	-0.28	-.37*

Variable	Function 1[a]		Function 2[b]	
Satisfaction with support and opportunity	0.27	.03	-0.15	-.18
Classroom Teaching Motivation	-0.02	-.19	0.12	.06
Macro-level motivation	0.23	.01	-0.68*	-.47*

*Practically significant coefficients with the effect sizes larger than .3 (Lambert & Durand, 1975).

Variables that are italicised but not bolded have either a standardised coefficient or a structure coefficient on one or more canonical functions that is practically significant.

Variables that are bolded have both a standardised coefficient and a structure coefficient on one canonical function that are practically significant.

Variables that are bolded and italicised have both a standardised coefficient and a structure coefficient on both canonical functions that are practically significant.

Variables that are neither bolded not italicised (i.e. normal font) have a non-practically significant standardised coefficient and a non-practically significant structure coefficient on both canonical functions.

[a]R_{c1} = .30; R_{c1}^2 = 8.77% (Eigenvalue = .10; Wilks Lambda = .85; F = 2.84, p < .0001)

[b]R_{c2} = .17; R_{c2}^2 = 2.95% (Eigenvalue = .03; Wilks Lambda = .93; F = 1.64, p < .002)

Endnotes

[1] The Leaders in Teaching initiative, launched by the Mastercard Foundation in Rwanda in 2018, aims to improve the quality of teaching and learning in secondary schools so that Rwandan youth can have the skills, knowledge and dispositions to succeed in the 21st century. This initiative is a long-term one with the goal of designing and implementing interventions for improving student learning outcomes in science, technology, engineering and mathematics (STEM) subjects. For more information about the Leaders in Teaching program, see the following link: https://mastercardfdn.org/all/leaders-in-teaching/

[2] The support provided include Continuous Professional Development (CPD) programmes for teachers and school leaders organised by Leaders in Teaching Implementing Partners (IPs) VVOB Rwanda and the University of Rwanda College of Education (URCE), alongside the Teacher Training Programme (TTP) delivered by the African Institute for Mathematical Sciences (AIMS).

[3] elearning.ur.ac.rw

[4] https://www.youtube.com/channel/UCCSm2s9wZC8B611SIslsUWg

[5] The effect size, as measured by Cramer's *V*, was.06, which represents a small effect size, using Cohen's (1988) criteria that $V < .1$ = negligible; $.1 \leq d < .3$ = small effect size; $.3 \leq d < .5$ = moderate effect size; and $d \geq .5$ = large effect size.

[6] The teachers who participated in both years ($M = 34.32$, $SD = 6.29$) were statistically significantly ($t = 2.86$, $p = .004$) older than were teachers who participated only in March 2021 ($M = 33.00$, $SD = 6.56$).

[7] Cohen's (1988) *d* represents the standardised effect size associated with the difference between two means. Cohen's (1988) *d* criteria for dependent (i.e. paired) samples *t* tests is $d < .2$ = negligible; $.2 \leq d < .5$ = small effect size; $.5 \leq d < .8$ = moderate effect size; and $d \geq .8$ = large effect size.

[8] The teachers who participated in both years ($M = 9.29$, $SD = 5.84$) reported statistically significantly ($t = 2.08$, $p = .04$) more years of teaching experience than did the teachers who participated only in March 2021 ($M = 8.34$, $SD = 5.49$).

[9] ($X^2 = 0.48$, $p = .49$)

[10] Teachers responded to the following question: "At the end of this school year, how many years of teaching experience will you have had altogether?"

[11] For more information about how the development of the measures of teaching quality was informed, please see Carter et al., 2020; Carter et al., 2021a, 2021b.

[12] These scales/subscales were all shown to have good psychometric properties via a series of first-order principal components analyses (PCAs) that was conducted to examine the structure of the Likert-format items contained in each section of the survey, as well as via the ensuing computation of reliability coefficients for each scale/subscale, which were all close to 0.70 or above, as recommended by Nunnally and Bernstein (1994). In the context of scale

development, principal component analysis is a statistical procedure performed on a set of items in order to determine which items in the set form logical subsets that are statistically independent from each other. Specifically, items that are statistically related to each other but are statistically independent from other subsets of variables are combined into a component, which yield a scale/subscale. Therefore, each component is assumed to represent the underlying phenomena/constructs that are responsible for the observed correlations among the items. As such, the PCA reduces the dimensionality of the set of items. A Likert-type or Likert-format scale is a symmetric agree-disagree scale (i.e. containing the same number of "agree" and "disagree" options) in which each participant responds to a series of statements (not questions) by specifying her/his level of agreement or disagreement. The creator of the Likert-format scale, the psychologist Rensis Likert, distinguished between a scale that stemmed from collective responses to a set of items (usually eight or more) and a scale wherein responses are scored along a range. Strictly speaking, a Likert scale refers only to the former. The phrase “Likert-format” scale is more appropriate than is the phrase “Likert scale” to distinguish the fact that the x-point scale (e.g. 5-point scale: 1 = strongly agree versus 2 = agree versus 3 = neutral versus 4 = disagree versus 5 = strongly disagree) represents a variation from the original Likert scale.

[13] Carter et al. (2021) named this subscale “Micro-Level Teacher Motivation Subscale”. However, for the present study, this subscale was renamed as “Classroom Teaching Motivation Subscale” because it more closely reflects what the scale was attempting to capture.

[14] Carter et al. (2021) named this subscale “Macro-Level Teacher Motivation Subscale”. However, for the present study, this subscale was renamed as “Teaching profession motivation” because it more closely reflects what the scale was attempting to capture.

[15] Each of the three measures that were adjusted (i.e. Perceived Teacher Knowledge and Pedagogy Scale, the Attitudes Towards Diversity Scale and the Satisfaction with Resources and Material Subscale) had one less item in the March 2021 survey than in the March 2020 survey. For example, the Satisfaction with Resources and Material Subscale, Item 5, namely “I am satisfied with the condition of the school infrastructure (e.g. classrooms)”, which was included in the March 2020 survey, was not applicable during the school closure wherein the students were involved in remote learning via online instruction. Therefore, in order to make the March 2020 and March 2021 measures consistent, the additional item in each of these three measures which was administered in March 2020 was not included in the analyses of the current study.

[16] Given the changes in the indicators, we had to re-evaluate the psychometric properties of the 9 measures (i.e. scales/subscales) that were administered in March 2021. This re-evaluation led to the conclusion that the score-validity of the 9 measures were extremely similar, with the factor analysis yielding the same factor structure pertaining to each measure for the March 2021 data as for the February/March 2020 data. With regard to reliability, interestingly, for all 9 measures, the reliability coefficient was higher for the March 2021 data than for the February/March 2020 data[16]. In fact, for the March 2021 data, the reliability coefficients ranged from .75 (Satisfaction with Resources and Material Subscale) to .94 (Inculcating Cultural Values Scale)—all exceeding Nunnally and Bernstein’s (1994) cut-point

of 0.70. In particular, with respect to the three measures which had one item removed for the March 2021 administration, for the Perceived Teacher Knowledge and Pedagogy Scale, the reliability coefficient increased from .64 (February/March 2020) to .79 (March 2021); for the Attitudes Towards Diversity Scale, the reliability coefficient increased from .58 (March 2020) to .80 (March 2021); and for the Satisfaction with Resources and Material Subscale, the reliability coefficient increased from .68 (February/March 2020) to .75 (March 2021). These validity and reliability findings provide important evidence that neither the changes to the stem of each scale (i.e. from the teachers being asked to indicate their current perceptions of their own teaching quality in February/March 2020 to being asked to indicate the extent to which the school closures affected perceptions of their own teaching quality), nor the changes in the three indicators, nor the changes in conditions (i.e. COVID-19 pandemic, school closures and school re-openings), nor the changes in survey administration (i.e. phone survey) adversely affected the psychometric properties of the measures. Rather, the psychometric properties of all 9 measures actually improved.

[17] Onwuegbuzie and Levin's (2005) Binomial Test of Trend involves the binomial distribution being used to determine whether the number of group differences in the same direction (positive/negative) should be regarded as either a statistically "real" or a statistically "chance" finding. Specifically, for a 5% level of statistical significance, "when a study includes at least five outcome measures (for directional alternatives) or at least six outcome measures (for nondirectional alternatives), the binomial formula can be used to determine the probability of obtaining the observed proportion of findings in the same direction, under the null hypothesis specification that p (the success probability) and q (the failure probability) are each equal to .5 (i.e. assuming that a difference in one direction is as likely as obtaining a difference in the opposite direction). If the observed proportion differs statistically from .5, an effect-size index (typically the observed proportion itself, which serves as an unbiased estimator of p), along with a corresponding confidence interval, could be reported and interpreted" (Onwuegbuzie, Levin, & Ferron, 2011, p. 130).

[18] School sizes were characterised as follows: small schools (< 300 total pupils), large schools (300 < total pupils < 600), and very large schools (> 600 pupils). Further, the school enrolment size is a function of the school's physical size because small schools tend to have approximately one half the number of classrooms—namely, 6 classrooms, on average—compared to large schools. In contrast, large schools—involving 12 classrooms on average—have one half the number of classrooms compared to very large schools, which have 24 classrooms on average.

[19] The standardised canonical function coefficients in Appendix Table 1 are computed weights that are applied to each variable in a given set in order to determine the composite variate used in the canonical correlation analysis. Therefore, standardised canonical function coefficients are analogous to beta coefficients in a regression analysis or to factor pattern coefficients in exploratory factor analysis/principal components analysis. In contrast, the canonical structure coefficients in Appendix Table 1 are the correlations between a given variable and the scores on the canonical composite (i.e. latent variable) in the set to which the variable belongs. Therefore, structure coefficients indicate the extent that each variable is related to the canonical composite for the variable set. Specifically, structure coefficients are

essentially bivariate correlation coefficients that range in value between -1.0 and +1.0, inclusive. Importantly, the square of the structure coefficient (not presented) provides the proportion of variance that the original variable shares linearly with the canonical variate (Thompson, 1984).

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